CHAPTER 3

Research for policy development: Industrial clusters in South China[1]

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Abstract

This research study analyses the development of industrial clusters in three institutional contexts in South China to better understand how policies have been developed and implemented to encourage innovation. The authors trace the growth of private enterprises within these clusters, and note that this growth was assisted by local governments and by links with foreign companies, which were instrumental in upgrading networks of suppliers and bringing in foreign expertise. The research shows that innovation centres have begun to create networks of enterprises, improve innovation capacities, and enhance communication with universities and research centres. In some districts, local government policy has promoted innovation centres, especially during difficult economic times, when a need for better quality and higher priced products made sense in China. As such, the innovation centres were mainly oriented toward servicing the local industry, rather than maintaining a competitive edge. The research team concludes that 'marketized' research centres have a greater probability of success than innovation centres because they base decisions on selling products.

Since 1999, China has actively promoted innovation policy to reinforce the technological capabilities of smaller firms, while continuing to promote larger multinational firms. At the same time, public research centres have undergone rapid 'marketization',[2] which has transformed many former public engineering research centres into enterprises. It is much too early to assess this strategy, but the speed with which private firms and collective enterprises have acquired, adapted and promoted new products, and new productive processes, is remarkable. Moreover, the information technology (IT) sector has grown at an unexpectedly rapid rate, and has become the main sector for investment and technological development.

This project used empirical evidence to describe the links between scientists and non-scientific clients in different institutional contexts in Guangdong Province. It had three objectives:

- to investigate the innovation system for research and development (R&D) in the South of China;

- to understand the dynamics of the relationships between research units and the non-research technological users in different social, economic, and institutional contexts (content of the links, motives, resources, and incentives); and
- to promote the creation of a pool of excellence on science and technology policy by providing an empirical basis to policymakers.

The institutions that were studied were located in three different institutional settings: Zhongshan University (City of Guangzhou); the industrial districts of Xiqiao (City of Nanhai) and Dachong (Zhongshan City); and a large industrial district producing motorcycles in Pengjiang (City of Jiangmen). Also, an industrial cluster that had no innovation centre (in Dongguan), but an important industrial base, was studied (Table 3.1).

Methodology

The Research Institute for Guangdong Development (ZURIGuD) of Zhongshan University studies social and economic problems in Guangdong. Local authorities see technological development and innovation as important and have expressed the need for new policies. To support policy development, research was required on the dynamics of industrial and technological development inside firms, and on the role of R&D and innovation in Guangdong.

Field research for a small project in the industrial cluster of Shuikou, Kaiping, which specializes in the plumbing industry, was conducted in

Table 3.1 The three institutional settings that include the industrial clusters and the university that were studied

Setting	*Example*	*Context*	*Activity*
Technology or 'innovation centre' focused on local industry	*Xiqiao (Nanhai)* textiles innovation centre; *Dachong (Zhongshan)* furniture innovation centre	Local industry	The centres provide service to local companies, mainly SMEs. Some centres also provide patterns for new products (e.g. moulds and patterns for textiles).
R&D unit servicing productive units of an industrial group	*Pengjiang (Jiangmen)* motorcycle R&D centre	National and global industrial corporation	Provide designs requested by production units, or in response to demand.
University undertaking research and linked to production units	*Zhongshan University (Guangzhou)*	National research system and its local implementation	Research collaboration and support for activities with high knowledge content (e.g. environmental monitoring). Also, common research laboratories with world-class companies.

January 2000 and March 2001. This was followed by research on the dynamics of the industrial clusters and the links among knowledge providers in the South of China. This research project was a complement to on going research by ZURIGuD on industrial clusters.[3] The ZURIGuD team focused on the roles of innovation centres, intermediate organizations (such as local associations of industrial firms), and enterprises in the industrial cluster. This project was designed to use qualitative analysis, a type of research relatively new to our team, and to include the active participation of students. Specific interview guides were designed to gather information on: origins and evolution of the innovation centres or institutions; sources of funding and the management of resources; flows of knowledge from academic institutions; relationships with enterprises; and incentives.

The students participated in the fieldwork, and in some cases, stayed quite a long time in the industrial districts to gain a better understanding of the situation. As the project progressed, more importance was given to the role of industrial clusters in the Guangdong region and the newly created 'innovation centres', because they were becoming sites of technological development. Project staff also participated in debates on how to modify the structure of the innovation centres and refurbish their policy tools. Cooperation as advisors to local authorities has been quite successful, and the local government of the Municipality of Nanhai, as well as the Province of Guangdong, provided partial support to our activities and access to the innovation centres. This exceptional situation allowed our research to focus on the role, context, and future of these innovation centres.

Guangdong: A region developed in successive steps

The development of Guangdong, and all China for that matter, is the result of successive steps to build a new economic environment. Guangdong received three successive waves of investment.[4] The first phase of expansion industrialized the countryside because initial reforms were aimed at that sector. The ability to grow and sell products outside the state planning system led to a rapid rise in agricultural production. In the early 1980s, profits from the sale of agricultural produce were massively invested in rural enterprises, the so-called 'township and village enterprises' (*xiangzhen qiye*). This growth lasted 6 years (1983–88). The investments were a boon for the local authorities and the most adept rural inhabitants. They found themselves in quite exceptional circumstances, given the absence of any competition and the existence of a large unsatisfied demand. This new economic opportunity permitted the development of an 'economy out of the plan' (Naughton, 1995).

The early 1990s saw the arrival of 'foreign' investments, mostly from Taiwan, Hong Kong, and overseas Chinese. In 1994, foreign direct investment (FDI) represented 20% of overall investment. In 2001, foreign investment from Hong Kong, Macao, and Taiwan continued to represent 18% of total investments (CNY158 bn)[5] and 47.5% of foreign investments (CNY55 bn) in

Guangdong Province. During this phase, two-thirds of the foreign investments were in the hands of small- and medium-sized firms from Hong Kong and Taiwan. These firms used labour-intensive production to assemble imported parts that they exported to international markets. This system received the blessing of local officials because it provided them with great decision-making powers. These firms did not represent direct competition to either the China-based township and village enterprises or private- or state-owned enterprises. However, they improved the trade balance and increased employment and incomes. Moreover, demands from the poorly paid labour force were directed to the low-quality products of the communal- and the state-owned enterprises. These enterprises continue to profit from growth in domestic demand. It also explains why these enterprises survived despite producing goods that were in many ways outdated. The Asian crisis of 1997 led to reduced orders being placed with Chinese enterprises, and slowed (relatively) this form of FDI.

The third phase of development began with the arrival of FDI from industrialized countries (e.g. the United States, Japan, and Europe). The Chinese government reacted extremely quickly and adopted a range of measures to attract this foreign investment. The huge campaign in favour of entry into the World Trade Organization (WTO) became the main objective of official policy. Since 1997, investment in real estate has increased rapidly, and large cities have become showcases of China's growth. Events, such as the Beijing Olympic Games in 2008 and the Shanghai Universal Exhibition in 2010, provide additional appeal to international investors. This increase in international investment has also triggered capital inflows from Taiwan and Hong Kong, which continue to be an important part of the overall FDI in China. These waves of investment can be thought of as a 'piling up' of productive systems (Figure 3.1).

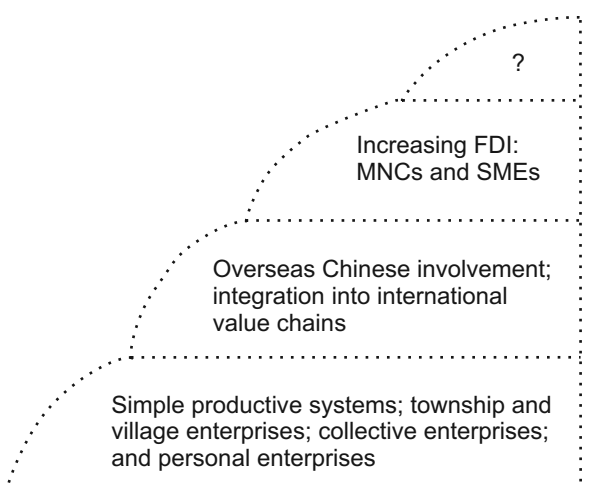

Figure 3.1 A schematic presentation of the 'piling-up' of productive systems

The first productive system includes township and village enterprises. These enterprises were established in the early 1980s and operated as private companies. However, for ideological reasons, they were officially registered as collective enterprises. They worked with raw materials, employed low-cost labour, and concentrated on various sectors of production, which they quickly dominated. At the same time, the larger collective enterprises that were already in place started to operate as 'private' firms (e.g. Yueqing in Shuikou Township, Guangdong Province). Starting as a tap manufacturing plant, Yueqing modernized and produced a myriad of small plumbing firms. Consequently, Shuikou Township is now the site of a whole industrial sector, and Yueqing is one of many new enterprises. Many other enterprises followed a similar path throughout China. Well-known brand names (e.g. Legend, TCL, Haier, Konka, and Galanz) arose with the first phase of expansion and prospered because their status as collective enterprises gave them access to public funds.

A second type of production system is evident in enterprises established during the second wave of investment from Taiwan and Hong Kong. Industries that produced textiles and clothing, electronics, and electrical household goods were relocated to the Pearl River Delta. Although these enterprises share features with the first wave, they have some unique characteristics. First, the investors not only established the enterprises; they brought with them their own networks of suppliers and customers. The Taiwanese and Hong Kong enterprises, established to take advantage of low production costs, were backed by more than 30 years of experience in supplying multinational companies. In addition, they had their own ways of doing business, to which the entrepreneurs from Guangdong were quick to adapt. Second, they brought with them more complex production techniques, even in the case of less sophisticated industries like shoes, clothing, and basic electrical goods. However, they profited from low labour costs and adapted to local conditions by making less use of intensive technologies. Third, these overseas Chinese established strong ties with mainland officials and local government bodies. They also included the local power structures in their operations in a much more intense way than local entrepreneurs. More effectively still, local authorities appealed to these firms to help strengthen technological development and launch technical education initiatives (e.g. practical demonstrations, technical training, and apprenticeship schemes). In some cases, innovation centres were created to promote technological innovation and to provide technical know-how to enterprises in a particular sector of production. In the industrialized world, such centres are usually organized by the chambers of commerce or public education bodies. In China, they were achieved by the joint enterprises to which the foreign partners brought both expertise and markets.

In the Pearl River Delta area, these FDI-dependent enterprises, which were owned by foreign capital, employed an estimated 30 million workers from the most impoverished inland provinces of China. The foreign enterprises have made good use of this continuing supply of low-cost labour. They have turned the whole area into one huge factory (Ruffier, 2006) with local concentrations

producing various products. Shunde is the main manufacturing centre in China for electrical household goods; Ronggui the largest centre in the world for air-conditioning units; Shaxi is centre for leisure wear; and Humen (Dongguan) a centre for clothing (Qiu, 2001: 234). By the end of the 1990s, this system had reached its limits, but it continued to coexist with other production systems.[6]

The third wave of investment in Guangdong was provided by industrialized countries, which installed 'third generation' systems of production that were more directly piloted by foreign firms. Four hundred of the largest global firms have investments in China. The world's leading manufacturers of telecommunications and oil-industry equipment, cars, and machine tools have set up their own production networks in China. Often focused in the Shanghai region, the foreign firms begin by setting up small offices and then establishing production sites. Foreign investors no longer only seek to establish manufacturing plants; they hope to develop a market in China.

Unlike the systems of production established under the first two waves of investment, these firms have no difficulty using efficient managerial techniques and establishing organizational structures geared toward their production goals and markets. Potential difficulties arise solely from their social environment. Future legal and institutional setting will be decisive for these 'third generation' systems of production. The foreign investors who back these firms are relying on the complete opening of the Chinese economy in accordance with international agreements. It is still too early to make a full assessment of this third wave, and of the eventual outcome of the superimposition of these three different systems of production. At the time of this research, these new systems of production were still at a preliminary stage, and the foreign firms were just beginning to perceive the problems any enterprise encounters when it first establishes operations (see Richet et al., 2001; Verillaud, 2001). Even foreign firms that were already established were finding it difficult to make any profit. For a foreign firm, everything is more expensive in China – land purchases and building costs, installations, employee recruitment and training, communications with headquarters, relations with government offices handling labour and the environment, and commercial dealings with suppliers. In many cases, it is more expensive to set up an integral system of production than to collaborate with a local supplier.

The logic of industrial development in Guangdong

Enterprises were the main actor of industrial development in Guangdong; therefore, our research framework placed technological learning by enterprises at the centre of the research. Technological learning is the main process by which an enterprise acquires and develops a technology and its productive processes (Pirela et al., 1993; Arvanitis and Villavicencio, 1998; Arvanitis, 2000; Arvanitis and Vonortas, 2000). Learning inside an organization creates the basic internal capabilities of the enterprise (i.e. the workshop, the production line,

the engineering or R&D departments, and the complementary departments such as maintenance, sales, marketing, and finances). But these internal structures must create external links through which experiences with new products, new processes, and new management procedures can be acquired by the enterprise. This *external learning* is acquired by *interacting* with clients, providers, and many socioeconomic actors (e.g. authorities, engineers, and experts). For developing countries, international technology transfers are a very frequent form of external interaction.

The literature that has grown on technology transfers in the last 10 years has been enriched by the perspective of 'user-provider'. However, the knowledge transfers that take place between a foreign client and a local enterprise are often not considered, although they should be seen as an essential form of technological learning. In developing countries, a large part of relating to new technology is based on technology transfer. Instead of focusing on the legal status of technology transfers, which brought the debate to a dead-end (Ruffier, 1996), the types of arrangements that can be made between buyers and sellers of technology should be examined. Guangdong presents many opportunities to study interactions of enterprises with their productive environments.

Technological learning in companies in Guangdong

Arvanitis and Zhao (2003) present six case studies that highlight relations of companies with foreign clients. Four models of learning were identified through these case studies. An important part of the learning comes from the client, who inspects the processes, provides blueprints, and pushes the provider to achieve high quality. The client is the provider of the technology, and the providers of the products are the users of the technology: the user-provider relationship is the inverse of the common understanding of the expression 'user-provider'. Various types of external links, or interactive learning, are summarized in Table 3.2.

Table 3.2 Characteristics of different models of interactive learning

Interactive learning	*Main characteristics*
OEM model	Dominated by FDI, the company is inserted in the value chain. Stable relations and regular and long-term commitment to client. Strong productive learning and design capabilities. No original design, no capacity to innovate strongly in models because the brand is the one that decides.
Contracted provider	Unstable relation to client. Strong local competition. Can be private or collective enterprise. Emphasis on quality control and productive processes.
Joint venture (subsidiary or affiliate)	Mainly internal learning. Transnational circuit inside the firms. Very stable relation.
Large local producer (OEM and provider under contract)	A mix of stable and unstable relations. External learning, emphasis on quality control, productive processes, and innovative products.

Original equipment manufacturing (OEM) is what made Taiwan famous. Particularly well suited to a globalized industry, the international brand gives productive orders. The local factory exploits low labour costs and ensures high quality control. R&D is not done unless it serves the purposes of the brand. The brand company makes higher margins and exploits its decisive advantage: access to markets. But this market access has no meaning if low cost is not maintained by the local producer. Taiwanese producers, after 1990, understood the full advantage they could get from coming to mainland China (Guiheux, 2002). Hong Kong investors came to Mainland China for the same reason, and transformed Hong Kong into an industrial desert (obliging HK to focus on a strategy to develop shipping, transport, logistics, financial and other services, and tourism) while providing the Pearl River Delta with the impetus for industrial development.

The most common type of arrangement in Guangdong is a contracted provider, a case well illustrated by the Shuikou industrial cluster (Arvanitis, 2001; Sun and Xu, 2002; Arvanitis, 2004a). This is a medium-range solution for companies looking for very cheap providers (e.g. the faucet and plumbing industry and all traditional industries). Difficult access to the international market obliges local companies to accept the conditions imposed by the foreign client. In fact, the local companies do this very gladly because they seek foreign clients. 'Our clients are our teachers', said one manager. Through these contacts with international clients, companies access higher quality models and improved quality. Sales to foreign markets also return better prices and make ISO (International Standards Organization) or similar certification easier. Companies become contracted providers for foreign clients not so much because they want to export, but because they must if they are to gain access to more products, better designs, higher quality, and better processes.

Joint ventures (JVs) were once thought to be a panacea. They were supposed to bring money and technology to Asia, mainly China and Vietnam. Vietnam today is experiencing a considerable fall in investments and China has instituted legislation to promote FDI in different forms. Foreigners are usually uncomfortable with JVs and most foreign companies now want to become wholly owned foreign enterprises because the law authorizes this new possibility. The partnership is a forced one, not a chosen one, and whatever the benefits, they are always seen with suspicion. There are great variations in JVs. Technologies usually flow well, and there is an important flow of know-how, as would be the case of any subsidiary of a transnational firm. However, there are no efforts that are genuinely local and independent. All decisions depend on the internal structure of the transnational or the foreign partner.

A mixed model would appear to be ideal, but it is not frequently observed. Dachangjiang (motorcycles) or Jinling (electro-domestics), both companies in Jiangmen, are two exemplary cases. They both attained technological capabilities and are simultaneously producing their own products and products under OEM arrangements with foreign clients. They are both dominant clients and contracted providers. They have a long-term strategy

for technological development, depend on rapid changes in local markets, act in very open and competitive markets, and have some more specialized and less competitive markets. Other large companies in China (e.g. Haier, TCL, Konka, Legend, and Fenghua) are probably similar in their pattern of development in the electro-domestic and electronics industries. A mixed model of learning means that these companies have learning strategies based on technological development and high standards of production, not exclusively on commercial and management aspects. These companies will never cut costs at the expense of investment. They develop collaborative R&D with outside sources of knowledge. The mixed model is efficient if it permits a company to offer lower costs to a client who, in exchange, offers entry to foreign technologies. Moreover, learning companies under this mixed model seek technologies and markets in foreign countries. This explains why more and more Chinese companies invest in productive or research facilities in foreign countries, although they seem not to be leaders in technology.

Arvanitis et al. (2006) report on the effects of different types of interactions on technological learning. Although theories on technological learning must take advantage of work on technological development (Tidd et al., 1997), they must also consider the particularities of corporate organization in China (Richet and Huchet, 2000). Companies have a strong capability to incorporate new technologies (Huchet, 1999), but they frequently have more difficulties competing in international markets if they are not linked to a foreign client who acts as a provider. Corporate strategies are not always successful in producing a coherent technological and economic strategy (Zhao, 2006). Moreover, technology is mainly provided through strong relations with clients who become the main sources of this technology (Arvanitis and Zhao, 2003).

Future challenges for Guangdong

The 'miracle' of South China industrialization seems to be based on a specific economic phenomenon: the creation of enterprises *de novo* in an environment in which close collaboration with foreign partners was made easy by specific policies (e.g. economic zones and promotion of FDI). Guangdong's development has relied on basically unskilled labour in productive units funded by foreign capital. Local entrepreneurs created companies using the same logic, but their difficulty was how to obtain productive technologies. Today, they are being forced to upgrade their technology. Very low labour costs do not provide sufficient incentives for firms to invest heavily, and there are signs of serious difficulties due to very intense price competition between companies.

Due to rapid growth, local markets seem particularly crowded, and already strong competition is being accentuated. These conditions are reflected in the strategy put forward by the provincial government of Guangdong. Not only will companies face strong competition; regions will also compete to keep companies. Guangdong Province has now become more expensive than other

regions. Competition between regions can be expected to grow to attract new FDI. The current model is thus reaching its limits. Although problematic because of scarce access to funds, growth in size seems necessary if companies want to maintain high technological abilities. In this context, companies are seeking special considerations from local governments, not just economic support, but also many other concessions.

Local authorities in Guangdong never directly fund a business. Rather, they work on enhancing the image of the city by providing support for commercial fairs and by promoting and publicizing the city outside the region. They also work to improve infrastructure and recently developed innovation centres, maintain close relations with companies, and provide easier access to foreign clients, which can be seriously affected by local authorities (e.g. visas, authorizations, imports, and exports). Some more direct relations probably exist between the financial office and specific companies. However, these are likely personal relations that in some cases are promoted by local government officials (with great care, because corruption is heavily punished).

Technological upgrading is essential and will dictate whether an enterprise survives or dies. Many small companies rely on their foreign client to upgrade their technology. Up to a certain point, the stability of this relationship will depend on internal learning and the strategic capability of the company. Can Guangdong, and China in general, manage the large array of competing learning models? There is no sign to be either overly pessimistic, or extremely optimistic.

Until very recently, there were no specific policies to promote enterprises in the Guangdong region. This is why we qualify development in Guangdong as 'spontaneous' development of companies. Given China's planning experience, this spontaneous development is of paramount importance to both local actors and authorities. Everyone in the industrial cities of Guangdong considers that private drive, with strong autonomy from the state, is the main engine of growth. Local entrepreneurs are proud of their independence, although they welcome collaboration with local authorities. Under these conditions, it is difficult to engage in processes that involve public knowledge but require private funding. Public–private partnerships will be difficult to establish.

The clustering process

The OECD (1999) and the World Bank see clusters as a sort of new panacea to industrial development, mainly because clusters abound in those areas of Asia where industrial development has been rapid (Mahmood and Singh, 2003). In a conference organized by ZURIGuD in April 2004, many examples of industrial clusters in Malaysia and Thailand were presented.[7] However, comparisons that go beyond a simple correlation between rapid growth and cluster formation are needed. Cluster dynamics must be reinserted into the general process of industrialization that is ongoing in these countries. Based

on the work of Guerrieri and Pietrobelli (2002), three types of clusters can be defined.

The first and most important cluster is the *Marshallian cluster*, which is named after Alfred Marshall who introduced the concept of an industrial district in 1876. It consists of a location of many small firms in the same industry. The concept has been used in many cases, mostly in the 1970s to describe the light industry in Tuscany (Italy), also known as the 'Third Italy.' Authors who have studied this type of cluster emphasize the role of long-term socioeconomic relationships among local firms, which involve trust and a blend of collaboration and competition. These relationships contribute to the 'industrial atmosphere' first underlined by Marshall.

The second type of cluster, the *hub-and-spoke cluster*, refers to a situation where one or more firms (usually large) within a region act as a hub of the regional economy. Suppliers and related activities spread around them as spokes of a wheel. It is a hierarchical relationship. Automobile industries usually are organized in this way, where the car constructor has all its providers surrounding it in the same region.

The third form of cluster is a *state-anchored cluster* (or satellite platform). These clusters are 'anchored' to a region by a public or non-profit entity, such as a military base, a university, or the concentration of government offices. Government policy plays an important role in the development of these clusters. Examples in Europe are the technological park in Sophia-Antipolis in France (Dalla Pria, 2004) and the development of nanotechnologies in Grenoble (France).

These are theoretical categories, and in practice, clusters are combinations of different sized companies that exhibit changes over time (Jastrabsky, 2004). As we will see in the conclusion, these three categories are not very clearly distinguished in Guangdong. Moreover, more thought is required on the formation of clusters and their integration into international value chains, because most theorizing on industrial clusters was done when international value chains were rather limited.

Innovation policy and innovation centres

Innovation policy attracted the attention of many scholars (Gu, 1999; Suttmeier and Cao, 1999; Liu and White, 2001; Cao, 2004; Huang et al., 2004) as the new technological landscape emerged in China (Sigurdson, 2002). These studies go hand-in-hand with the recent effort by the Chinese government to define an innovation policy beyond classic science and technology (S&T) policy – a drive that was predicted and recommended (IDRC, 1997). The government of Guangdong also tried to integrate this new orientation into its policy for technology (Guangdong Office of Science and Technology, 2002).

Innovation policy in China

In August 2001, the tenth 5-year plan (2001–6) was launched. Its stated objective in science and technology was to 'establish an efficient innovation system, with enterprises as the main location of the source of innovation. Government forces are necessary, but at some point they must give way to market forces'. This launch was the logical conclusion of a course of events that began in 1999 with the National Convention on Innovation in Beijing. Since then, innovation has been the buzzword in S&T policy.

Although 'innovation policy' was not located under a specific authority in China, a complex of activities and policies taken together can be considered instruments of innovation policy (Arvanitis, 2004b). These can be grouped into five categories: creation of science and technology development parks and high-technology (high-tech) zones; support to specific enterprises with high potential for technological development; 'marketization' of research centres; creation and support of industrial clusters; and creation of 'innovation centres'.

Creation of S&T development parks and high-tech zones

Hong et al. (2004) noted that there were 85 high-tech zones, 32 mid-sized economic and technology zones, and 58 university science parks. The five special economic zones (SEZs), of which the most famous is Shenzhen, which was created in Guangdong in 1980, should be added to this count. SEZs are all located on the coast, from Dalian in the North to Zhanjiang in the South, and were created to attract foreign capital. Guangdong hosts three of these SEZs (Shenzhen bordering Hong Kong, Zhuhai bordering Macao, and Shantou), which buffer these former foreign colonies that are hubs of commercial and maritime transportation. As a result, the disequilibrium between the Chinese hinterland and the coastal cities was accentuated. This led to a policy known in China as the 'Drive to the West', which promoted heavy infrastructure in the less endowed provinces in the north-west of China.

However, even more industrial zones appeared and local 'economic and technological development zones' (*jinji jishu kaifa qu)* were created in every part of the country – from urban buildings housing small software companies to larger national technology zones that covered a vast and growing geographic area. This expansion made Chinese policy less clear to investors and was denounced for the loss of arable land. Since 2004, the central government has tried to address this situation, which now involves as many as 12,300 industrial clusters. Most of these are vast, lucrative real estate operations that responded to incentives launched by the central government, mainly the Torch Programme (1988) – 'Windows Opening to the Outside World'.

These large high-tech zones function less as a tool for technology policy than as a magnet for foreign investment and large national investments. Local authorities are proud to show the abundance of new companies in these large,

clean, healthy industrial zones. However, they have little influence on the strategies of the companies, their links to other companies, or their integration into the industrial set-up of their province. The dynamic of the high-tech zones is thus not directed by local authorities but rather determined by the companies themselves. An evaluation of these high-tech zones is needed. However, one measure of their success is the number of companies and the amount of investment: high-tech companies accounted for about 12% of the value of gross manufacturing output in China and invested CNY31.4 bn in R&D, which is 24.4% of the gross expenditure on R&D and 40% of business expenditure on R&D (MOST, 2004).

Support to specific enterprises with potential for technological development

This includes various forms of direct support not usually reported under statistical headings: direct funding; tax-relief measures; non-tax support, such as facilities for installation and other administrative facilities; and public procurement of products from these enterprises. These measures usually include strategic (like satellites and electronics for military use) and 'sensible' areas (such as the production of anti-retroviral drugs for AIDS). In the case of strategic areas, military orientations are important, or as the 863 Programme[8] announced: 'the combination of military and civil uses of science'.

Locally, small- and medium-size enterprises (SMEs) can receive this kind of support, but not usually in the form of direct financial support. Support usually includes helping enterprises get authorizations and assistance: visas for travel abroad; licences for exports and imports; invitations to workshops and meetings; help in making contacts with foreign clients; promotion of training for engineers and entrepreneurs; assistance with environmental facilities; and assistance with payments for land to install a workshop. Most of the measures are dealt with on a case-by-case basis and focus either on infrastructure or on facilitating contacts with authorities.

Policy measures are specifically oriented toward high-tech firms under Programmes 863 (since March 1986) or 973 (since 1996). Support to high-tech companies has effectively created technological resources. However, there has been no evaluation of these policy measures. To some extent, they have been successful because they gave birth to enterprises (mainly collectives) that are now engaged in R&D and technological development (Sigurdson, 2002).

The 'marketization' of research centres

'Marketization' of research centres is a vast programme to privatize the old public research institutes. This programme has received little attention from external observers, but some Chinese researchers have noted profound changes (Kong, 2003; Tang, 2003). Research centres now must be viable financially without public support. They must transform into enterprises that sell products. This policy was successful, in part, because many of the centres were related to large

public corporations and had market knowledge. Moreover, they were able to easily find markets because Chinese client enterprises found it easier to buy products than to engage in research collaboration or technological alliances. This privatization has continued through years of successive reforms of the engineering and research centres that belong mainly to ministries of large state-owned enterprises (Gu, 1999). Over time, more initiative has been given to the research centres. What is new today is that this reform affects not only large public enterprises, but research centres related to specific ministries, like agriculture and forestry, and the Academy of Science.

Creation and support of industrial clusters

The creation of industrial clusters is a basic aspect of industrial policy in China. Most of these districts exist when the policy is announced. The industrial cluster appears because of the initiative of entrepreneurs, usually workers who were employed by a public company in this location. At the end of the 1990s, in Guangdong and Zhejiang, where clusters were common and economically strong, the authorities understood that they needed to support the clustering process to avoid overcrowding of the industrial sector, harsh competition, and degeneration of the entrepreneurial spirit. Most clusters that are supported by the government are located in traditional industries.

They resemble the Third Italy clusters in many aspects: autonomous growth; traditional industry; and later support by the government. However, there are differences in terms of management and clients. The companies in the Italian industrial districts provide highly specialized products of high quality in relatively small quantities, with competition based on quality and specificity of products. In China, the clusters service a large market, where competition is based mostly on price for low-quality products. More rarely, some of the industrial districts are organized around an industry that makes intensive use of human resources and provides products to international clients, like the *maquiladoras* companies in Mexico and Central America (these companies are called *san lai yi bu* in Chinese). Entire industrial districts, like Qingxi in Dongguan, have been created on this basis. However, some qualification is necessary. *Maquiladoras* enterprises were mostly inserted into the strategy of a large industrial group, mainly located in the United States or Japan. The industrial clusters in electronics in China were second-tier industries, which serviced some companies, usually from Taiwan or Hong Kong, and were providers to American or Japanese international groups. The presence of overseas Chinese in the Guangdong region facilitated this process.

Creation of 'innovation centres'

This is probably the most original policy measure implemented in China. Innovation centres are located inside an industrial cluster and support SMEs. Among their objectives, links with research activities in universities and

public research institutions have been paramount. They participate directly in the modernization of enterprises within the industrial cluster and are well adapted to local industrial conditions.

Innovation is more than rhetoric in Chinese S&T policy. Among the priorities of the National S&T Plan, innovation is the primary objective. Questions could be asked about why there is this strong perspective and how this orientation affects all other scientific activities. However, innovation is a national objective implemented locally in every part of China. Guangdong is not an exception; it has been the site of experiments in every aspect of China's national innovation policy.

Guangdong has been particularly active in providing experience to policymakers in Beijing. Before the 1999 National Conference on Innovation held in Beijing, the Department of Science and Technology of Guangdong Province had already initiated local government intervention in technical innovation centres. In 1998, the Department launched the project 'Experimental units of technical innovation in specialized towns in Guangdong Province'. Each town that was specialized in one product had to create a 'platform' for the promotion of technical innovation – an innovation centre for each specialized town. An appropriation of CNY300,000 by the Department of Science and Technology was supplemented by other funds from local governments to provide initial funding for these technical innovation centres (ICs). This was the beginning of measures geared at technical innovation by local governments. Today, 50 industrial clusters participate in technological innovation pilot locations organized by the Department of Science and Technology.

Research and development in Guangdong

The Chinese government is responsible for most basic R&D funding. Nonetheless, 'funding amounts are not high enough to allow research structures to engage in large projects in the long term; research structures coexist without any previous selection and with a lack of initiative' (Guangdong Office of Science and Technology, 2002). Local governments usually fund little basic research. This is considered an advantage because the central government structures are more dedicated to basic research, which allows innovation and technology-related research to be conducted by local research structures. Guangdong follows Beijing, but is ahead of Shanghai in terms of R&D spending (Guangdong Office of Science and Technology, 2002: 78). Although Beijing and Shanghai have better diffusion channels, research in Guangdong is characterized by strong ties to enterprises. In 2001, overall spending for research in Guangdong was CNY13,423 million, or 1.27% of GDP (more than the national mean) (Guangdong Office of Science and Technology, 2002: 65). Enterprises contributed up to 88% (CNY9,520 m) of this spending on research in 2000 and 90% in 2001 (CNY11,370 m). This is exceptional because enterprises in China, in general, spend little on R&D. In Guangdong, 1.4% of

revenue was spent on R&D in 1991 and 1.6% in 2001. Guangdong had 2,733 research and technology organizations[9] in 2001, and the City of Shenzhen has profited the most from rapid growth in the number of research organizations. Shenzhen now has 521 R&D organizations, and 91.7% are inside enterprises.

Of the 1,453 research centres in the Province of Guangdong, 979 are located inside enterprises (67%). In 1998, 23% of the large enterprises (national or foreign) had their own R&D centre. This figure grew to 43% in 2000. In 2001, 85% of small- and medium-size collective enterprises 'operating in technical fields' had an R&D unit. In 2001, of the CNY25.6 bn invested in S&T in Guangdong, 71.4% came from enterprises in the province. In 2001, large- and medium-size enterprises invested CNY9.45 bn, which was CNY4.17 bn more than in 1997.

In 2001, of the 4,082 high-technology products developed in the province, 62.8% were developed in collaboration with enterprises, universities, and research centres (Guangdong Office of Science and Technology, 2002: 73–4). The report does not provide specifics on the type of collaboration involved.

The number of patent applications has grown very impressively in Guangdong.[10] However, many of the patents are not for inventions but rather for designs and utility models. Moreover, foreign companies tend to patent inventions; whereas, Chinese companies tend to patent utility models and designs. This means the core technologies are still in the hands of the foreign companies, and most of the revenues from patents in core technologies enter the accounts of foreign companies (Cao, 2004).

Finally, there is a strong deficit in education in Guangdong as compared with other provinces because the province does not have enough universities and lacks strong S&T structures (Guangdong Office of Science and Technology, 2002). It is a priority of the local authorities to strengthen the educational level in Guangdong and to provide additional resources for universities and other educational centres.

Case studies

Three case studies were undertaken to examine the main issues and problems with the policy of innovation centres in the Pearl River Delta. In addition, an industrial cluster with no innovation centre and Zhongshan University were studied.

Mahogany furniture cluster, Dachong, Zhongshan

Dachong, in the municipality of Zhongshan,[11] is an industrial district that specializes in mahogany furniture. There are more than 300 enterprises, with the larger ones employing 400–500 workers. The innovation centre acts as a technical centre and has good relationships with universities and research centres on specific technical questions. The innovation centre tries to modernize production, improve knowledge, and enhance the quality of

production from the enterprises. Its objective is to become 'a platform for the diffusion of innovation among enterprises'.

The economic situation in this industrial cluster was characterized by local actors as 'not good'. The market is no longer a 'sellers market,' where it suffices to produce and sell. Enterprises are more conscious of the need to improve the quality of their products and to specialize. The authorities, and many enterprises, want to enhance production standards and quality norms, and more generally, the overall quality of the enterprises. There are also plans to market a 'Made in Dachong' brand as a sign of guaranteed quality levels. The situation of Dachong is common to most of the industrial districts in the Pearl River Delta, which experienced rapid and relatively easy growth until the late 1990s. Since then, competition among enterprises has increased and new products are harder to copy.

The industrial cluster

Dachong, a district of 28,000 permanent residents and more than 30,000 immigrant residents, also known as 'Longdu', is located in the south-west of Zhongshan, Guangdong Province. Dachong specializes in the production of mahogany furniture and jeans, and per capita income is CNY5,000.

The wood industry is not native. It originated, in the late 1970s and early 1980s, when immigrants from Zhejiang came to work in small workshops owned by individual families. In 1993, there were about 300 mahogany furniture enterprises with more than 30,000 employees. Their output accounted for 60% of the national output (according to the officials interviewed), which makes it the largest manufacturer of mahogany furniture in China. Since 1999, the Party Committee and the government of Dachong have treated the mahogany furniture industry as a 'key characteristic industry', and it has become an activity of special interest for local authorities.

The chamber of commerce

The Dachong Chamber of Commerce, established in 1994 at the request of Zhongshan General Chamber of Commerce and promoted by many manufacturers,[12] is one of the earliest business organizations established in Zhongshan. Until then, market issues had been the responsibility of the Private Enterprises Office of the local government.

With the growth of the mahogany furniture industry, the Chamber of Commerce created a subordinate 'Joint Association of Mahogany Furniture' in 1997. This association accounts for 70% of the workload of the Chamber of Commerce. The government provided the Chamber of Commerce with 3,335 m^2 of land, which was sold mainly to affiliate enterprises. Other resources of the association include stores, with an area of more than 800 m^2, that have become permanent rights-and-interests property of the association. The Chamber of Commerce also promoted the creation of businesses for insurance,

transportation, and tourism. The Dachong Chamber of Commerce now has more than 180 affiliate enterprises, among which are 105 mahogany furniture enterprises, 69 clothing manufacturing enterprises, and 10 enterprises in hardware and plastics.

The innovation centre

The innovation centre was established in 2001 by the local government of Dachong City (with an initial investment of CNY1 m). Additional financial support was received from the scientific committee of Zhongshan City (CNY300,000) and the Department of Science and Technology of Guangdong Province (CNY500,000). The local government donated land for the offices and has covered equipment and salary costs since establishment of the centre. As well, the scientific committee, the office of technical control, and the commercial association for mahogany furniture, all from Dachong City, have become part of this centre. The real leader of this centre is the local government, which has provided all funds and human resources and promoted its technical programmes.

The objective was to create an efficient network among enterprises, universities, and research centres. It was called a 'technical innovation system', and was designed both to provide support and services to small and medium enterprises in the city and to link the local government, the industrial association, and the enterprises.

The innovation centre analyses difficulties faced by mahogany furniture enterprises, diffuses technical solutions, and trains specialized employees. Other actions include: organizing training sessions, exhibitions, and other means to promote the newest information about techniques and management; establishing direct relationships with institutes, research centres, and specialists in China; and improving cooperation and communication among enterprises in the Dachong area. The centre provides both free and paid services.

The innovation centre has addressed three technical problems of the mahogany furniture industry: improving the drying process for the wood used in making furniture; promoting better designs for products; and improving the quality of paints and coatings to comply with environmental standards. The centre believes these are the main obstacles to expansion of the market and improvement of quality.

To address the problem of drying the wood, the centre bought and developed a computerized monitoring system. Three enterprises were interested in using the system, and they were each charged CNY50,000. Solutions to the other two problems were given free of charge to encourage the use of new technology and methods. In the near future, the centre plans to offer all services for a fee and to offer assistance with ISO certification.

The innovation centre has established contacts with universities and research centres to tackle these technical problems. The computerized system for drying timber was developed in association with the Guangzhou

Energy Research Centre of the Academy of Science (Zhongguo Ke Xueyuan Guangzhou Nengyuan Yanjiusuo). This system allowed enterprises to obtain the necessary certificates to enter markets in Northern China. This is an expensive system with high investment fees, and services are not free. In addition, some enterprises invested in their own drying systems. During an interview, the director of the innovation centre, Mr Xie, noted that initially the local government refused to invest the CNY30 m necessary to build a common system. This meant the centre either had to wait for the enterprises to grow rich enough to invest themselves, or convince the local government to invest. Even if the local government invested in that system today, the director is not sure the enterprises would use it: 'we cannot afford to have such capital losses in the future.'

The second major technical development was the design of new models. With an initial investment of CNY200,000, the centre signed a contract with the Forestry Institute of South China (Zhongnan Lin Xueyuan) to develop new products. This institute had one year to provide the innovation centre with eight new models for four series of furniture. The institute was also responsible for developing manufacturing techniques and for providing technical support to the enterprises. Some models have already been produced and used by the enterprises.

The third development was the use of environmentally friendly paints. An initial investment of CNY380,000 was made with the Institute of Chemistry and Environment of the Xi'an University of Transport (Xi'an Jiaotong Daxue Huanjing yu Huagong Xueyuan) to develop a paint specific for mahogany furniture. This project is just starting, and product trials are ongoing. If this project is successful, it would allow the Dachong enterprises to sell 'green products' and to lower the time and cost of production.

The innovation centre has also promoted exchanges with specialists and established a policy to attract them. In 2001, during the 'first research session on the development of the mahogany furniture industry in China', the innovation centre selected 14 specialists as consultants in production, sales, R&D, and management. In collaboration with the local government, the research centre on Chinese Traditional Furniture of the Forestry University of Beijing (Beijing Linye Daxue Zhongguo Chuantong Jiaju Yanjiusuo) established a department in Dachong to encourage professors and researchers to collaborate. The innovation centre plans to form an information and communication network with the Forestry University of Beijing and the South China Forestry University.

The innovation centre has also concentrated on publicity to establish a 'Made in Dachong' brand. It encourages enterprises to participate in commercial fairs and exhibitions. For example, in 2002, it helped some enterprises go to the 'Dongguan Chinese and International Furniture Exhibition', the 'Shenzhen Furniture Exhibition', and the 'Changsha Centre of China Cultural Festival of Furniture'. This effort is common to both the mahogany furniture industry and the garment industry, which is also quite strong in Dachong. The plan is

for the mahogany furniture industry to become a leader throughout China by expanding its services and networks to SMEs outside Dachong.

Some issues

This case is typical of small industrial enterprises in the South of China. The industry in Dachong grew from craft work in wood, not from the creation of an industrial sector with previously well-established industrial markets and criteria. Companies in Dachong have, with some exceptions, low investment capacity and low technical skills in their employees and managers.[13] There are several pressing issues.

Changing market: Competition has increased during the last few years, and the links between the producers and the market have changed. For the Hong Xiqian company, it is more difficult to sell because all factories now have direct relationships with their clients.

> Before, in Dachong, the sector was flourishing. The lorries were in front of your door, waiting for products, we just had to produce and all was sold. Today, supply and demand have changed; the market is no longer good, so we have to improve the quality. Now that quality is improving, and prices are dropping, 95% of the commercial firms from Shenzhen and Dongguan, which export to Taiwan, have come back to Dachong (Hong Xiqian).

The activities of the innovation centre are accepted mainly because of this change.

Overlapping responsibilities: There are overlaps in the responsibilities of the local government, the innovation centre, and the industrial association. The director of the innovation centre is also the vice-director of the economic department in the local government and president of the commercial association. This was presented as an advantage. Before the innovation centre was established, the industrial association was in charge of all commercial and technical problems faced by the enterprises. The idea of creating an innovation centre came from the fact that the association did not have the appropriate means to resolve specific technical problems. Finally, the very active director of the innovation centre is to be credited for its positive results.

Different demands: The enterprises and the innovation centre must find a durable way to work together. The innovation centre has few *direct* relations with enterprises. Hong Xiqian said that if they have a technical problem, they do not go directly to the innovation centre but rather to the commercial association or the local government director. Hong Xiqian has established a technical department to design furniture with its own designers. On the contrary, Hexin takes the designs offered for free by the innovation centre and adapts these designs according to their production. Although these two companies seemed satisfied with the technical help provided by the innovation centre, the demands made by the enterprises are diverse and quite specific to their own situation.

High cost of technical development: Most companies find it difficult to engage in technical development because of high costs:

> I know this [automation dry equipment] is a good thing, which can improve product quality, shorten production time, and enlarge the market. However, when can I get return on such a high cost? For example, a stove costs two or more million CNY. For us, the most urgent thing is sales, for example in the Beijing market, where distributors control the sales network. They buy our products, put their brand on them, and sell them as their own. In such cases, we can only take about one tenth of the profit (Interview at Gush Enterprise, Dachong).

The problem of copying: Companies want to see improved protection of property rights and measures to fight copying. 'We develop our models very slowly, and after we show the new products, we are sure they will be very quickly copied. Now we have a new model, but we cannot sell it because it was copied with poorer, cheaper materials' (Hexin). Copying may appear to be a common problem in China, but in this industry copying is a new threat. In fact, the craft (before rapid industrialization) was based on specific craftsmanship, a know-how that is difficult to copy. The wood industry in Zhongshan was developed by Zhejiang immigrants who knew the woodworking craft. As production of furniture has become an industrial process, copying has become a very real threat. This issue is new and difficult for the innovation centre.

Few relationships between enterprises: The companies have few relationships and little cooperation. The only relations occur during the meetings of the industrial association, of which, now, practically all enterprises are members. When Hong Xiqian was established, it registered as a member. It participates in all events, such as trips, loans, anniversaries, market analysis, and meetings. Some of the activities promoted by the association are common issues, such as the possibility of an insurance policy: 'For example, if we have to rent a lorry, and this lorry has a problem, an accident, or lose the products, what can we do? But the association has enough money to be a guarantor, and this reassures us to sell and send more products' (Hong Xiqian).

Textile industry cluster, Xiqiao, Nanhai

Xiqiao is an industrial area in Nanhai District that specializes in textile production. The Xiqiao textile cluster is a typical success story in the Province of Guangdong. Xiqiao is composed mainly of SMEs. It is one of the four top textile-producing sites in China and has a long history in textiles. As early as the Jiaqing period in the Ming Dynasty, it was granted the title of 'hometown for textiles' and produced silk that was famous throughout the nation. Today, Xiqiao has 1,670 enterprises that include weaving mills, dye works, textile print factories, clothing firms, and two chemical-fibre factories. The labour force is 137,000, of which 60,000 are in the textile industry.

Production of textiles represents half of the total industrial production of Xiqiao. Enterprises mostly produce fabrics (1,265 factories with an annual production of about 1 billion metres of fabrics). There are also printing factories (56 printing and dyeing factories; 11 dyeing factories; and 6 fabric printing factories); garments producers (25 manufacturers without their own brand); and about 2,800 small trading companies. Labour is not well developed and this creates difficulties because the enterprises alone cannot master all techniques.

In the 1990s, after unprecedented expansion, the textile industry revealed many competitive problems. Most companies seemed to lack funds, 'over-used' machines and equipment, and were creating virtually no new products. To rescue this traditional industry, the local government developed policies under the banners 'support the strong, the big, the outstanding' and 'support the advanced, help the backward, and promote the medium.' The idea was to help companies renew their equipment, upgrade their technologies, obtain better patterns for textile weaving, and achieve better access to information. The local authorities devised two instruments: the 'southern textile industry information network' and the 'southern technological innovation network'. Both initiatives were located inside a newly created technology development centre.

The innovation centre

At the beginning of 1997, the Xiqiao District Government and the China Textile Information Institution established a non-profit institution to develop new textile patterns and provide technical support. The government raised CNY200 m to introduce and run a high-level computer-aided design (CAD) system from Korea to make Jacquard weaving designs. It also hired experts to develop new products and provide technical services. The pattern-making department was created in May 1998, and has developed several thousand new patterns. Using CAD to make the patterns has greatly reduced the cost of technical development and information collection. Companies acquired a wider range of products and quality was greatly enhanced. Some larger enterprises in this district have already established their own pattern-making units.

The information centre also developed a web-based network. The 'South Textile Information Network' provides SMEs with information on supply and demand and with guidance on e-commerce and business on the Internet (business to business). The network gathers information on trends in both domestic and overseas textile markets and helps enterprises develop new products to match market demand.

In 1998, the government wanted enterprises to improve their technical innovation because the market, due to sudden overproduction, had become a 'buyers' market. The local government also wanted to further develop the textile industry because the market had been fluctuating greatly, and that

government was convinced that, alone, the enterprises would not be able to improve their production. In 1999, an innovation centre was added to the textile pattern centre established in 1997.

The Xiqiao government invested CNY70 m to expand the centre into a 'South Technology Development Centre of Guangdong', which combined the information network and the CAD service. It also monitors contacts with scientific research institutions and intermediary organizations. The whole system, which is called the 'Xiqiao Textile Innovation Network', has three levels. The core level is the technology innovation system, which covers the main activities of the centre, and includes the CAD company, engineering technology research, and the Guangdong Textile Material Engineering and Technical Development Centre. All activities are designed to enhance machines and equipment and provide new products to the industry. The middle level is the innovation services, which includes the Xiqiao South Textile Information Network, the Nanhai Productive Force Promotion Centre (Xiqiao Branch), and other independent professional services. These groups sell services related to information, sales, purchasing, and financial capital to many SMEs. The periphery level is the service system (in Chinese, the social service system), which provides both training and contacts with higher education institutions, scientific research organizations, and professional training departments. Contacts are maintained with Donghua University, the National Institution for Scientific Information on Textiles, the Hong Kong Productivity Bureau, the Guangdong Textile College, and Qinghua University.

In 2000, Xiqiao was included in the first batch of 'Experimental Units of Technological Innovation for Specialized Towns', a programme conducted by Guangdong Province. The technical centre was given responsibility to act on behalf of the whole textile industry in the province, and was granted the title of 'Technology Research and Development Centre for Textiles of Guangdong Province'. The centre is an example of how to promote innovation in specialized zones of small and medium enterprises.

Some issues

In 2001, to establish the pattern-making centre, the government invested CNY4 m to buy equipment and pay employees, and then invested CNY73 m to build the new main office building for the innovation centre. In 2003, more than 50 employees worked in this innovation centre, which is one of the largest of its kind in the Pearl River Delta. This exceptional case merits close attention.

Success in modernizing SMEs: The local government continues to offer financial support to the centre for new equipment and projects. In theory, the local government follows the motto 'you get rich, I develop'. But in fact, the innovation centre and the enterprises depend on the government: 'We had already become a technical incubator for a few dozen enterprises, let's say a hundred enterprises. The large ones could do R&D alone and buy a CAD

model, as we did…these enterprises could also establish a R&D system, like us…' (Mr Pan, Innovation Centre).

The innovation centre's main task appears to be to modernize small- and medium-size traditional enterprises. It must also modernize itself by improving its technical level and operations. As in Dachong, the activities of the innovation centre are: to test and diffuse techniques; to train its own employees and the workers in the enterprises; to encourage enterprises to participate in exhibitions and fairs; and to spread information about new managerial methods and new techniques. The industry's innovative capability has been strengthened by tracking new clothing fashions throughout the world. In the last 3 years, the centre has created nearly 800 new products, and 30–40% of the new textile products in Xiqiao are based on patterns and models developed by the innovation centre. In the process, the creative capability of the enterprises themselves has been strengthened. Most textile factories have gradually come to realize the importance of technological innovation and human resources. Over the past 3 years, more than 1000 professional technicians have been attracted to Xiqiao enterprises in product development and process engineering. Some enterprises have even begun to set up their own R&D or design units. Finally, the production structure has also changed. The proportion of fabric used for clothes, decorative cloth, and industrial cloth has changed from a ratio of 95/3/2 in 1997 to 53/42/5 today. The transformation from pure fibre to mixed textiles, cotton, raw edge, and sackcloth has been achieved. Xiqiao cloth has completed the transition from low-quality products to higher quality ones. The mean price of cloth per metre has risen by 15–20%, and the clothing fabrics and decorative cloth produced in Xiqiao are of the highest quality in China and have won awards for quality and design.

Links between local enterprises and other institutions: Close collaboration with educational institutions, such as the Institute of Fine Arts, Guangdong Province, are now common. The centre invites professors and students to help develop modern designs and acts as a bridge between students and entrepreneurs: 'When there is an exhibition by the newly graduated students, we (the innovation centre) send enterprise bosses to attend' (Mr Pan, Innovation Centre). Collaboration with universities is also seen as mutually beneficial. The centre plans to enlarge its influence to the national level by establishing a national research centre. The centre has already developed close collaboration with the University of Zhejiang. The centre was also impressed by the work of a research centre in Shanxi Province that specializes in cotton fabrics and wants to develop with it a national series of seminars on new techniques in fabrics making. Mr Pan encourages participation in industrial design competitions because they provide opportunities to advertise products.

Public or private? The status of the centre is unclear. Is it a private institute or a government body? What are its links with the commercial association? What is the decision-making power of the innovation centre? This uncertainty seems to be an obstacle rather than a benefit. The innovation centre is

quite independent from the local government, but its directors are selected and nominated by the government and many things are decided by local government officers.

The Technology Centre in Xiqiao (the inner circle of the innovation system) is responsible for its profits and losses, its employees and finance, and it pays rent to the innovation centre. Although it is an autonomous organization (very much like an enterprise), it is not totally independent because the innovation centre provides it with contracts and tasks and has administrative responsibilities for the technical centre. And although the technical centre has direct commercial relations with enterprises and autonomously manages its resources, it is still part of the innovation centre.

> For people outside our structure, we are one department of the innovation centre, but, economically speaking, we alone manage our resources. We do not have to ask the innovation centre for that…The organization of our department allows us to manage our services according to our own objectives, each department has its own concrete business plans, but we act in the name of the innovation centre…Management, outgoing and incoming are separated, and nobody meddles…We collaborate only in technical fields, or when we need to renew equipment (Mr Rong Lan, Director, Department of Pattern Printing).

One difficulty relates to staff. Most management personnel were initially recruited from the public sector, but personnel are neither civil servants nor private-sector employees. Their salaries are fixed, without bonuses or penalties. In future, this needs to be clarified, especially in light of the high demand for professionals, and the high turnover that exists in the Guangdong region. The innovation centre team recognizes that government employees cannot resolve their problems, because they do not have the necessary economic and market competence.

Another difficulty is that the government has the last word in meetings with private partners. Mr Liang, the manager of a large company, shows scepticism about the power of the commercial association:

> During the meetings of the association, we have no right to take a decision without the approval of the government. For example, if we want to organize travel, we have to discuss it with the government, so we do not have any rights. The secretary of the association in the Light Industrial and Textile Special District and the secretary of our association are from the government…Associations have very low utility. The only thing the government can do is gather you together and give you a name (Mr Liang, Deyao Textile Industrial Ltd.).

The government itself is conscious of these difficulties. In an official document issued by the Province of Guangdong:

> Accelerating the separation of government and trade association…related departments in the government must be separate from trade associations in operations, human resource, etc. They must not work together. Government employers cannot take a post in managing the trade association. Government officials who act as association leader must resign within two years (Suggestions on Further Transferring Government Functions and Fostering the Industry Institute: 2–3).

The privatization of research centres is a general trend in China and Guangdong. The Xiqiao innovation centre is scheduled to become a 'private centre', which would then sell services for higher fees. However, its services to SMEs would then become too expensive. This issue is the most important aspect facing today's centres. The products and services developed by the innovation centre are a non-profit public service. The new weaving patterns are sold to the local private and privately owned enterprises for CNY300, which is considered below cost.

Diversity of techniques and insufficient competence: Important problems include the lack of software development and technical knowledge. There are few specialists, and the technicians' level of knowledge is low. Because of high turnover, imitation and copying of products is very common. The enterprises themselves do not develop and design products, they make products according to orders from clients (a common feature for all industrial sectors). Also common are a lack of marketing and little knowledge of the market: 'In this industrial sector, the mastery of techniques is different, for example, than in the motorcycle sector. The more you produce one component, the more you learn how to produce it perfectly. But, with textile materials, selecting, dyeing, and mastering the techniques is very hard…' (Mr Xiong, Secretary, Nanhai Textile Association, and Director, Office for Diffusion of Information, Committee of the City of Xiqiao).

Relations between companies and innovation centres: Interviews with managers of Xiqiao enterprises point to some lack of confidence and trust between the main partners. The reasons are numerous: companies do not feel the need for technical enhancement; companies say they do not need the centre because they have their own R&D structure; there is a lack of confidence because the centre is a public-sector entity; and lack of specific competence at the centre in relation to the enterprise. Here are some examples.

Mr Huang owns a small enterprise, which has been selling textile fabrics since 1994, and has also produced garment fabrics for a few years. It is located in the Light Industry and Textile cluster. He regrets that he invested in production because the economic situation is bad. For him, there are no benefits from the cluster in Xiqiao because there is no particular specialization. This feeling is shared by other managers in Xiqiao.

> Now we do not have a lot of technical relationships. In Xiqiao, there are not a lot of enterprises producing garment fabrics and one of the reasons it is difficult to prosper is that there are few enterprises and no incentives to

> open one…This district is too small in comparison with Hangzhou, Wuxi, and Changzhou, which are well-developed. Here in Guangdong, you just have Xiqiao, but with too disparate textile specializations. In Guangdong, the textile industry has not been seriously developed, not like the situation in Zhejiang Province (Mr Huang, Light Industrial and Textile Special District).

Nonetheless, Mr Huang has technical links with the innovation centre. He asks for help with pattern-design techniques and with printing his material. He is also a member of the commercial association and travelled with the group to the Wenzhou exhibition (one of the largest in China).

Even if relationships with the innovation centre are difficult to create, they can evolve over time and with experience. For example, here is the story of Mr Li, Manager of Hongye Textile Factory, and his relations with the commercial association:

> In 1995, I became a member of the association…people of this district in medium and large enterprises must enter this association to have common activities, such as participate in exhibitions, and go outside for visits. In fact, I entered this association quite unconsciously, it was like a worker entering a workers association…but I now participate actively in the activities. Before, there were few activities, just once or twice a year. In 2001, the association began to send faxes to us to announce exhibitions or travel, but before I did not go. You know, I am quite old minded, at first I did not trust these sort of things. After I saw that the effects of these activities were great, I decided to go there.

Managers also point to high turnover of enterprises and workers.

> SMEs always have the same problem, despite 20 years of reform; they still do not have real high-skilled managers. Except those very few who followed me during these 10 years, all my managers have left. Having someone stay 3–5 years in the same enterprise is extraordinary (Mr Liang, Deyao Textile Industrial Ltd.).

Difficulties are also encountered in competing with textile districts in the provinces of Zhejiang and Jiangsu. According to the interviews, the managers believe it is important to lower taxes, to educate and keep skilled workers, and to imagine a commune-leading brand.

Deyao, Mr Liang's company, is a large enterprise. Mr Liang is also the vice-chairman of the business association in Foshan, Nanhai. His enterprise was established in 1990. It produces industrial materials, jeans, and accessories for women.[14] It has its own design department. Deyao has no linkages with other enterprises. Mr Liang admits that the absence of collaboration with other large enterprises is a problem, although he does not explain why he has refused collaboration:

> …maybe the capacities of other people do not follow the development of the enterprise, but between managers of large enterprises, the collaboration cannot last more than two years, we have to stop…The fact that we just use our own capacities to develop is not working. Sooner or later we will have to change.

Mr Liang says he cannot collaborate with the innovation centre because he has his own R&D department, and the innovation centre is not able to help large enterprises: 'SMEs can use the services of the innovation centres, but not the large ones. It is because the development of products for large enterprises exceeds CNY10,000 or 20,000. The innovation centre cannot support projects worth CNY100,000 or 1 million. It would be too risky…it just cannot do that.'

Another company states the same argument (Mr Mo, Manager of Fengli Textile Company):

> No, we do not need to collaborate with the innovation centre…we have our own capacities. The innovation centre does its job, we do our own. I do not say it has no use, I say we do not need to participate in its work… the innovation centre has no particular products, it does not even think how to develop the market, it just gives techniques…I think the job of the innovation centre is to give reports to the government, to prove to the government that it is doing something.

A large variety of issues arise from the existence of this large innovation centre and the quite large industrial cluster. Our impression was that the innovation centre's development logic was rather different from the industrial logic. The industrial enterprises act as though the innovation centre is of little interest. They develop their own design and development capabilities and have little interest in links with other enterprises or institutions. Nonetheless, the innovation centre has helped create better conditions for industry and attracted higher skilled labour to the city.

Motorcycle area in Pengjiang

Pengjiang, Jiangmen City, is an ancient industrial base for machinery and hardware. Once a large trading city, it has become one of the largest motorcycle production sites in China. The motorcycle trade started in Pengjiang in the late 1980s and early 1990s. In 1991, Dachangjiang Corporation was founded and became the first manufacturer of motorcycles in Pengjiang. Since then, the industry has developed rapidly and the marketing network has been improved. Pengjiang was given the title 'Professional Motorcycle Manufacturing Area in Guangdong', and became one of the officially recognized industrial clusters in the province. The Dachangjiang Corporation created an R&D centre that services the corporation and all Suzuki-related branches in China.

The industrial cluster

The motorcycle industry plays a central role in Pengjiang's economy. The production value of motorcycles reached CNY2.87 bn in 2001, and accounted for 38% of total industrial production (CNY7.55 bn). Production of accessories was about CNY0.7 bn, and exports of motorcycles accounted for 39% of total production. Presently, Pengjiang has three factories manufacturing motorcycles (Dachangjiang Corporation, Dihao Motorcycle Corporation, and Yunbao Corporation) and about 30 motorcycle accessories enterprises. Dachangjiang Corporation is the leader in motorcycle manufacturing in Pengjiang and also a major market. There were 602 distributors of motorcycles and accessories at the end of 2001. It includes the largest market for motorcycles in the Pearl River Delta, the Shuanglong Professional Motorcycle Market, which was built in 1992 and includes 160 shops with an annual turnover of CNY 1.5 bn.

Pengjiang began to import motorcycles after Chinese policy reforms in the 1980s.[15] Foreign enterprises developed this production. Dachangjiang Great River Group was established in 1992 as the largest state-owned commercial enterprise specialized in motorcycle imports. Its output accounted for 70% of the production of motorcycles in Pengjiang (46,000 units worth CNY2.66 bn in 2003). Its gross assets are estimated at CNY2 bn with seven affiliated enterprises. With an annual output of one million motors and one million motorcycles, it is one of the four largest motorcycle-making enterprises in China. One of its three brands is the famous Haojue, a popular and robust 125 cc motorcycle.

Another large firm is Huayi Group (interviewed in 2003). This enterprise specializes in the production of spare parts for motorcycles, principally frames and moulds (60% of the South China market). Established in September 2000, it imports most of its equipment and raw materials. Another large enterprise, Minglong Group (interviewed in March 2002), imports motorcycles, specially the 'Guangyang', produced by Honda and by a Taiwanese enterprise based in Taiwan and in Changsha and Changzhou cities.

Dachangjiang has depended on Suzuki, and still depends on it, for techniques, management, investments, and international sales channels. The Huayi Group, which is quite new in this sector, wants to expand from the Chinese market to the international market, and is convinced that it can do so within 3–5 years. It is thus possible that competition will become stronger in the near future.

Dachangjiang (Great River) Group

Dachangjiang developed rapidly. From 1992 to 1997, annual output increased by an average of 143% each year. Gradually, Dachangjiang built a test station and assembly lines to make cushions, shock absorbers, engines, and whole motorcycles. In 1998, Dachangjiang's output became the tenth largest in China: 240,000 motorcycles, with a production value of CNY1.4 bn. Gradually,

Dachangjiang attracted many suppliers who were eager to cooperate. It set up several factories in Jiangmen, and the Jiangmen Machinery (Axletree) Company began to produce motors for Dachangjiang. The light industry in Jiangmen can also produce other kinds of accessories. About 30 accessory factories in Pengjiang became suppliers for Dachangjiang. Presently, the supply network includes more than 400 accessories suppliers that supply 80% of the accessories in a motorcycle and 70% of the total cost. The network has expanded far beyond Pengjiang to cover many other areas in China (e.g. Chongqing, Jiangzhe, and Guangdong). Engines are mainly made by Dachangjiang's subordinate enterprise, Wangjiang Lingmu (Suzuki) Motor Limited Company. Dachangjiang, which benefits from technology support from the Japanese Suzuki Corporation, has created its own R&D team.

Apart from key accessories, all other parts are mostly outsourced. Generally, accessories with the same specifications are produced under a 'multi-supplier' system – two or three companies supply the accessories at the same time. This multi-supplier system guarantees quality, improves delivery time, and maintains a competitive market. The multi-supplier system increases the competitive pressure on the suppliers.

The motorcycle industry demands a large work-force. The assembly of one motorcycle includes more than 1,000 accessories. What a single enterprise can do by itself is very limited. Therefore, the construction of the accessory-supply network for the core enterprise is very important (as is the case in the automobile industry).

In the beginning, it was the accessory producers who supported the industry's development. They offered a steady source of accessories for its motorcycles. At first, accessory production was not the firm's specialty. Many supplying factories were ahead of Dachangjiang in production technology and specialized in certain parts. When Dachangjiang matured and achieved production scale and competitiveness, it promoted its own providers. The change took place about 1998. By then, Dachangjiang had distinguished itself in China's motorcycle industry. Technology R&D took a stronger position inside the company. In 1998, it cooperated with the Japanese Suzuki Corporation and set up Dachangjiang Precise Machine Ltd., which focused on research, development, and production of engines, and is now known as one of the most modern engine producers in Asia with world-class equipment and assembly line. The company maintains close cooperation with the Japanese Suzuki Corporation, and in 2002, it built a large R&D centre. Dachangjiang maintains a rather high percentage of accessory outsourcing (about 80% in recent years). According to our research, the proportion of Dachangjiang's outsourcing represents at least 30% of the final product, and over 80% of the sales of the providers.[16]

Some issues

What structures the industrial space in Pengjiang is the suppliers' network for the large enterprises. This has immediate influence on neighbouring companies:

> Our neighbour was a factory, called Zongyi. It was ready to collapse, but its equipment was still there. Dachangjiang has its own engine factory, but it has a reputation of producing only the best, so [if it produced] low quality engines that would be with [the same] high costs. It is the reason why we have now an arrangement with Zongyi; we buy some engines from them. For technical matters, we send technicians to this factory to control the process (Mr Shi Yan, Manager, Dachangjiang Technical Centre).

Large enterprises, such as Dachangjiang and Huayi, have built a nation-wide network that includes both retail and wholesale agents and agents to sell spare parts. Dachangjiang alone has a network of more than 30 commercial agencies, and works with more than 40 manufacturers. These enterprises attach importance to marketing strategies, regularly study market trends, and try to adapt their production to the needs of the consumers. For example, they developed a small motorcycle for men and another one for women, with specific colours and designs:

> We have some regular and very important clients. Our largest client buys about 20% of our production, so we send a specialist there to provide help services, if there are some quality problems with our products, we are always ready to help resolve problems, we offer the spare parts, they assemble them…The degree of trust you share with your client depends on the way you complement one another, but for us the question if we can trust the client does not exist anymore, because there are so many years, we know each other very well. The only question is whether they can produce all the things we need or not' (Mr Rong Dexiong, Vice-Manager, Huayi Group).

Large enterprises have some links with universities and research centres in technical fields, but no relationships in management fields. Dachangjiang sends people directly to Japan to be trained, and once a year, it organizes training classes. Its R&D centre has relationships with the University of Tianjin and projects for undergraduate students at the University of Wuba. The Huayi Group organizes special meetings with other motorcycle enterprises because it finds it useful to understand the problems and assets of the entire sector. This group also has relations with the University of Wuba for design purposes. The Minglong Group has its own test centre to monitor all the motorcycles it sells and to test the products of its suppliers. All large enterprises agree on the lack of highly specialized workers. They expect the local government to invest more in training and education.

Faced with increased competition in the motorcycle industrial sector and market saturation, enterprises are not willing to declare a price war, but

compete rather in quality and marketing. In 2002, from January to November, 800 enterprises in Guangdong went bankrupt and closed. Managers said that the crisis began in 2000. In the past, it was possible to sell more than 200 vehicles per month. Now if an enterprise sells more than 40 vehicles that is good. The Minglong Group chose to cut profits and reinvest in improved production and increased advertising. Dachangjiang counts on innovation to maintain its economic growth. The Huayi Group wants to develop a quality brand. In terms of future prospects, here are the thoughts of Mr Shi Yan, Manager, Dachangjiang Technical Department:

> After China enters WTO, the most important problems this sector will have to face are management, quality, and certification. Just with certification, 80% of the enterprises will be eliminated. From this point of view, it is the most incredible sanctions this sector will have. In fact, violation of rights and copyright are very hard.

These enterprises must also deal with the better quality and know-how of enterprises in other provinces. For Mr Shi Yan, from Dachangjiang: 'it is not that Guangdong people are stupid, but that, in Jiangsu and Zhejiang provinces, people are particularly smart, because they have accumulated years of experience'. Mr Rong Dexiong, from Huayi Group, also said that motorcycle production in Guangdong Province is not bad but cannot be compared favourably with the best production of Chongqing: 'A cluster has to be successful, if it is not successful, it cannot attract other enterprises in its territory. The work force is quite sufficient here, but we have a lack of high skilled workers, as in technical skills…'

An area with no innovation centre: Qingxi, Dongguan

Because of its importance in the Pearl River Delta, it is interesting to look at Qingxi, in Dongguan Province, which has 77 companies involved in information technology (IT) and electronics. Here, there is no innovation centre and most of the industry was developed by foreign capital, mainly from Taiwan (23%), Hong Kong (8%), and other countries (32%). A large number of companies (35%) are *san lai yi bu*[17] and there is only one collective enterprise. Most companies in Qingxi were established between 1984 and 2002, and, on average, have existed for fewer than 9 years. The enterprises are quite large: 82% had more than 100 employees, and of these, 41% had between 101 and 500 employees. Similarly, 20% had capital of more than of CNY50 m, and 36% had between CNY10 and 50 mn. Smaller enterprises (capital of less than CNY10 m) accounted for 44% of the total. This distribution is quite representative of the local area. Almost 40% of these enterprises established their factory outside Qingxi. Linkages are sparse between companies inside the Qingxi cluster: more than half (56%) of the enterprises spend less than 5% of their budget for spare parts with their Qingxi partners. Enterprises that spend more than a quarter of their total spare-parts expenses locally represent

only 8.4% of these enterprises. Most of these enterprises buy spare parts from foreign enterprises or joint ventures. Finally, about a third (38%) of these enterprises have established a suppliers network for spare parts with Qingxi collective enterprises, but this represents a small part of the output of these enterprises.

The main reasons for coming to Qingxi are low-cost resources (labour, water, and electricity), the proximity of harbours and the port of Hong Kong, and transportation facilities. However, most enterprises are not satisfied with the economic environment. They feel the local government should offer better conditions in terms of electricity supply, security, accommodation, and schools. Foreign capital enterprises feel insecure in China because they are unsure of administrative costs and taxes, and worry about payments from their Chinese clients. The technical level of companies is quite low, even in quality control. Foreign-owned companies generally have higher technical skills than the Chinese enterprises in the industrial cluster, which are often 'family managed' or 'individual managed' enterprises.

Foreign-owned companies control the more basic parts of the process, but have transferred some of the R&D to China: 'All the structure of R&D has been transferred from Taiwan to Qingxi, and we operate an OEM process. The main objective of our new R&D department is to improve the techniques of production, especially for products for Samsung or Sony' (XG electronics). However, the most complex R&D remains in the country of origin:

> R&D is divided in two parts. The first one, involving difficult or high technology levels and know-how, is done in Taiwan. In Qingxi, we do the second part, the one with simple techniques and crafts. We have 20 employees in the R&D department. In Taiwan, they only have 5 or 6 employees, but they do the highest technology work (CA electronics).

Another common arrangement is that: 'technical development remains in Japan; in Qingxi we have all the equipment to test the quality, and technicians come from Japan' (Siguo Electrical Lines). The less technically developed 'just transform the raw material, the design and development of products is done in Hong Kong' (Cheng Xiang Electronics).

Industrial associations

Although there is no innovation centre, there are three associations of enterprises in Qingxi: one for Taiwanese enterprises (since 1990); one for Hong Kong enterprises (since 1998); and one for Chinese enterprises. They were established with no help from the local government of Qingxi. The government did provide support by offering offices for free, but it limits its actions to help the enterprises. In 2003, the Taiwan association had 245 members, and the Hong Kong association 109 members. Half the members of both associations are enterprises specialized in IT. The other half produce many different products, from electroplating to gloves and umbrellas. However, the

influence of these associations among enterprises is not strong. The Chinese commercial association of Qingxi was established by the government under the leadership of the main commercial association of Chinese collective enterprises in Dongguan City. This association controls 32 villages, and by August 2003 had established 25 local branch associations. However, these associations are not acting as an innovation centre.

The Qingxi government has made many efforts to attract enterprises. It published a guide for investment, offered services to enterprises willing to invest, created well-equipped industrial parks, and renovated the city centre. The government has also helped enterprises to hire specialized workers from other cities, or provinces, by: facilitating administrative obligations (they provide a *hukou*, a local working and living permit that must be approved by the police and is compulsory in China); obtaining loans for housing; and developing cultural and sports activities. One of the main problems for Qingxi is that high-skilled workers, and even whole enterprises, often move to bigger cities, such as Shenzhen, Suzhou, and Shanghai, where employees can live more comfortably and find modern equipment and cultural life.

One enterprise suggested the need to create a training body and placement office. This issue is critical for highly skilled personnel:

> Today the main R&D structure is in Taiwan, and the R&D structure for production technology is in Shanghai. In Qingxi, we just do the production. In Shanghai, they have a high technology cluster, because workers come from there, and have been there a long time. In Dongguan, most of the workers come from outside and the turnover is high, maybe because they earn money very quickly and then go away. So, in the R&D units of the company, to attract employees, they attach importance to long-term development in Shanghai. It is also the reason why we will move in the Central China region – there the workers may stay longer in our enterprise and the improvement of technology will be better (CA Electronics).

Is an innovation centre needed?

Qingxi has no innovation centre, and some enterprises would welcome the establishment of such a centre because it could help with professional certification; connections with other innovation sites in the Pearl River Delta; training; and the running of specialized fairs and meetings. Some enterprises, such as San Yang, believe that an innovation centre would enhance the services offered by the government:

> [The government] always offers us a foretaste of a service, how to attract buyers, how to attract enterprises…The government always helps, but it always gives us superficial services and never deep services. [The government should] participate in the production process…It would be perfect if some structure could gather all these services in one location, even if we, the enterprises, had to pay for these services (San Yang Company).

Finally, testing and certification processes could be handled by an innovation centre:

> …when we want to test equipment, which happens very often, we have to send it to Guangzhou or Shenzhen, because in Dongguan there are no such facilities. It is very annoying. Another example is environmental norms. In Europe, North America, and Japan, they have these norms for products without toxicity and without lead and other metals. I do not know if the Government of Qingxi has already spread the news that every enterprise working for Sony has to respect a new Sony standard, called SS0009. It is a continuous testing process. If we can have such a structure in Dongguan, some sort of 'Department for Technical Tests, Dongguan City' and implement a subsidiary in Qingxi, this structure could help us to obtain the approval of companies like Sony, and we would not need to go to Shenzhen anymore (GQ Electronic Company).

Zhongshan University

Zhongshan University is the largest university in South China. It specializes in basic academic disciplines, as well as in humanities, social sciences, economics, and business management. The university is well respected and some of its laboratories are state-of-the-art in bioengineering, optoelectronics, chemistry, physics, and computer science. The relations of the university with the productive world are ample and diversified, but they are managed on a case-by-case basis, depending on the contacts, the nature of the involvement, or the amounts that are at stake. Many contacts are made through specific enterprises and academic personnel who act individually.

Like all universities in China, Zhongshan has undergone profound reforms. In September 2002, the university amended its internal legal statutes to give additional incentives to professors who linked their research activities with enterprises and R&D institutes. This change allows professors to obtain additional payments for their research activities outside the university. The new regulations are managed by the Office of Science and Technology. Compared with the former regulations, the new regulations include bonuses of up to 30% of the value of the project. Another prominent change is to strengthen patent protection for innovation products. Since being put into practice, the new regulations have greatly enhanced participation by teachers and researchers in activities linked with industry.

Table 3.3 summarizes data on links between the university and enterprises in 2000–2. The number of projects is quite low, and no additional details were available on the size and nature of the projects. This table only includes projects that were directly managed by the Office of Science and Technology. There is no technology transfer unit in the university to promote innovative projects, or to manage technology transfer to the productive sphere. In these projects, management is the responsibility of the Office of Science and Technology,

which manages all projects that receive funding from public or international sources. Nonetheless, an effort is being made to promote innovation through research.

Environmental research provides an example of strong links between the university and specific enterprises. These efforts are undertaken to comply with environmental regulations. This is useful because it gives students some fieldwork experience, but it is not research. Many students take part in environmental research to gain experience and to help the enterprises solve technological difficulties. For example, Prof. He Jianguo, who is a professor working at the School of Life Sciences in Zhongshan University, undertook a project in collaboration with Hengxing Technology Development Co. Ltd. to study biochemical development. In his research, he conducted fieldwork with his students. As a result, the students improved their practical skills, while the project created innovation.

Many links are not technology innovation links but services to enterprises (mainly in training, where the demand is quite high). For example, the School of Management developed a curriculum in business management for students from management positions in various enterprises. The courses included business management skills and theories the students could use in their daily work. Almost 1,000 students have now graduated.

The services provided by the university can be quite elaborate, as is the case for studies and research projects done to respond to development issues. The university has set up a research institute (ZURIGuD) that responds to demands made by public or private entities to mobilize the intellectual capabilities of the university. ZURIGuD has undertaken a number of research projects since 1999. The institute integrates most of the major social sciences and has formed an internal network with numerous intellectual resources. When ZURIGuD undertakes projects, it mobilizes teachers with credentials that match customer needs. For example, to undertake a study of the Foshan Industrial Development Strategy, professors from economics, management, sociology, and urban planning with different intellectual and academic perspectives participated in the project. In addition, some enterprises have

Table 3.3 Research innovation projects that linked Zhongshan University to enterprises

Year	*Total projects*	*Degree of novelty*			
		Those with internal collaboration	*Innovation at international level*	*Innovation for first time in China*	*Innovation that already exists in China*
2000	12	5	5	0	7
2001	10	0	7	2	1
2002	9	0	5	2	2

Source: Various reports produced by the Office of Science and Technology, Zhongshan University (2000–2).

installed R&D laboratories on the premises of the university. For example, the Canadian company Nortel Networks installed R&D facilities in 1995 to adapt hardware and software products to local clients. This facility had 398 personnel at the end of 2003, of which more than 90% had higher education diplomas.

Apart from specialized services such as reports on development issues, the common opinion of many professors is that the main activity of the university should be education, not service. The very high prestige of the university is not 'on sale' for specific projects, and professors are very careful not to mix their research and education activities. The professors believe they should do useful things for society and help the development of the region and their country, but not at the cost of education. Moreover, the university has no mechanism to recognize the social activities, or services rendered to society, in the careers of the professors. Because most demands come from SMEs and for projects with a low level of technical expertise, the university is not seen as the appropriate entity to respond to these demands. Rather, it is seen as being best suited to provide support to large-scale projects in the basic sciences. The university does not appear to be oriented to the practical questions of SMEs or even large enterprises. Its role is to create a highly qualified workforce and an environment conductive to technological development.

Lessons and results

Neo-Marshallian industrial clusters

Industrial clusters are an important form of industrial organization. Because of the presence of SMEs in South China, most clusters resemble the *Marshallian* type of industrial cluster. Nonetheless, the empirical studies show that it is difficult to accept the notion of a 'Marshallian cluster' without some qualification. First, the links between industries are rare and rarely formal. It might be, as Alfred Marshall wrote, that the 'secrets of the industry are in the air', but the information travels through informal social relations rather than through specific collaboration between enterprises. Family ties and personal contacts certainly play an important role. Second, the suppliers are rarely part of the industrial cluster, and most of the technology is provided not by the providers of technology (like equipment providers) but by the clients, who introduce new designs and know-how in the productive processes. Suppliers of raw materials have little or no impact on the productive process. Equipment providers, because technologies are quite standardized and simple, are represented by traders within the cluster who are commercial agents with some technical personnel who provide maintenance in rare cases. Large process changes are introduced by the companies and the industrial clients, and new products are usually designed on behalf of a client or by copying designs from a client. These could be called neo-Marshallian clusters.

Xiqiao and Dachong represent this kind of neo-Marshallian industrial cluster in Guangdong. They specialize in one geographic area in the production of a single type of product. Mainly private enterprises have grown within these clusters, and the local government is involved in this process. The relations of the enterprises with local authorities are quite fluid, and there have been some strong complaints from the enterprises.

The Jiangmen cluster of companies around motorcycle production represents a 'hub-and-spoke' cluster, where a large company acts as a structural agent that organizes a network of supplier companies. As in Italy where Fiat has organized the whole industry around Turin, or Piaggio around Pisa, Dachangjian has organized most of the industry in the district of Pengjiang in Jiangmen. This company has not only developed a network of suppliers, but has become the largest company in the district. In addition, the link between Dachangjian and Suzuki has been instrumental in upgrading its provider network and bringing the experience of the Japanese corporation into the production in Jiangmen.

State-anchored clusters are best represented in China by the science and technology development zones. Clusters and high-technology zones are not the same because the dynamics are very different and the types of enterprises, and thus activities, are different. Technology zones are hubs open for investment; whereas, clusters are usually created by local entrepreneurs. This research did not study any science and technology development zones.

The imprecise role of innovation centres

Part of the difficulties of innovation centres lies in their objectives. For local SMEs, it is difficult to separate the technical and commercial aspects, and the commercial aspects are most important. Improvements to commercial aspects, and relations with the market, are essential. As well, as in practically all SMEs in Guangdong, funding is a difficult issue. So far, local governments have done little in this area because they believe financing should be undertaken by the enterprises themselves. However, there may be room for improvements in procedures for credit and loans.

In the Qingxi (Dongguan) industrial cluster enterprises are closely dependent on the value chains of foreign companies. The whole cluster depends on these value chains and it is not by chance that there is no innovation centre in this cluster. In another cluster we visited, which specializes in shoe making and where large companies are mainly Taiwanese producing for foreign markets, the local government wanted to create an innovation centre. Difficulties were encountered, and the government sold the centre to an entrepreneur, and then later bought it back from him.

Suzuki chose to locate its R&D centre in Jiangmen as a service centre for all China because of the driving force of the local Dachangjian Company. Of course, the dynamics of an R&D centre are different from an innovation centre that would serve SMEs in the region. Moreover, because Dachangjian

is so strong, there is little room for an independent technical centre. The competitors, who are other motorcycle companies, are equally large, and the providers are equally dependent on them. In this case, the local government relies entirely on the private company, which has a strong pulling effect in the local economy.

The innovation centres have begun to create networks of enterprises, to improve innovation capacities, and to enhance communication with other bodies, such as universities and research centres. Their future development will depend on the homogeneity of policies, charges for their services, e-business, and relationships with other specialized industrial areas in China. Their survival is neither guaranteed nor impossible. In some districts, the policy of the government is to promote these innovation centres, as in the case of Nanhai. Many changes are occurring. The most prominent change has been in the management of innovation centres controlled by local governments. For example, the innovation centre in Xiqiao changed its management mechanism in May 2004. The network of the innovation centre is now managed by one of the largest private textile enterprises in Xiqiao. The Xiqiao district government does not interfere with the daily business of the centre and grants more development space to the innovation centre. Therefore, the dynamics of the innovation centre are dictated by private enterprises rather than by the government. This allows the centre to better meet the needs of the market and to develop independently.

The innovation centres are also facing new issues, such as intellectual property rights and action on competition. In Xiqiao, the innovation centre plays a central role in the structure of the industry. It is also aware that it modifies the conditions of competition (therefore, the rule 'sell a pattern only to one enterprise at a time'). From the beginning, Xiqiao authorities have taken a broad view of the industry and shown a willingness to structure the industry to ensure it ranks high in China. The main differences in Xiqiao and Dachong are differences in scale, not differences in nature, but the demands made by SMEs to innovation centres are the same.

Table 3.4 shows the main problems that innovation centres are facing. Local governments are now reconsidering their role in the process of technology innovation. Initial investment in innovation centres by local governments is necessary, but the ownership and management of innovation centres should be separate. Innovation centres should be made public platforms for technological innovation. Governments should be responsible for providing infrastructure and maintenance, but the innovation centres should remain a public resource. However, the management of the innovation centres should be transferred to private companies or trade associations.

We suggested to the government of Nanhai District that the local government should move one step forward and one step backward in terms of the technological innovation of the industrial cluster. 'One step forward' means that the local government should vigorously support the development of a trade association; whereas, 'one step backward' means that, when the

Table 3.4 Main problems reported by innovation centres

	Priority problems		
Centre	*First*	*Second*	*Third*
Guangao kou	Lower the activity (intervention) of the local government	Increase its position in the market, products innovation, and services	Enhance logistics (how to transfer logistic functions from government to enterprises)
Yanbu	The role and functions of the innovation centre and its position	Lack of funds	Lack of human resources
Pingzhou	Increase relationships with specialists in the sector; offer suitable services and information to SMEs	Intensify relationships and communication among enterprises; increase members of the cluster	Strengthen communication between members of the industrial association
Jinsha	Bring together the associations, the local government, and the enterprises; increase the services offered by the innovation centre	Increase the responsibilities of the employees inside the innovation centre; create a team	Improve the knowledge and capacities of this team
Xiqiao	Increase knowledge and know-how	Modernize the functioning of the centre	Open the centre to society and lower the financial expenses of the government
Heshun	Increase agricultural knowledge and funds in the centre	Increase technical capacities in the agricultural park and create leading products	Complete the tests on seeds and germination
Songguan	Support of government	Complete the installation of basic equipment	Wait for the support of the government to strengthen knowledge
Dali	Answer to the needs of enterprises, answer to their problems, and attract specialized service organizations	Attract in this area specialists in management, administration, and technology	Obtain agreement from the government to perform scientific and technological research

trade association becomes mature, the functions and management of the innovation centre should be gradually transferred to the trade association.

Links of enterprises and one large national university, Zhongshan University, were also examined. In the economic context of Guangdong, the links between Zhongshan University and the private economy seem quite loose. Usually, the innovation centres rely on universities that specialize in engineering or in some specific trade and technical specialty. Zhongshan University has few of these specialties, which explains why few contacts are made with the economic world. The relations are more often through some form of service (e.g. environmental reports and regulatory studies). Contacts with enterprises

are not rare, but they are rarely technology based, and are usually in business management and training for managers. Zhongshan University is a higher educational institution where research is considered to be basic research. Only within the business school or the school of economics were regular contacts established with enterprises (e.g. service contacts provide training in business management).

The fact that the university has few 'official' contacts with enterprises, but many informal contacts through individual professors, does not mean the university could not establish more formal links. Moreover, no technology cluster has yet appeared around the university. The university, because of its importance in training and its cultural presence, has a role that goes beyond specific links between professors and enterprises. Its importance goes beyond practical, everyday, direct links with economic activities: professors participate in social and political activities; the university invites many foreigners as students or professors; respect for professors makes them social models of behaviour; engineers and managers from enterprises who come to the university become aware of modern up-to-date methods and theories; and the university attracts talented people to the city. All these factors make universities a stronghold of development, and explain why all special economic zones have tried to create a university. However, the experience of Zhongshan University, which has a campus in Zhuhai on the frontier of Macao, shows that direct links between the university and the economic world are difficult to establish.

Role of ZURIGuD

By integrating specialists and researchers in different subjects, such as economics, management, sociology, and economic geography, ZURIGuD played an important role in the study of cluster development in Guangdong. In the future, ZURIGuD could provide additional services such as: participate in the study of cluster development in Guangdong and draft research reports to the government of Guangdong Province; hold specific lectures and training on cluster development for local governments; evaluate the Guangdong Industry Upgrade Demonstration Zone, and draft a 'Blueprint for the Establishment of a Guangdong Industry Upgrade Demonstration Zone'; establish indicators to evaluate the Guangdong Industry Upgrade Demonstration Zone; and analyse cluster development in Guangdong with these indicators.

Conclusion: Toward a Regional Innovation System

This research was designed to help policy development by seeking to understand the technological development process in Guangdong. It has shown that the evolution of investments in the Pearl River Delta went through successive waves that produced different types of productive units. Local investors generally create SMEs that link to foreign clients not so much to encourage

exports but to acquire technology and products. Learning in enterprises is quite rapid, but is linked to changes in markets and is based mainly on a short-term view of the environment.

It is, therefore, very surprising to see the surge in R&D that has occurred recently in China. The increase is mainly due to large collective firms and foreign-owned enterprises. High-tech zones and enterprises have a preference for Guangdong because it has a good business environment, something that is quite new and the product of public policy oriented toward infrastructure. Collective enterprises abound in Guangdong and they are the main investors (along with foreign firms and firms with strong links to foreign clients). It is these enterprises that invest in R&D.

The policy to promote innovation centres appeared during a period of more difficult development in economic terms, when a need for better quality and higher priced products made sense in China. The government promoted innovation centres as a way to fulfil these needs; and the innovation centres were mainly oriented to servicing the local industry, most SMEs. The structure of these centres is still quite uncertain; however, in some cases, they have achieved a quite impressive record in traditional industries.

'Technology poles' and incubators of scientifically based companies seem more difficult to create. In China, it is common to mention the famous Zhongguancun technological pole in Beijing. A careful examination of local situations and the experience of Zhongguancun shows that universities, although they have many links with the economic world, are not large producers of high-tech firms or firms created by academics. Rather, foreign firms, collective enterprises, and private SMEs (as well as some large private groups) are the main development actors in Guangdong. These enterprises have little in common with the university. However, all these firms face problems in training – mainly in overall management, engineering, and mid-level management. The university is one place where such training could be provided.

On the contrary, 'marketized' research centres seem to succeed much better, usually because they are able to sell products and can transform quite rapidly. These centres have a long history of creating and developing products and of maintaining links with productive units. Not all of these centres will succeed, but those engaged in the market will be able to survive as enterprises, not as research centres.

Finally, the policy for innovation could be powered by a regional structure. This structure does not yet exist. To create such a structure it would be necessary to have a network of research units, of innovation centres, and a group of professionals to analyse both S&T and industry using appropriate indicators. These possibilities have been discussed with Guangdong provincial authorities.

Endnotes

1. With the help of Eglantine Jastrabsky, Du Junrong, Anne-Sophie Boisard, and Qiu Cuiwei.
2. 'Marketization' (*shichanghua*) is the privatization of public organizations by selling shares, or by obliging the organization to provide for its own expenses by selling products.
3. In 2000, the French Institut de Recherche pour le Développement (IRD) authorized a prolonged stay for Rigas Arvanitis. This cooperation gave birth to the Chinese–French Centre of Industrial Sociology and Technology in Zhongshan University, a cooperative endeavour between Zhongshan University, IRD, and the Université Lyon III. In 2003, additional funding was secured to conduct fieldwork on the Qingxi (Dongguan) Electronic Industrial Cluster and the Nanzhuang (Nanhai) Ceramic Industrial Cluster. Additional research at the end of 2003 and January 2004 studied the Dali (Nanhai) Aluminium Industrial Cluster; the Jinsha Hardware Industrial Cluster; the Xiqiao Textile Industrial Cluster; the Guanyao Toy Industrial Cluster; the Songgang Electronic Industrial Cluster; the Pingzhou Shoemaking Industrial Cluster; the Yanbu Underwear Industrial Cluster; and the Heshun Vegetable Industrial Cluster.
4. Although there is a large body of literature on the development of Guangdong (Vogel, 1989; Sung et al., 1995; Douw and Post, 1996; Yeung and Chu, 1998; Sanjuan, 1999; Cheng, 2000, 2003; Segal, 2003; Yeung et al., 2004), we conducted an economic analysis that better fitted the needs of our research (Arvanitis et al., 2003).
5. US$1 = CNY7.86.
6. This phenomenon can also be observed in the border regions of Northern Mexico, where the *maquiladoras* developed from being simple low-cost assembly plants to more complex systems of production that participated in the international flows of capital and commodities: the latter are in turn the source of investment capital for the factories located in Mexico or other foreign countries. Not only have the *maquiladoras* changed in form and function, they have become part of a truly innovative economic and technological dynamism (Villavicencio, 2003).
7. Regional innovation systems and science and technology policies in emerging economies: experiences from China and the world, 19–21 April 2004, Guangzhou, China. Some examples were published in a special issue of *Science, Technology and Society*, 2006, 11(1).
8. The 863 Programme was created in March 1986 to promote mainly basic research. The later Super 863 Programme in 1996 was designed to follow up this initial effort.
9. The report is not explicit in its definitions of 'research structures' or 'research organizations'. Later, in the same report, the figures appear to be lower because a more strict definition of 'research centres' is used (but it is no more explicit).
10. See Guangdong Office of Science and Technology 2002, Annex Table 6, pp. 246–249; China Statistical Yearbook on Science and Technology 2003, p. 434.

11. Not to be confused with Zhongshan University, which is located in the city of Guangzhou (Canton).
12. The first session of the Chamber of Commerce was attended by more than 70 enterprises (mahogany furniture manufacturers, clothing manufacturers, and plastic factories).
13. In-depth interviews were conducted with two companies: Hong Xiqian, which was established in October 1997 as a manufacturer and commercial agent, whose main products are sofas, commodes, and bedrooms; and Hexin, which produces ancient-style furniture and lacquered furniture.
14. Since 1995, it has developed very quickly and well: in 1995, it had 600 employees with an annual production of no more than CNY 20 mn; in 2003, it had 300 employees, but an annual production of CNY 1.3 bn. His manager recognizes, however, that the economic situation is bad.
15. Before 1978, Pengjiang specialized in the construction of machines and hardware.
16. Details on contacts between providers and Dachangjiang can be obtained from the authors.
17. *San lai yi bu* is short for *Lai liao jiagong, lai yang jiagong, lai jian zhuanpei, he bu chang maoyi*, transformation of materials, plans, and parts, obligation to resell. They are the Chinese version of *maquiladoras* enterprises in Latin America.

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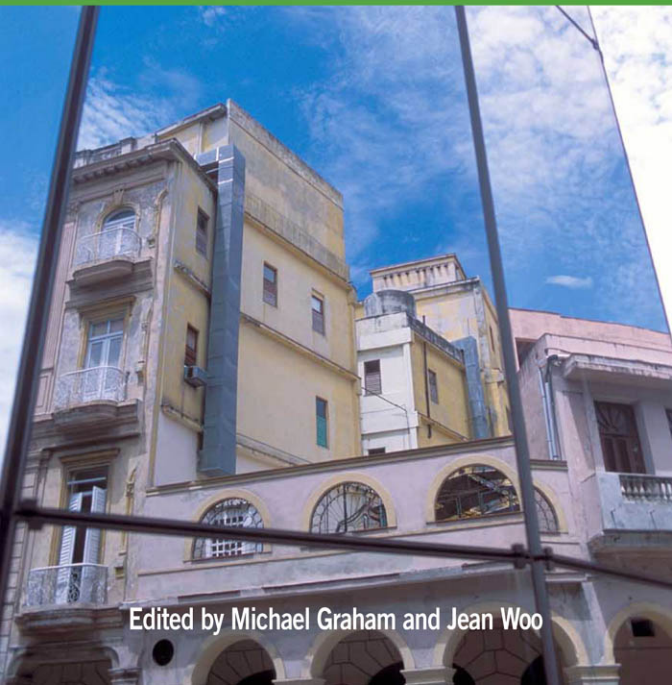

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