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Article

Science Parks and the Co-location of High-tech Small- and Medium-sized Firms in China's Shenzhen

Fangfang Cheng, Frank van Oort, Stan Geertman and Pieter Hooimeijer

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Abstract

Science parks (SPs) have received special attention as a policy tool to facilitate localised economic growth by attracting high-tech firms, especially small- and medium-sized enterprises (SMEs). The effectiveness of this strategy has been called into question. Empirical studies suggest that the benefits of SPs for high-tech firms are limited. While this debate is mainly concentrated in the US and Europe, this paper sheds light on the role of SPs in China. It is found that, despite the presence of alternatives, the locations of high-tech SMEs in the region of Shenzhen are determined by hierarchically structured and governed SPs. This finding supports the notion that SPs can play a positive role in attracting high-tech SMEs. Moreover, these effects occur in the relatively unexplored Chinese context of increasingly liberalised but governed market circumstances, where a mature innovation system is still lacking.

1. Introduction

Modelled on the success of the Silicon Valley, many countries have pursued the development of science parks (SPs), which are believed to be a universal tool to attract technology firms and stimulate economic growth (Massey and Wield, 1992; Storey and Tether, 1998; Phan *et al*., 2005). Similar trends have been observed in China. The number of national-level SPs grew from 27 in 1991 to 88 in 2011 (Ministry of Science and Technology, 2011); and provincial and municipal SPs are estimated to be twice as numerous (Chen, 2009). Given the phenomenal magnitude of China's SP growth, understanding their effect is of great importance for planning and policy-making.

SPs are perceived to be beneficial for high-tech small- and medium-sized enterprises (SMEs), which are considered as the new engine of economic growth. SPs are

Fangfang Cheng, Frank van Oort, Stan Geertman and **Pieter Hooimeijer** are in the Faculty of Geosciences, Utrecht University, PO Box 80115, Utrecht, 3508 TC, The Netherlands. Email: fang fangcheng.work@gmail.com, f.g.vanoort@uu.nl, s.c.m.geertman@uu.nl and p.hooimeijer@uu.nl.

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property-based initiatives that provide resources and services in logistical, administrative, marketing and financial areas, most of which are essential yet difficult to access for high-tech SMEs (van Dierdonck *et al.*, 1991; Westhead and Batstone, 1998). However, recent empirical studies have led to doubts regarding the effectiveness of SPs. Evidence has indicated that SPs are ineffective in establishing knowledge linkages with local research institutes, stimulating regional technology development, increasing profits and employment (see for example, Garnsey and Heffernan, 2005; Chen, 2009; Chan *et al.*, 2010).

While on-going debates are concentrated in developed countries, this paper attempts to understand the role of SPs in China, which is characterised by strong government support but a weak innovation system (Leung and Wu, 1995; Cao, 2004). Strategically, the Chinese government gives priority to promoting technology transfer from multinational corporations (MNCs) to domestic firms (Zhou and Xin, 2003), rather than developing an indigenous innovation system from scratch. SPs are constructed to provide geographical proximity between MNCs and domestic firms, aiming at creating a catalytic environment for technology transfer (Fang and Xie, 2008). A distinction should be made between SPs and industrial parks (IPs), as the former focus on but are not limited to technology-oriented activities whereas the latter are more production-oriented. A unique feature of Chinese parks is that an administrative (national, provincial, municipal or local) level is assigned to each park as a certificate. Parks at higher administrative levels have priorities in policy incentives and resources allocation (Walcott, 2002). And parks with outstanding performances can be promoted to higher levels.

Specifically, this paper explores whether the presence of SPs increases the probability of a location attracting high-tech SMEs, and whether the administrative hierarchy makes a difference. Shenzhen is chosen to be our study area, given its sufficiently large high-tech sector, relatively liberalised market and enthusiastic local government favouring high-tech development. Electronics is chosen to be our study sector as it is the most prominent high-tech sector in Shenzhen or even China. We classify our study firms into high-tech SMEs, non-high-tech SMEs and large firms to differentiate individual firms' actual technology level. Comparisons between these three groups of firms are included to improve understanding and interpretation of the empirical results.

2. High-tech SMEs' Locations, Science Parks and Chinese Industrial Policy

The empirical literature suggests that high-tech SMEs are heavily concentrated in certain regions, cities and towns. This section discusses high-tech SMEs' location factors in general such as agglomeration and SPs in particular. The last part explores the historical and institutional development of industrial policies in the China context.

2.1 Knowledge, Agglomeration and High-tech SMEs Locations

Research conducted in the spirit of economic geography and urban economics has focused on exploring the geographical aspects of knowledge externalities and the localisation of innovative or high-tech firms, stressing the fundamental role that proximity plays in mediating the processes of knowledge creation, transmission and appropriation (Audretsch, 1998).

The creation and diffusion of knowledge are critical drivers for high-tech firms' development. New knowledge changes products, markets, market structures, production technologies and organisational structures. It can be seen as a separate production factor or as an attribute linked to capital goods and labour. In endogenous economic growth theory, knowledge is seen as an output of investment in research and development (R&D) (Aghion and Howitt, 1992). This kind of investment can be defined more broadly as knowledge-intensive inputs, as in new capital goods and new labour, to increase R&D.

R&D investments, however, are often too expensive and risky for small firms to afford. The growing literature on innovation and high-tech firms has found that knowledge spillovers play an important role in fostering firms' innovation and economic performance (Doring and Schnellenbach, 2006). High-tech SMEs tend to locate in areas with dense R&D activities, such as universities and private R&D activities (Ponds *et al.*, 2010, Varga *et al.*, 2012).

Agglomeration economies may be another important location factor. The agglomeration economies incorporate the urbanisation economies and localisation economies. Urbanisation agglomeration economies refer to externalities associated with the co-location of productions and services from a wide range of activities (Jacobs, 1969; Scott, 1988). Localisation economies are externalities associated with the presence in the locale of many other firms in the same industry or sector. These firms share common inputs for production and similar technologies in the production process (Chinitz, 1961; Enright, 1994; Malmberg, 1997). Both approaches lead to the hypothesis of expected higher productivity in cities, especially in small conglomerated areas such as SPs and campuses (van Soest *et al.*, 2006).

A trend of co-location of high-tech firms with firms engaged in related manufacturing activities has been noted (Feldman and Florida, 1994; Bathelt *et al.*, 2004). A distinction, however, should be made between large firms and SMEs. A large firm, often the leading firm in a sector, is very likely to use up-to-date technology relevant to this sector and there is a high chance of knowledge diffusion in its geographical proximity through formal (for example, sub-contracting, spin-offs) or informal linkages (Sternberg and Tamásy, 1999; Rama *et al.*, 2003). By contrast, regular SMEs share similar material inputs with high-tech SMEs and often use conventional technologies in the production process; they may compete with and even become high-tech SMEs if they upgrade their technology level in the development process.

2.2 The Role of Science Parks

SPs are policy instruments that provide tenant firms with a wide range of support services and resources to localise knowledge and economic growth. Particularly, SPs provide tenant firms with privileged (geographical and organisational) access to knowledge (universities, research institutes or knowledge-based firms) (Westhead *et al.*, 2000). Establishing at a SP would thus be considered to be beneficial for high-tech SMEs, which may be in urgent need of those resources and a platform to interact with other firms and universities, suppliers and customers.

Without a uniform definition, SPs around the world vary significantly in form, scale and function. Siegel *et al.* (2003) suspect that existing empirical studies could be masking significant differences of various types of SPs. Therefore it may be important to distinguish them.

Most SPs are policy-driven, government-sponsored initiatives, whereas others originate from spontaneous clusters (Huang *et al.*, 2012). Policy-driven parks may enjoy sufficient resource allocation and supportive policies from the government. However, that does not necessarily lead to successful development of those parks. For example, Anttiroiko (2009) describes a complete failure of the SPs in Osaka. In addition to bad timing (the Japanese economic downturn in the early 1990s), over-involvement of the government leads to major problems such as site selection, budget overruns, overrepresentation of government departments on site and, most importantly, a missing well-functioning innovation system. Also, Phillips and Yeung (2003) find that the Singapore government's policy to stimulate knowledge transfer in the Singapore SP barely succeeded. Instead, firms chose to locate there to take advantage of the physical infrastructure, support services, convenient location and preferential government policies, rather than to establish links with universities or other tenants. Knowledge flows between tenants and university as well as the local embeddedness of firms are rather weak. This is largely due to the park's lack of consideration regarding the affordability of operation costs and a careful match between infrastructure/resource provision and firms' needs.

Most European and North American countries focus on developing linkages with universities. For example, almost all SPs in the US and the UK are affiliated with local universities and/or research institutes (Castells and Hall, 1994, Westhead and Storey, 1995). This reflects an assumption that technological innovation stems from scientific research and that parks can provide a catalytic incubator environment for the transformation of 'pure' research into production (Westhead, 1997). In other countries such as Germany and Japan, SPs do not focus exclusively on establishing linkages with universities (Storey and Tether, 1998; Anttiroiko, 2009). Despite the difference, it is expected that, within SPs' geographical proximity, a certain level of formal and informal synergies among tenant firms, universities, producers and consumers can be promoted for the cross-fertilisation of ideas and knowledge.

Exemplar case studies, however, show different evidence relating to the effectiveness of SPs. By comparing on- and off-SP firms in Sweden, Lofsten and Lindelof (2002) find that on-park firms are more likely to establish links with local universities. Using similar methods, Colombo and Delmastro (2002) find that SPs in Italy perform well in attracting high-technology firms and increasing employment. Avnimelech *et al.* (2007) found that SPs in Israel are influential to firms' location decision and effective in (re)shaping the geographical distribution of high-tech SMEs.

Based on a high-tech firm survey in Israel, Felsenstein (1994) suggests that SPs location and university links have only a minor role in promoting innovation. Locating at a park is rather for image building, which is also confirmed in many other countries (see for example, Westhead and Batstone, 1998; Phillips and Yeung, 2003; Ferguson and Olofsson, 2004). This is especially true in developing countries, where conventional production/locational factors instead of knowledge are the major determinants for firm growth.

2.3 Industrial Policy and Firm Location in China

Before the economic reform, China's economic system was a socialist command economy. Firms' location decisions were heavily influenced by socialist ideology, national defence and economic pragmatism (Lo, 1987). Economic laws and mechanisms barely existed and therefore had little relevance in China at that time.

A market economy has been progressively established in the 1990s (Wu, 2010), which led to a soaring number of private firms and changing spatial distribution of firms. By 1998, private firms constituted 98.2 per cent (7.8 million units) of China's industrial enterprises (State Statistics Bureau, 1999). Market mechanisms and competition drive both private and state-owned firms to seek higher profits and lower costs. He *et al.* (2007) detect increasing geographical concentrations of firms in (large) cities with natural advantages and/or policy incentives, suggesting that firms now respond not only to policy but also to market forces in their location decisions.

The past two decades have seen a policy-driven movement towards high-tech sector development. SPs[1] are frequently used as policy instruments to stimulate high-tech development (Walcott, 2002). There were 54 national-level and 107 provincial-level SPs by 2007. The number of municipal SPs is estimated to be even higher, but no reliable data are available (Chen, 2009). How those parks have influenced the location decisions of high-tech firms may be different than in Western countries, given China's different context in at least two respects.

First, China is still in the process of industrialisation, price competition and an accelerating Fordist economy. High-tech developments in China mainly concentrate on the production of high-tech goods rather than upgrading the innovation system (Westhead *et al.*, 2000). Consequently, many parks function as the distribution, processing and trading centres for foreign technology firms instead of technology hubs (Cao, 2004). On-park domestic firms were primarily engaged in assembling and manufacturing high-tech products (Walcott, 2002). The motivation of those firms to locate in SPs may be seeking lower production costs and/or sub-contracting opportunities from adjacent foreign technology firms, rather than pursuing technology advancements.

Secondly, what distinguishes the Chinese context is the hierarchical structure of SPs. National-level parks enjoy the most preferential policies, such as direct federal government funding, government-sponsored programmes and tax incentives. For example, national-level park firms enjoy up to 10 types of tax exemption or reduction (State Administration of Taxation, 1991; State Scientific and Technological Commission, 1991). Those firms also receive financial assistance and social assistance for employees, such as subsidised housing and local *hukou* (residence permit) (State Scientific and Technological Commission, 1991; Guangdong Provincial Government, 1992). Correspondingly, the entry barriers to national-level parks are more demanding in terms of the firm's sector, R&D capacity and pollution control.

In recent years, political decentralisation, characterised by fierce competition between local governments (Zhang and Wu, 2006), has revealed a more complicated picture of the distribution of high-tech firms. Encouraged by the national policy of technology development, hundreds of SPs and IPs were constructed in the late 1990s (Chen, 2009). The local governments compete with their counterparts to attract more firms to their parks, to sell off land for more revenue (Felsenstein, 1994) and to generate higher growth rates (Storey and Tether, 1998). This results in extremely low-priced land and extensive tax exemptions (Zhang and Wu, 2006). Local governments also manipulate the rules of SP management—for instance reducing the entry barriers for firms that would otherwise be unqualified, seeking not only low operation cost but also a park's 'brand name'. This phenomenon has created an extremely mixed and chaotic distribution of high-tech and regular manufacturing firms in SPs.

These combined forces have greatly shaped the landscape of SPs and high-tech firms in China. What is missing in the literature, however, is the recognition of the hierarchical structure of SPs in the Chinese context and its critical role in determining the spatial distribution of high-tech firms in comparison with regular manufacturing firms. In this paper, we try to bridge this gap by modelling the impact of SPs at different administrative levels based on the probability that a locality will have high-tech firms. The presence of SPs, together with policy plans at different levels, are part of the output of a political process in which urban space is assigned certain qualities and through which these qualities can be (re)shaped. If firms are certified as high-tech firms or have high levels of R&D investment, they are more likely to be admitted to enter SPs, or become more interested in locating there. With more political power and resources to support technology upgrades at manufacturing firms (especially SMEs), parks at higher administrative levels are more attractive to high-tech firms than to other firms. Thus, we hypothesise that the probability that a location will attract high-tech firms is positively related to the presence of SPs and their associated administrative levels.

3. Methodology

3.1 Study Area and Data

Shenzhen is one of the most important and dynamic high-tech cities in China. It was originally established as a special economic zone (SEZ) in 1980 to operate a socialist market economy given its proximity to Hong Kong (Zhu, 1996). Over the following three decades, Shenzhen received a huge inflow of industrial investments, most of which have been low-tech manufacturing activities like assembly (Enright *et al*., 2005). Compared with their foreign counterparts, Shenzhen's manufacturing firms have thin profit margins (Linden *et al*., 2009), which have further been eroded by the rising costs of land and labour in recent years (Gu and Chen, 2001; Shenzhen Planning Bureau, 2006).

The central and local governments realised the urgent need for technology upgrading to support sustainable economic growth (Shenzhen Bureau of Trade and Industry, 2001; Ng, 2003). A key strategy implemented was to build SPs to promote high-tech clusters and growth. The first science park in China, the 'Shenzhen science park' (*Shenzhen Keji Yuan*), known as Shenzhen High-tech Industrial Park (SHIP) today, was established in 1985 (Rama *et al*., 2003), followed by a soaring number of other types of high-tech parks and IPs. By 2007, there were 52 parks in Shenzhen, including one national-level (SHIP), 16 municipal-level SPs and 35 local-level IPs (see Figure 1).

The various types of parks exhibit significantly different development paths and mechanisms, shaped by the objectives of the parks' key players. SHIP was established in 1985 by the Shenzhen Municipality and the Chinese Academy of Science, aiming to promote technology-based manufacturing activities in Shenzhen. It was certified in 1995 as the first national-level park in China. More than 3000 firms are located in SHIP today, one-third of which are high-tech firms, generating about 15 per cent of the total output of Shenzhen—that is, 335 billion Yuan in 2011. The management, however, has gradually shifted from joint management to sole management by the government. The increasing government involvement on the one hand guarantees stable resource allocation, while on the other hand reinforces the role of SHIP as a political showcase instead of an innovation hub. Whether this is attractive for high-tech SMEs remains to be answered.

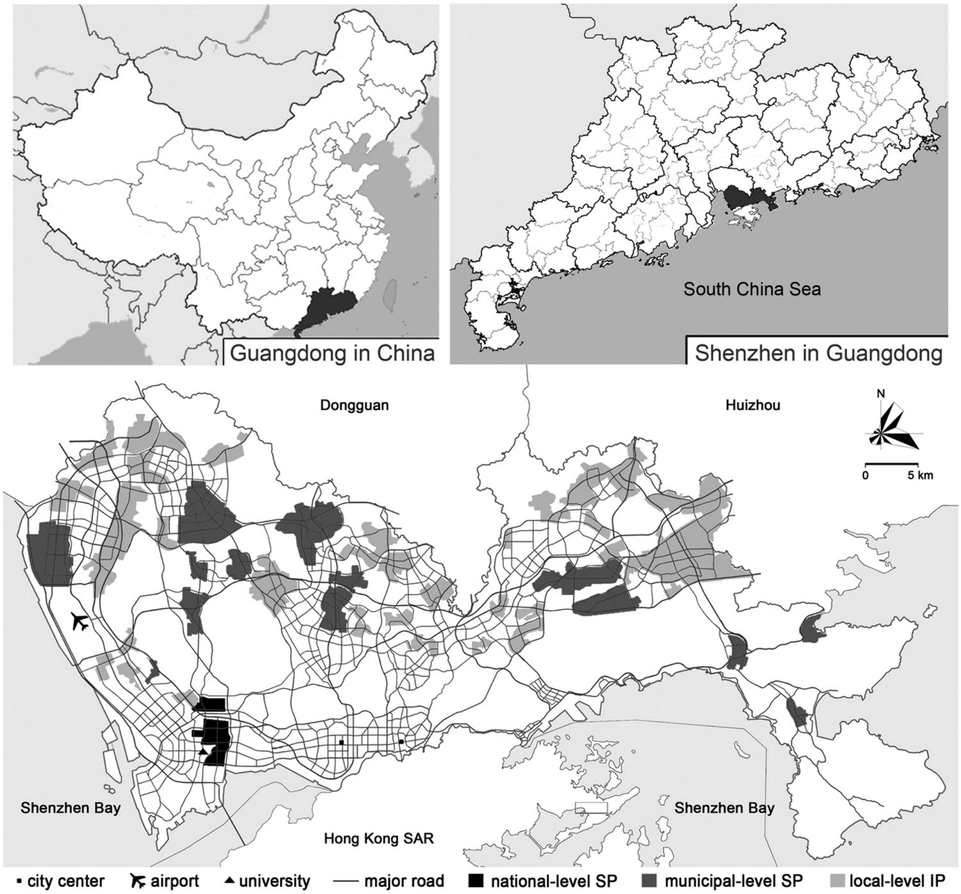

Figure 1. The spatial distribution of parks in Shenzhen.
Source: Shenzhen Planning Bureau (2009).

Municipal- and local-level parks are often jointly established by the local government and private firms and/or developers. The local governments regularly provide land and preferential policy; private firms and/or developers provide funding. The main objective of these parks is to generate quick revenue, both for local governments and for manufacturing firms. The target firms are therefore production- rather than research-based, given their short-term economic growth objectives.

For the empirical analysis, we use a database of 2076 firms in electronics manufacturing, a fast-growing high-tech sector. Firm-level data were obtained from the Shenzhen Industrial Enterprise Survey 2007, maintained by the Shenzhen Bureau of Trade and Industry (SBTI). The survey provides firm-specific information, including firm location, employment, annual turnover, R&D employment and R&D expenditure. Firms with an annual turnover of less than 5 million CNY (approximately 0.8 million USD) are not included given the large number of firms (0.3 million in total). Although biased downward, this survey consists of companies that generate 97 per cent

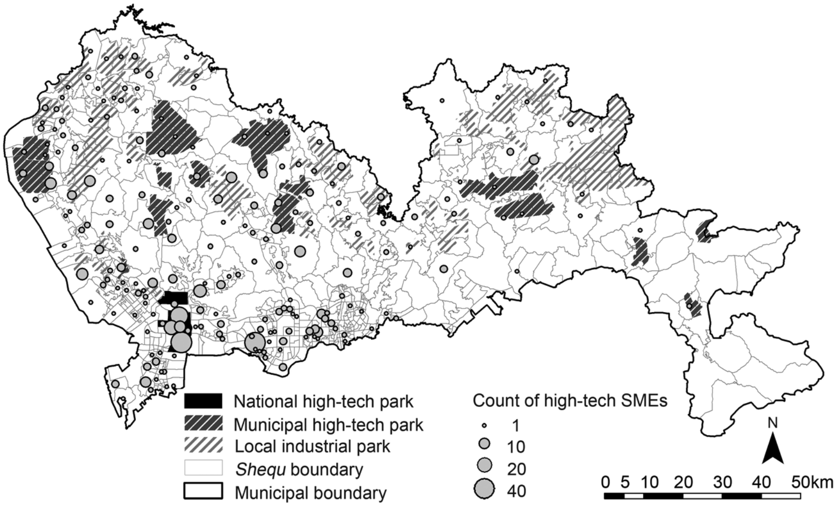

Figure 2. The spatial distribution of high-tech SME counts.

of the industrial output (Shenzhen Statistics Bureau, 2008) and thus we consider the bias to be rather limited and acceptable.

As there is no universal definition of a high-tech firm (Grinstein and Goldman, 2006), we define firms with a research intensity[2] that is one-third higher than the average to be high-tech. Consequently, 700 high-tech SMEs,[3] 1020 non-high-tech SMEs and 353 large firms are identified. Figure 2 illustrates the uneven spatial distribution of high-tech SMEs. High concentrations are found in the south-west region of the city, particularly in areas adjacent to SHIP. In contrast, the majority of the eastern areas have zero high-tech SMEs.

3.2 Empirical Model

To estimate the effect of place-based circumstances, we use the smallest administrative spatial unit in China, *shequ* (literally translated as community), as the geographical unit for the analysis. Each firm is allocated to one of the 601 *shequ*s in Shenzhen and the numbers of three types of firms (high-tech SMEs, non-high-tech SMEs and large firms) in each *shequ* are used as dependent variables.

We have seen the uneven distribution of high-tech SMEs. To explore the factors that determine this distribution, we first considered a Poisson model, which is often used to analyse count data. An alternative method, the zero-inflated Poisson (ZIP) model, is also considered given the large amount of zeros (Burger *et al*., 2009). The ZIP model is used to distinguish between two different processes: one only generates zero counts due to certain constraints, while the other generates zero as well as other outcomes that follow a Poisson distribution. With predictor variables for the zero-inflation condition (i.e. the reasons for excessive numbers of zeros) the ZIP model allows us to model the two processes simultaneously.

The independent variables employed in this analysis serve as proxies of the four groups of factors discussed in the second section. Additionally, the predictor variable, which explains the zero inflation, is also discussed here. Table 1 gives an overview of the descriptions and data sources for the variables used in this research.

Table 1. Measurement and data source of independent variables

Independent variable	*Measurement*	*Data source*
Science park		
National-level science park	Dummy (yes=1; no=0)	Development plan 2006–10 (SPB, 2005)
Municipal-level science park	Dummy (yes=1; no=0)	
Local-level industrial park	Dummy (yes=1; no=0)	
Agglomeration economies		
Population	Number of residents (persons)	Population survey 2007 (SPO, 2008)
LQ of electronics	Employment LQ of electronics in manufacturing	Shenzhen Industrial Enterprise Survey 2007 (SBTI, 2008)
Related firms		
Large firms in electronics	Number of large firms in electronics	Shenzhen Industrial Enterprise Survey 2007 (SBTI, 2008)
Regular SMEs in electronics	Number of regular SMEs in electronics (i.e. not engaged in high-tech activities)	
Knowledge spillovers		
Distance to university town	Network distance based on road network (metres)	Transport network (SPB, 2008)
R&D investment (capital)	10,000s CNY (approximately 15,000 $US)	Shenzhen Industrial Enterprise Survey 2007 (SBTI, 2008)
Planning restriction		
Share of planned manufacturing land	Planned manufacturing land area/total land area (percentage)	Zoning plan 2006–10 (SPB, 2005)

Explanatory variables for the Poisson process

Science parks. Based on the Development Plan of Shenzhen (2006–10), three types of parks can be identified—namely, national-level SPs, municipal-level SPs, and the local IPs. There is no provincial-level park in Shenzhen, due to its distinct status as a so-called special economic zone. Three separate dummy variables are generated to represent the presence of those three types of park.

Agglomeration economies. The agglomeration economies incorporate the urbanisation economies and localisation economies. Urbanisation economies are reflected in the size of the total population of each *shequ*. Population is the standard measurement of urban size in studies of urbanisation economies (Bathelt *et al.*, 2004; Hanink *et al.*, 2011). The data used for the calculation of this variable are derived from the population survey conducted by the Shenzhen Police Office. A log transformation is performed to achieve a normal distribution. The location quotient (LQ) is often used by economic geographers to measure the overrepresentation or concentration of a particular activity (for example, Krugman, 1991). In this paper, we use employment LQ of the sector of electronics to capture localisation economies in each *shequ*. The LQ is calculated as a *shequ*'s share of employment within the electronics sector to its share of Shenzhen's total employment.

Related firms. The numbers of large firms and non-high-tech SMEs in each *sequ* are used to measure the effect of manufacturing firms in the electronics sector.

Knowledge spillovers. Proximity to universities is considered an important location factor due to its potential of knowledge spillover for high-tech firms (McGee, 1991). The effect of universities is measured by the network distance from each *sequ* to the University Town in Shenzhen (*DUNIV*). This University Town hosts the only university in Shenzhen, the Shenzhen University, and three graduate schools of top universities in China—Tsinghua, Peking University and Harbin Institute of Technology, which are all based in other cities in China. Those graduate schools function as their branch campus in Shenzhen. To calculate the distance, we first constructed the transport network based on the spatial database provided by the Shenzhen Planning Bureau (SPB). Subsequently, with the help of ArcGIS Network Analysis, the distance from each *sequ* to the University Town is calculated.

Private R&D activity is considered another important location factor for high-tech SMEs. To measure the effect of private R&D, we use the aggregated R&D investments made by electronics manufacturing firms in a *sequ*. Given the fact that 90 per cent of the R&D investments come from private firms in Shenzhen, and public R&D investments are often complementary to private ones (Yi *et al.*, 2011), this proxy for the localised stock of R&D can serve the purpose of our analysis.

A predictor variable for zero inflation

Planning restriction. In the ZIP model, we need to specify a predictor variable for zero inflation—i.e. an excessive amount of zero observations. In this study, a major factor contributing to the number of zeros is the planning control in Shenzhen, which requires manufacturing firms to locate in certain areas. The regulatory detailed plan (*kongzhixing xiangxi guihua*, equivalent to zoning) restricts manufacturing activities at sites designated for non-manufacturing land uses. Those *sequ*s without planned manufacturing land in those two plans have no chance of containing firms—i.e. they are structural zeros. Therefore, planning restriction, measured by the *share of planned manufacturing land*, is taken as our predictor variable for zero inflation.

4. Empirical Analysis

Before running the model, we first calculate the variance inflation factor (VIF) in Stata to check for possible multicollinearity.[4] The results are satisfactory, with the highest VIF of 2.59 and a mean VIF of 1.67, indicating that the proposed variables are not highly correlated.

Furthermore, we tested for spatial autocorrelation of the variables using Moran's I. Spatial autocorrelations are detected in the variables of *population, LQ of employment, the number of large firms* and *R&D investment*. A spatial lag model was then employed to correct for spatial autocorrelation. However, none of the spatial lag variables is statistically significant; neither statistical tests nor comparisons with the original ZIP model show significant improvement. Therefore, we decided to retain the original ZIP model. Details of the spatial autocorrelations and spatial lag model estimates are available from the authors upon request.

4.1 Estimates for SPs

The national SP exhibits strong positive impacts on high-tech SMEs, as expected (Table 2). Both national- and municipal-level parks are found to be positively related

Table 2. Zero-inflated Poisson regression results

Variable	*Model 1 Number of large firms*	*Model 2 Number of non-high-tech SMEs*	*Model 3 Number of high-tech SMEs*	*Model 4 Number of high-tech SMEs*
National-level science park (SHIP)	1.177**	−0.404	0.773**	1.192***
Municipal-level science park	0.987***	0.497***	0.539**	0.162
Local-level industrial park	0.716***	0.437***	0.354	0.124
Urbanisation (ln(population))	0.391***	0.414***	0.246***	0.107
Localisation (LQ of employment)	1.192***	0.322***	0.485***	0.604***
Number of large firms				−0.024
Number of non-high-tech SMEs				0.121***
ln(distance to university town)	−0.138	−0.250***	−0.528***	−0.391***
R&D investment (standardised)	0.023	0.066***	0.061***	0.011***
_cons	−4.196**	−1.012	2.936**	2.340
Inflate				
Percentage of planned manufacturing land	−0.202	−0.170***	−0.081***	−0.136*
_cons	−0.043	0.767***	0.652***	0.308
Wald chi^2 (df)	206.85 (7)***	113.91 (7)***	331.29 (7)***	486.62 (9)***
Log pseudolikelihood	−443.33	−986.26	−822.05	−688.91

Note: ***, ** and * denote significance at the 0.01, 0.05 and 0.10 levels respectively.

to the probability of having more high-tech SMEs, without considering the effect of the presence of other firms (model 3, Table 2). After controlling for the effect of other firms (the number of large firms and non-high-tech SMEs), the effect of the national-level SP—i.e. SHIP—is substantially stronger and it becomes the only type of park that is significant (model 4, Table 2). This finding suggests that it is SHIP in particular, rather than parks in general, that determines the probability of having high-tech SMEs. This is probably because SHIP has many more formal links than other parks with higher education institutes (HEIs), including Shenzhen University, the Chinese Academy of Science and a number of graduate schools at the top universities in China.

The effect of municipal parks is significant in model 3. However, once the effects of non-high-tech SMEs and large firms are considered, it becomes insignificant (model 4, Table 2). This result suggests that some high-tech SMEs choose the municipal-level parks for co-location with non-high-tech SMEs and/or large firms in the same sector. This suggestion is actually in line with the rationale of municipal policies and plans. In the Shenzhen master plan and development plan, the spatial policy emphasis is on sectors and a number of specified (large) firms instead of a group of firms based on new technologies. The emphasis of those policies is to promote a production chain rather than an innovative system, which reflects the government's attempt to establish a bridge between the existing low-tech and emerging high-tech firms (Shenzhen Planning Bureau, 2009). In this context, the municipal-level parks give priority to firms in certain sectors, without specific measures to distinguish between the technology levels and research intensities of firms.

Local IP is not an attractive destination for high-tech SMEs, regardless of whether we control for the presence of other firms (models 3 and 4, Table 2). This result is in line with our expectation, as local IPs mostly originate from early clusters of low-tech manufacturing firms developed by local communities, such as indigenous village collectives (Hao *et al.*, 2012). Those parks are mainly dependent on autonomous management instead of government support. Rental factory premises in those parks constitute important sources of income for the local communities, which dictate short-term profit-maximising exercises instead of longer-term planning for technology development. Only limited resources can be offered to high-tech SMEs and incentives to attract high-tech development are completely lacking.

Interestingly, SHIP also exhibits a high probability of attracting large firms (model 1, Table 2). From a management perspective, it is understandable that SPs would have more resilient and stable tenants, such as large firms, which are more capable of coping with business uncertainties and, thus, thriving in the local economy of SPs. This finding is also confirmed by the significant positive effect of municipal- and local-level parks on large firms.

For non-high-tech SMEs, the effect of SHIP is neither significant nor positive. SHIP's demanding entry barrier deters non-high-tech firms from locating there. In contrast, both municipal-level and local-level parks show a positive effect on this group of firms. It is easy to understand why non-high-tech SMEs prefer local IPs, given the low rent and flexible entry barriers. Additionally, as we have explained, municipal-level parks put emphasis on the high-tech sector without distinguishing the real technology level of firms, and thus can be attractive to the non-high-tech SMEs in a high-tech sector (in this case electronics).

4.2 Estimates for Other Location Factors

The effects of other location factors are mostly in line with our expectations. Agglomeration economies show a significant positive effect on all three types of firms, with high-tech SMEs being only exception after controlling for the effect of other firms (model 4), and the urbanisation (population) factor is not significant. This finding contradicts the results of many empirical studies, which have found that high-tech firms are more likely to locate in densely populated areas (Viladecans-Marsal, 2004). This phenomenon could be explained by the different technology strategies that have been adopted by Chinese cities, emphasising technology transfer in a confined territory, such as SPs or industrial zones, rather than indigenous innovation which favours densely populated areas to increase the level of intellectual interaction and knowledge exchange.

Both measures of R&D activities, university[5] and private R&D, have a positive influence on the probability of having more high-tech SMEs (models 3 and 4, Table 2). The effects of those two variables, however, became weaker once we controlled for the presence of other firms (model 4, Table 2). This result indicates that other firms may play a complementary role in attracting high-tech SMEs to the vicinity of universities and private R&D. Note that the impact of university and private R&D is not significant for large firms (model 1, Table 2). This finding is consistent with previous findings that large firms in China tend to rely on in-house technology development rather than external research sources (Leung, 1993; Sun, 2002).

Contradictory to our expectation, large firms do not have a significant impact on the probability of having high-tech SMEs. The non-high-tech SMEs, however, are found to have a significant positive effect.

5. Discussion and Conclusion

The phenomenon of SPs reflects a trend of structural changes characterised by the rise of technology-based activities since the late 20th century. In this context, SPs can be seen as both a policy tool and a strategy for spatial development aimed at clustering firms and new technologies. Despite the increasing number of SPs in both developed and developing countries, it is still unclear to what extent they have been successful. To address this, we have used fine-resolution data to examine the impact of SPs on the locations of high-tech SMEs.

The contribution of this paper to the literature on SPs is two-fold. First, it disentangles the effect of SPs from other IPs in the location of firms. Secondly, it compares the locations of high-tech SMEs with non-high-tech SMEs and large firms. Thirdly, this paper adds empirical evidence from China to the literature on SPs, which has so far been concentrated on Europe and North America.

We found that, as a tool for policy intervention, the presence of SPs significantly increases the probability of attracting more high-tech SMEs. The empirical results are consistent with our hypotheses and confirm the general assumption of the positive effects of SPs in attracting high-tech SMEs.

The hierarchical structure of parks distinctively differentiates the Chinese case from previous empirical studies in developed countries. Clearly, the national-level parks focus on high-tech firms, the local-level IPs concentrate on non-high-tech firms and the municipal-level parks play an intermediate role between non-high-tech and high-tech activities. Within the generally low-tech dominant Chinese manufacturing context, the hierarchically structured parks at different administrative layers function as an integrated system, which attempts to balance the development of both high-tech and low-tech firms.

The national-level SP, which benefits from more favourable policies and a more active R&D environment, is particularly favoured by high-tech SMEs and large firms. This finding implies potential competition between high-tech SMEs and large firms for space and resources. In this case, high-tech SMEs are in a more vulnerable position, as local policies have offered greater support to large firms since the late 1990s (see for example, Shenzhen Municipality, 1996; Shenzhen Bureau of Trade and Industry, 2003; Shenzhen Customs, 2009). The principal reason for this policy imbalance is the knowledge-based nature of high-tech SMEs; as knowledge is intangible and incrementally developed (often slowly), these firms can rarely meet ambitious economic goals (often set to be realised in a short time). In contrast, most large firms, if not entirely successfully, concentrate on manufacturing activities, which are more tangible and provide faster returns than knowledge-based activities. To sustain long-term economic growth, the vulnerable and emerging high-tech sector must be securely anchored. Supporting policies should be implemented to develop and value services and resources for high-tech SMEs at the SPs by providing sufficient space, building knowledge infrastructure and establishing a platform of cooperation between high-tech SMEs and large firms.

Interestingly, we found that municipal-level parks are attractive to non-high-tech and high-tech SMEs if we do not control for the effect of other firms. One explanation could be that SMEs in an early stage of development seek less expensive and more accessible locations. The municipal-level parks can be envisioned as appropriate environments for currently low- and medium-tech SMEs to grow and gradually transform into high-tech firms because their entry barriers are relatively flexible.

This study is an initial attempt to quantify the effect of SPs on the development of high-tech clusters in the Chinese context. The empirical results should be treated with caution. One major limitation is that we used a cross-sectional dataset, which may mask the underlying dynamics dictating the high-tech SMEs' locations. Testing hypotheses related to these dynamics requires additional data to detect temporal patterns in the distribution of high-tech SMEs and would be an interesting topic for future research. Moreover, our study is based on the case study of Shenzhen, which is distinctly different from most high-tech cities because it does not have a strong academic research profile. In Beijing and Shanghai, for instance, a substantial amount of high-tech firms are actually university spin-offs. Therefore universities and research institutes in those cities may have stronger roles in determining high-tech firms' locations. There are also some cities such as Suzhou, where the links between local universities and firms are weak. SPs may provide complementary resources for high-tech firms to cluster and prosper. Therefore our research findings should not be generalised without careful analysis of these differences. Nevertheless, qualitative investigations are essential to understand the critical differences among a variety of parks other than their administrative status, to exemplify the mechanisms of those differences in shaping the distribution and performance of high-tech SMEs and to prescribe more effective policies for the future development of high-tech SMEs.

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Notes

1. Terms for SPs in Chinese: *kejiyuan*, *gaoxinqu* and *gaoxin jishu kaifaqu* and the like are used interchangeably.
2. Research intensity is measured as the share of R&D employees and share of R&D expenditure to total sales.
3. Firms with less than 500 employees are considered as SMEs.
4. As a rule of thumb, a variance whose VIF values are greater than 5 may merit further investigation. Tolerance, defined as 1/VIF, is used by many researchers to check the degree of colinearity. A tolerance value lower than 0.2 (equivalent to a VIF of 5) suggests that the variable could be considered as a linear combination of other independent variables.
5. The distance to the University Town as a reverse measure of the university's effect.

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