Interaction Analysis among Industrial Parks, Innovation Input, and Urban Production Efficiency

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Abstract

The high-tech development zones engendered by industrial parks reflect policies that rely on city settings to create industrialization through urbanization in China. To understand the effectiveness of such policies, this article regards the city and park as the spatial unit of economic output. The production efficiency of the city and industrial park and their mutual impact are explored through the input of various production elements operating in a specific space. In addition, as innovation is an important factor affecting efficiency, this investigation explores the overall impact of innovation input on the production efficiency of the city and park. The results show that production efficiency realized for large cities has not been as high as was generally expected and that small cities showed modest efficiency gains. Critically, the calculation of production efficiency in this study simultaneously accounts for both input and output, revealing the decreasing returns-to-scale and, in some cases, the production inefficiencies that can be caused by the excessively large scale of the city and park. The high-tech industrial development zone will not greatly affect the production efficiency of the city. However, the precise degree of the park's impact on the production efficiency of the city cannot be verified. This indicates the presence of other factors that will affect the production efficiency of the city; and innovation input does enhance production efficiency. This investigation uses input for testing. When production yields increasing returns-to-scale, it indicates insufficient input of production elements, and policies encouraging investment of production elements should be strengthened. Production showing decreasing returns-to-scale is connected to excessive input of production elements, and policies governing the input of production elements should be carefully assessed.

Keywords: Industrial park, Production efficiency, Innovation input

1. Introduction

Since it reflects an organization's efficiency, productivity is an indicator of competitiveness (Solleiro and Castanon, 2005). Urban economists have offered assessments of urban productivity and efficiency over the past several decades (Alonso, 1971; Carlino, 1982; Castells, 1985). Many studies have identified industrial structure, capital density, technology adjustment capacity, labor quality, and agglomeration economies to number among the main factors affecting urban productivity (Beeson and Husted, 1989; Moomaw, 1983; Williams and Moomaw, 1989). The extent to which these factors relate to urban scale has also been examined (Kim, 1997). Usually the larger the urban scale, the higher the urban productivity will be (Segal, 1976; Sveikauskas, 1975). (Note 1)

Broadly speaking, productivity represents the relationship between inputs and outputs in the production process. The efficient transformation of inputs into outputs, thereby boosting productivity, is an important key for a city to become economically competitive. The production factors include land, labor, capital, and entrepreneurship; to improve productivity, the focus must be on the quality and quantity of labor, capital investment and

manufacturing locations (Kresl, 1995). Therefore, if a city uses inputs of the same quantity as other cities, but realizes increased outputs, it means this city has higher production efficiency (Kim, 1997; Zhu, 1998).

Based on the above thesis, this article assumes that the higher the urban production efficiency, the higher the city's productivity, which in turn is affected by the relationship between input and output. Therefore, this study first focuses on 221 Chinese cities (including 4 municipalities and 217 prefecture-level cities) to explore the relationship between production efficiency of urban manufacturing industries and urban scale. Development of a city's manufacturing and emerging industries must be based on a functioning land supply system (Glaeser et al., 1992). Industrial park development is an important policy tool adopted in many industrialized countries (Hakansson and Johanson, 1993; Masser, 1990). The technology growth supported by parks creates job opportunities, improves urban productivity, and maintains the country's competitive environment (Markusen et al., 1986). In addition, manufacturers in the industrial park obtain greater benefits with lower costs compared to those in other areas. In terms of overall economic development, there are positive benefits for the regional economy as job opportunities are created and incomes rise (Castells and Hall, 1994). These shifts, coupled with expanded investment in R&D, change in the industrial structure of the local region and upgrade its quality of life (Keeble, 1989).

The development of the Industrial Park is an important means for China to enter the world economic system. The 53 high-tech development areas, similar to science parks and science cities, are knowledge-intensive and technology-intensive industrial zones. They are emblematic of regional economic development and they have brought a decisive stabilizing effect to economic reforms in China (Gu et al., 1998). This study explores the production efficiency and the relevant factors that affect efficiency performance in 53 high-tech development zones and examines whether industrial park development affects the production efficiency of the urban manufacturing industries.

Innovation capacity is the main source of a manufacturer's competitiveness (Feldman and Florida, 1994). Manufacturing capacity and time-efficient product releases are necessary tools for competition (Sen and Egelhoff, 2000). Innovation stimulates economic growth and development, but also plays an important role in the long-term competitiveness and performance of the manufacturer (Howells, 2002). Innovation links technological progress and development, bringing economic growth, international trade and regional prosperity (Acs et al., 2002); therefore, the production efficiency of manufacturing industries is closely related to innovation. Urban productivity advantages are derived from the innovation capacity of the city, because the city is where various economic activities are centered and is also the place where technology innovation may occur. Innovation capacity is often regarded as an important factor in improving efficiency (Sveikauskas, 1975).

Innovative environments increase manufacturing performance (Camagni, 1995). These environments integrate industry clusters, manufacturers' R&D, manufacturers' cooperative networks, manufacturers' innovation level, and other factors (Shefer and Frenkel, 1998). The R&D activities also can be considered as central to innovation activities (Evangelista et al., 1997), and the input of R&D funds means there will be an output of innovation (Hagedoorn and Colldt; 2003). Based on this premise, the third focus of this article, in addition to exploring whether the industrial park will affect the production efficiency of urban manufacturing industries, is to regard R&D expenditures as an innovation input that affects innovation output and include this factor in analysis in order to understand how the innovation input affects the production efficiency of cities and parks.

The text is organized in six parts. The second part presents theory and hypothesis; the third part describes the history of China's industrial park development; the fourth part describes the research method, which comprises the logical structure for the relevant data testing; the fifth part contains the empirical section and the analysis of the test results; and the final part contains conclusions and policy suggestions.

2. The establishment of theory and hypothesis

This paper explores the production efficiency of urban manufacturing industries, the efficiency of industrial park development, and the impact of industrial park development and innovation input on the production efficiency of urban manufacturing industries. The relevant theories used to establish the empirical hypothesis for this article will be reviewed.

2.1 The production efficiency of urban manufacturing industries

The definition of productivity varies depending upon research purposes and objects. Economists hold that productivity is used to measure the technical status of the production goods or services, and management scholars deem that productivity can measure the performance of the production unit (Kim, 1997), that is, production efficiency. In general, the main factors affecting spatial productivity include industrial structure,

capital equipment density and time of input, technology adoption rates, labor quality, and agglomeration economies (Beeson and Husted, 1989; Kendrick, 1977; Moomaw, 1983; Williams and Moomaw, 1989).

The higher a city's industrial profitability, the higher the city's productivity will be because industrial development and the expansion of scale will lead to economic growth (Frenkel, 2000). This implies the expansion of industrial scale and increases in financial goods and labor production consumption. Correspondingly, full usage of resources and production efficiency characterize industrial development progress and industry scale and positively impact local competitiveness (Begg, 1999). The density of the capital equipment and related maintenance downtime is closely linked to industrial productivity because older capital equipment usually means outdated technology with low reliability that requires more maintenance, thus reducing an industry's productivity (Kim, 1997). New technology usually arises from new investment. Regions, particularly metropolitan areas, that have more advanced technical knowledge achieve higher productivity than areas with older technology (Berry, 1972).

Factors associated with the labor force, such as education level, technical expertise, age, and gender also affect urban productivity. Higher "capital-labor ratio" or capital density is also considered one of the elements that improves productivity and because capital and labor are mutual substitutes, increasing either capital or labor can raise productivity (Moomaw, 1983). The manufacturers holding a higher "capital-labor ratio" have more advanced production technology, and laborers applying the new technologies in new processes will be able to produce more goods. Capital productivity rises along with labor productivity, so the region or the city can be considered as having higher productivity if it has a high capital-labor ratio (Kendrick, 1977).

Agglomeration economies are regarded as one of the most important factors affecting productivity and they are shaped by the professional division of labor, the rate of technological change, manpower capital accumulation, and the number of nearby universities (Beeson, 1990). The process and outcome of geographical agglomeration on production and consumption create opportunities for comparison between the agglomeration spaces. A region's productivity growth rate is dependent on the extent and speed of technical transfer and on economies of scale, and these in turn will be affected by agglomeration (Kaldor, 1970). Therefore, agglomeration economies are considered to comprise the external economy combined with urban scale and economic activities of space (Kim, 1997).

Bostic et al. (1997) divided the factors that affect urban productivity into two categories. The first category consists of internal economic factors, including labor, capital input, and internal economies of scale. Economy of scale may be obtained from optimal productivity, procurement negotiation capacity, the application of national advertising, research, and ongoing personnel training, all of which facilitate a drop in unit cost as the number of products generated increases. The second category entails external economic effects, including the urbanized economy, localized economy, and the extent of industry specialization.

Most published studies have assumed the perspective of urban agglomeration economies to establish the production function. Through returns-to-scale parameters or Hicks-neutral productivity parameters of the agglomeration economies, the effects of external economies generated by the urbanized economy and the localized economy to productivity have been explored.(Note2,3) Henderson et al. (1995) conducted a dynamic external test (including dynamic localized economy and dynamic urbanized economy) on eight kinds of manufacturing industries, including five kinds of traditional industries and three kinds of high-tech industries within 224 standard metropolitan statistical areas in the United States in 1970 and 1980. Empirical results show that the mature industries possess characteristics of a dynamic localized economy but not a dynamic urbanized economy; however, the high-tech industry has the features of both a dynamic localized economy and a dynamic urbanized economy. This conclusion is identical to the urban specialization and product cycle theory; namely, emerging industries flourish in large urbanized areas with a more complex industrial structure, and the mature industries are concentrated in the smaller cities with a higher percentage of professionals in the work force.

The results of these studies have found that urban productivity is affected by technical factors and the localized economy or the urbanized economy. Therefore, if the city is regarded as a spatial unit of economic output responding to input of various production elements, then the technical efficiency and scale efficiency that represent the combination of various elements like these technical factors. The localized economy or urbanized economy will consequently reveal the source of efficiency differences between the cities. Therefore, this article has established the first research hypothesis:

Hypothesis 1: The production efficiency of urban manufacturing industries has nothing to do with the city size.

2.2 The industrial park development and productivity of urban manufacturing industry

Marshall was first concerned about the importance of industrial localization to the regional development of the modern industry. He concluded that enterprises or factories are able to share a number of production elements, such as land, labor, capital, energy, and transport, through agglomeration. Marshall's findings led to the concept of the external economy (Evangelista et al., 2002; Gordon and McCann, 2000). Manufacturing plant adjacencies reduce production costs and transaction costs through sharing of the infrastructure, skilled labor, and production resources in the region; thus, the external economy and reduction of the transaction costs are the main factors in the formation of industry clusters.

When industry clusters reflect manufacturing specialization or the geographical proximity of the relevant departments, they generate external technology that favors the manufacturers in the region, while the operation of the local production system strengthens the manufacturers' specialization, and the relationship between local manufacturers and local institutions becomes closer (Storper, 1995). One of the sources of regional competitiveness is the operation of local production systems (Porter, 2000). Such regional economic vitality sometimes cannot be created or imitated in other regions. In other words, the economic activities of the manufacturers are affected by territorialization (Storper, 1997), and such strong growth in a highly localized location can be attributed to the special environment that retains production elements, namely, the adhesion of space (Markusen, 1996).

Therefore, the industrial activity space implicitly contains natural endowments as well as labor and opportunity advantages which result in the manufacturers situating in the same industrial area. Because of knowledge spillovers, technical labor mobility, benefits of mutual trust, and shared values within the group, these companies experience better economic performance than manufacturers outside the industrial area (Cainelli, 2008). Additionally, the linking of expertise, information sharing, group norms, systems, and labor in an industrial area are very important for the development of industries in the region and enhance regional competitiveness (Lee et al., 2000).

Based on Marshall's concept of the industrial area and the theory that the manufacturers indeed will benefit from agglomeration in the same industrial area, governmental industrial policies have often encouraged specific industries to assemble in a particular area. Indeed, government policies can actively encourage specific industries, balance regional urban and rural development, and construct cooperation networks, all of which guide industrial development in a given region (Higashi, 1995). Industrial park or science park development is one example of such a policy. The network created through an industrial park positively affects the area endowments, as mentioned in the industrial area discourse; therefore, it is regarded as greatly contributing to the economic strengths of the region. This paper now proposes the second hypothesis as:

Hypothesis 2: The industrial park has a positive impact on the production efficiency of the urban manufacturing industry.

2.3 The innovation input and the production efficiency of urban manufacturing industries

Innovation is the main way for manufacturers to maintain a competitive advantage and enter new markets (Brown and Eisenhardt, 1995). Innovative performance is related to the manufacturer's own attributes (Love and Roper, 2001; Thornhill, 2006), and knowledge spillovers are related to the regional environment (Feldman and Florida, 1994; Fritsch, 2003). In addition to the manufacturers' R&D input, innovative behavior, innovation capacity (such as the establishment of R&D departments and the recruitment of R&D personnel), and other internal factors, the atmosphere of innovation in the local environment will also affect the manufacturers' innovation performance (Camagni, 1995). The city is the gathering place for all kinds of economic activities and also the place where innovation can occur. The urban productivity advantage does not come from static specialization but from the dynamic benefits of urbanization (Sveikauskas, 1975). The effect of agglomeration economies highlights the inter-regional differences that arise from the different cultural environments, systems, and industrial structures. Common norms and knowledge spillovers spur face-to-face learning and technological exchange that stimulate R&D input in the region (Cabral and Dahab, 1998; Feldman and Florida, 1994; Jaffe et al., 1993).

This environment is not purposely made by manufacturers; it is created by various actors sharing the same culture and norms within the region (Fritsch, 2000). The regional innovative atmosphere enhances the manufacturers' innovation capacity (Kleinknecht and Poot, 1992; Shefer and Frenkel, 1998). The R&D input and public R&D activities for the regional innovation output have a positive effect (Griliches, 1986; Jaffe, 1986), and the amount of spending will positively affect the manufacturers' R&D and the efficiency standard of other innovative activities (Luis et al., 2006). Therefore, this article regards R&D expenditures in an industrial park as

an urban innovation impact factor that influences the production efficiency of urban manufacturing industry.

Indeed, a manufacturers' R&D input reflects an innovative atmosphere and the manufacturers' own commitment to innovation (Feldman and Florida, 1994; Love and Roper, 2001). A variety of studies have suggested that small manufacturers (i.e. fewer than 500 employees) have flexible operations that enable them to quickly absorb new knowledge and promote innovation (Acs et al, 2002; Robertson and Langlois, 1995). Alternate views hold that larger companies have greater resources available for research and development, and organizational adjustments to encourage flexibility can be made, so innovation performance is not necessarily worse than that seen in smaller manufacturers (Britton, 2003; Shefer and Frenkel, 1998). With regard to employees, Gu and Tang (2004) point out that a manufacturers' innovation effectiveness is highly correlated with the number of high-quality employees on staff, as high-quality employees will generally show initiative in implementing R&D results, thereby increasing the assimilation of new knowledge into manufacturing processes.

Innovative activities can result in new products, new technology, and new types of supply or organizational types. Many studies measuring innovative activities have focused on the number of a manufacturers' new products or patents (Acs et al., 2002; Feledman and Florida, 1994; Jaffe, 1986). However, innovation is a complex process, extending from initial concept, basic research, and preliminary design to new product release and marketing, and it is difficult to use a single indicator to measure this process (Hollenstein, 2003). Patents and new products involve implicit knowledge that is not amenable to calculations, so adopting the number of patents and new products as measuring indicators for innovation may create the problem of underestimation (Griliches, 1990; Gu and Tang, 2004).

Hollenstein (2003) proposed that innovation measuring indicators should include R&D input, number of patents, patent citations, and the number of new products. In addition, Hagedoorn and Cloodt (2003) believe that R&D input is directly related to innovation output. Using patents or new products as proxies for innovation is problematic. The effectiveness of codified knowledge and tacit knowledge should also be considered. For instance, a manufacturer whose effectiveness contributed to new products or processes but is not party to a patent application can also be taken into account.

This investigation suggests that tacit knowledge, transfer effects, and technical upgrades should be included in innovation discussions, so the thesis referred to as "R&D input will bring innovation output" proposed by Hollenstein (2003) and Hagedoorn and Cloodt (2003) is adopted. The manufacturers' R&D input expenditure is used as the measuring indicator for innovation input to avoid the shortcomings of underestimation caused by adopting the number of patents or new products. The third hypothesis of this article is proposed as follows:

Hypothesis 3: Innovation input affects the production efficiency of the industrial park and the city.

3. The development process of China's industrial parks

The demarcation point for the development of industrial parks in China is 1984, as there was no such prior development. State-mandated economic and security policies determined the layout of industrial development. (Note4) In June 1984, in response to global technological change, the Chinese government conducted studies and established preferential policies for new technology parks and enterprise incubators. With Deng Xiaoping's approval, the Chinese State Council created 14 urban economic and technological development zones. These differed from the Special Administrative District format. Leaders within the new zones recruited foreign investment and encouraged industrial growth.

In the same year, the basic foundations for the economic and technological development zones were introduced. (Note5) 1. The zones would rely on cities within the zone for resources, funds, manpower, industrial foundation, and infrastructure; 2. Zones would have clearly defined boundaries in order to facilitate the control of licensing and to implement outreach activities. 3. These economic and technological development zones would attract foreign technology and lead to productive joint ventures among Chinese and foreign entities. These manufacturing production, design, and development initiatives would stimulate the expansion of regional advanced production and management techniques which would benefit the coastal zones and adjacent inland areas; 4. Implemented in a platform style design, the investment environment would improve without interfering with the enterprise management; 5. License control and foreign investment protocols within the economic and technological development zone could be relaxed appropriately, accordingly to policy guidelines; 6. Manufacturers in the industrial park could enjoy preferential income tax status.

The High-Tech Development Zones were set up as incubators for national and regional industrial modernization. They are analogous to western research parks that raise the level of technology-based products, commercialization, and internationalization of products, re-develop traditional industries, and accelerate the

growth of emerging industries, all to facilitate national economic development.

In March 1985, China promulgated the "Decision on the Reform of the Science and Technology Management System" to encourage emerging industries. Preferential policies for pilot high-tech zones were created.. In July of the same year, the Shenzhen Science and Technology Industrial Park was founded. In 1988, the "Beijing High-Tech Industrial Development Experimental Zone" was founded. The Beijing Zone's design was similar to Taiwan's Hsinchu Science Park in its focus on promoting the development of high-tech industry.

In June 1991, the "National Torch Plan" was promulgated with the aim to convert science and technology research results into market commodities to meet the aims of "commercialization," "industrialization" and "globalization." Subsequently, 26 state-level high-tech industrial development zones were approved with their own tax policies and regulations, business identification conditions, and procedures. Actively promoted by Deng Xiaoping, additional zones were created and in 1997 the last High-tech Development Zone was established at Yangling in Shaanxi. The zone takes advantage of regional strengths in agriculture and education. The number of state-level high-tech industrial development zones currently totals 53.

Castells (1985) finds that the high-tech industrial zone not only has benefits on an economic level but is also a regional and national industrial development indicator. In China, the "High-tech development plan outline," also known as the "863 Plan," steers resources to develop seven high-tech fields including biotechnology, space technology, information technology, laser technology, automatic meter technology, energy technology, and new materials technology. This focus has significantly impacted China's economic and social development. Gu et al. (1998) defined high-tech zones as complexes possessing dual functions of production and consumption, functioning in symbiosis with adjacent cities.

4. Research methods and framework

4.1 Research methods

The efficiency measurement methods include ratio analysis, multiple criteria evaluation method, Transcendental logarithmic (Translog) production function analysis, regression analysis, and data envelopment analysis (DEA). This study considers China's 221 municipalities and prefecture-level cities and 53 high-tech development zones. Due to limited access to input-output, DEA is used as the main tool for discussion, as DEA it is more applicable to multiple input-output efficiency assessment.

As the DEA efficiency assessment value only measures the relative efficiency value of the decision-making unit, it cannot point out the impact of the exogenous variable, which produces neither the input nor the output on the production efficiency of the decision-making unit and will often need to be tested again by regression analysis. This paper adopts methodology described by Coelli et al. (1998) and Fried et al. (1999) to sort out the impact of exogenous variables on efficiency; the analysis is conducted using the two-stage method. The first stage is to estimate the efficiency of each assessed unit using DEA. The second stage is to take the estimated efficiency value as the response variable and use the regression model to assess the marginal effect of the exogenous variables on production efficiency. As the efficiency value estimated by DEA model is between 0 and 1, it is classified as censored data, and as the distribution of the sample data displays neither normal distribution nor symmetrical distribution, it is different from the response variables in the least squares (OLS), which are the consecutive numbers. If the regression analysis is conducted directly with least squares, it may cause bias or inconsistency within estimated parameter values; therefore, we use the TOBIT truncated regression model for further analysis.

4.2 The research framework

In this study, the production efficiency test includes two geographical spaces, the city (4 municipalities and 217 prefecture-level cities) and the high-tech development zones (53). The logical relationships among them are shown in Figure 1. With regard to inputs, urban production requires elements such as capital stock, labor, and technology. Output production values were tested assuming a linkage of greater-input .Therefore, if we regard the city as a spatial unit of economic output, then DEA can be used to evaluate changes in urban efficiency changes. This study takes the cities' possible production boundaries as a reference standard to ascertain the reasons for of inefficiencies in specific cities.

The high-tech development zone is a industrial park complex that possesses the dual functions of production and consumption and is in symbiosis with the city (Gu et al, 1998). This symbiotic relationship provides land, labor, capital, energy, transportation, and other production elements that manufacturers share, thereby increasing economic benefits (Evangelista et al., 2002; Gordon and McCann, 2000). Therefore, if the high-tech development zone is regarded as a spatial unit of economic output, the technical efficiency and scale efficiency

that is generated by production elements such as land, labor, capital in a specific space will also reveal the sources of the efficiency deviation among the parks, assuming greater-input, greater-output. Therefore, using DEA can pinpoint the efficiency differentials in parks. Determining the highest-efficiency park can ascertain the causes of inefficiency of other parks.

4.3 Research variables

This study uses data contained within the China City Statistical Yearbook (2004), the China Urban Development Report (2004), and from the Investment Division of the Ministry of Science and Technology (2004) to explore the production efficiency of 221 municipalities and prefecture-level cities and 53 high-tech industrial development zones. The study variables are as follows:

4.3.1 Production efficiency test variables of manufacturing industry in prefecture-level cities

The production efficiency of manufacturing industries in cities is mainly affected by internal and external economies (Beeson and Husted, 1989; Bostic et al.1997; Kendrick, 1977; Kim, 1997; Moomaw, 1983; Williams and Moomaw, 1989). The internalized economy includes factors such as labor and capital investment while the externalized economy includes, among other elements, the localized economy and the urbanized economy. When the city is regarded as the spatial unit of economic output, the source of differences in efficiency among the cities can be gauged. With respect to input variables, this study selected four input variables. These are the average annual number of employees, investment in fixed assets, the amount of actual use of foreign capital, and the number of industrial enterprises to represent the capital and labor factor of production. With regard to outputs, GDP was taken as the measuring indicator and was further divided into domestic enterprises GDP, Hong Kong / Macao / Taiwan-invested enterprises GDP, and foreigner-invested enterprises GDP. The descriptive statistics of each variable of prefecture-level cities are referred to in Table 1.

To understand the impact of industrial park development on the production efficiency of urban manufacturing, the result of the DEA model is taken as a response variable with which to conduct a second TOBIT test. The prefecture-level city with a value of 1 is considered to be production efficient; otherwise, the production efficiency value is between 0 and 1. The independent variable was whether or not to set up the high-tech industrial development zones, represented by the dummy variable, which if present has the value of 1.

In addition, in order to explore the impact of innovation input on urban production efficiency, this article also takes industrial park scientific expenditures as one of the independent variables. Because scientific expenditure and R&D activities are closely related, they are expected to be positively correlated, indicating that the greater the scientific expenditures yields higher production efficiency.

4.3.2 High-tech Development Zone testing variables

Production efficiency of the high-tech development zones represents the interplay of production elements such as the land, labor, capital required for production in a specific space. This investigation selects four input variables and two output variables to explore differences. The former includes the total floor area completed, the number of enterprises, the number of employees at year-end, and year-end assets respectively representing the land, labor and capital production elements. The latter are industrial GDP and the actual tax paid.

In addition, because the manufacturers' own innovation-related attributes will affect the innovation efficacy (Feldman and Florida, 1994; Love and Roper, 2001), and R&D input will yield innovation output (Hagedoorn and Cloodt, 2003; Hollenstein, 2003), the manufacturers' scale (Acs et al., 2002; Britton, 2003; Robertson and Langlois, 1995; Shefer and Frenkel, 1998) and the number of high-quality employees (Gu and Tang, 2004) will also affect the company's innovation efficacy. In order to explore the impact of the innovation input on the production efficiency of the park, this study employs three variables, namely, R&D expenditures, number of employees for scientific and technological activities, and the manufacturers' scale [represented by the number of employees at year-end (thousands) / number of enterprises (100)] to explore using the TOBIT model.

The descriptive statistics of each test variables are referred to in Table 2.

5. The empirical results and hypothesis authentication

5.1 The production efficiency of urban manufacturing industry

In this article, the DEA model testing includes the CCR model, the BCC model, and scale efficiency tests.(Note6) Assuming returns-to-scale is fixed, the CCR model test of 221 prefecture-level city shows that production-efficient cities include 31 prefecture-level cities such as Changchun, Suzhou, Xiamen, Qingdao, Dongguan City, accounting for 14.03% of the total tested cities. In 31 prefecture-level cities, there are 6 in the coastal areas, 25 are inland. The inefficient prefecture-level cities include 190 cities such as Beijing, Tianjin, and

Shanghai, accounting for 85.97% of the total tested cities, 51 in coastal areas, and 139 inland. The efficient prefecture-level city's efficiency parameter value is 1, the inefficient prefecture-level city's minimum parameter value is 0.132, recorded for Shangrao City, and 221 prefecture-level cities' mean efficiency value is 0.521 (see Table 3).

The BCC model assumes that returns-to-scale is variable; if not in the efficient state, then returns-to-scale are either increasing or decreasing. In 221 prefecture-level city test results, the production-efficient cities, in addition to 31 prefecture-level cities in the CCR model, still include 14 prefecture-level cities such as Tianjin, Shanghai, and Hangzhou yielding a total of 45 prefecture-level cities and accounting for 20.36% of all cities tested. The production-inefficient prefecture-level cities were reduced to 176, accounting for 79.64% of the total cities tested, in which 47 are in coastal regions, and 129 are inland. In the BCC Model tests, the efficiency parameter value is also 1, the minimum parameter value in inefficient prefecture-level cities is 0.173 for Yichang City, and the mean efficiency value of 221 prefecture- level cities is 0.614, slightly higher than 0.521 of the CCR model.

In the results of the state of returns-to-scale, 31 cities had scale efficiency, 6 were in coastal areas, and 26 inland; 137 cities displayed increasing returns-to-scale, and 52 showed decreasing returns-to-scale.

Furthermore, according to Norman and Stoker's (1991) classification on the overall strength of efficiency value(Note7),the scale efficiency and changing scale technical efficiency can be used to classify the cities, in order to better understand the efficiency state of the cities. The 31 cities with optimal scale efficiency include 3 manufacturing clusters, Suzhou, Xiamen, Dongguan, 3 provincial capital cities, Changchun, Kunming, and Lanzhou, and the municipality of Chongqing, which all account for 14.48% of the total cities tested. Liaoyang and Weinan can improve their production efficiency in a short period of time, and 88 cities showed production inefficiency, accounting for 39.82% of all the cities tested. Fifteen (15) provincial capital cities showed increasing returns-to-scale or decreasing returns-to-scale respectively and the scale efficiency is close to 1. However, because of poor technical efficiency, these cities are productively inefficient and account for 57.69% of provincial capital cities. Twenty-five (25) cities have excessively large scale, accounting for 11.31%, including three municipalities, Beijing, Shanghai and Tianjin, and 7 provincial capital cities, Nanjing and Wuhan among them. Small scale cities account for 33.93%; most are medium or small prefecture-level cities with small population scales. Xining City is the only provincial capital city in this category, with a population of less than two million.

Therefore, although urban productivity is usually positively related to scale (Kim, 1997; Segal, 1976; Sveikauskas, 1975), when manufacturing production efficiency is used to measure urban productivity, relative to the optimal scale of cities, the big cities because of their excessively large scale generally show decreasing returns-to-scale. In terms of the two municipalities, Shanghai and Beijing, the population increase may result in decreasing returns-to-scale or reduced technical efficiency. The former indicates that input is higher than the best input for the optimal output, while the latter indicates that it may be an oversupply of a single element that has caused the decrease in efficient use of manufacturing elements. Consequently, the increase in population scale may lead to decreasing urban returns-to-scale. Therefore, this study's first hypothesis "The production efficiency of urban manufacturing industry has nothing to do with urban scale" is verified.

In order to determine whether or not urban productivity is affected by industrial park development, we use the DEA model to test the urban production efficiency value as the dependent variable. TOBIT model testing used establishment of a high-tech development zone and economic and technological development zones in the city as dummy variables and urban science expenditure (continuous variable) as an independent variable. In the BCC model, the high-tech development zone's setting passed the test, which indicates that the high-tech development zone's setting will positively correlate to the production efficiency of the urban manufacturing industry. However, this is not true for scientific expenditure. In the CCR model, urban production efficiency had no correlation with the industrial park zone's setting but was affected by the science expenditure (See Table 4).

The empirical results show that when manufacturers spatially share production elements such as infrastructure, technical labor, and production resources, they may reduce trade costs and generate external economies (Evangelista et al., 2002; Gordon and McCann, 2000). Efficient operation of local production systems is enhanced and the regional competitiveness improves (Cainelli, 2008; Lee et al., 2000; Porter, 2000). When China set up the Economic Technological Development Zone program in 1984, the hope was to rely on city resources of capital, manpower, industrial foundation, and infrastructure to introduce technology that would improve the investment environment, but the empirical findings do not confirm that industrial park settings improved the urban production efficiency. However, support for knowledge-intensive and technology-intensive industrial zones with the hope of replacing traditional industries, accelerate the development and expansion of

new industries, and enhance economic development indicates that the high-tech development zone raised urban manufacturing industry production efficiency. So the second hypothesis of this investigation, "The industrial park construction has a positive impact on production efficiency of urban manufacturing industry" is partly verified.

5.2 Production efficiency of High-tech Development Zone

This study uses the DEA model to test production efficiency in 53 high-tech development zones using 4 input variables and 2 output variables. In the CCR model, 6 high-tech development zones reached production efficiency, accounting for 11.32% of total zones tested, of which 4 zones are in coastal areas and 2 inland; 47 high-tech development zones did not reach production efficiency, accounting for 88.68% of total zones tested, 13 of which are in coastal areas and 34 inland. In the BCC model, 9 high-tech development zones reached production efficiency, accounting for 16.98% of the total zones tested, 2 of which are coastal, for a total of 6 coastal zones and 3 inland zones.

The testing of returns-to-scale status demonstrated the same results as the testing in the CCR model. The six high-tech development zones are efficient. A total of 47 high-tech development zones were inefficient in scale, and a total of 11 high-tech development zones are of increasing scale, accounting for 20.75% of total zones tested; 36 high-tech development zones are of decreasing scale, accounting for 67.93 % of total zones tested (see Table 5).

The same findings were noted with Norman and Stoker's (1991) methodology. Based on the scale efficiency and changing scale technical efficiency to classify the high-tech development zone, Beijing, Guiyang, Xiamen, Shenzhen, Huizhou, and Foshan, present optimal scale efficiency, accounting for 9.43% of the region tested; Beijing is China's political center and Xiamen and Shenzhen are SEZ(Note8)cities. The policies and resources input may have received a suitable setting and control. However, 24 development zones are production inefficient, accounting for 45.28% of the total zones tested. Eighteen (18) development zones have excessively large scale, including 3 municipalities, namely, Shanghai, Tianjin and Chongqing, accounting for 33.96% of total zones tested. Five (5) development zones are excessively small scale and account for 9.43% of the total zones tested, mostly linked to small and medium-sized cities.

Of the factors affecting the efficiency of high-tech industrial development zones, the test results by the TOBIT model showed that three variables, namely R&D expenditures, employees with advanced scientific training or R&D personnel, and manufacturer's scale (employees at year-end / number of enterprises) demonstrate statistical authentication. Namely, the higher of the High-Tech Development Zone R&D expenditures, the higher the production efficiency; and the larger of manufacturer's scale, the higher the production efficiency will be. The production efficiency of high-tech development zones showed negative correlation in the initial stage of input, which indicates diseconomies of R&D personnel input scale, and with the input rising to a certain level it turns to a positive correlation (see Table 6). These results are the same as the results of past studies that showed R&D input, manufacturer's scale, and R&D personnel will affect innovation effectiveness (Acs et al, 2002; Britton, 2003; Hagedoorn and Cloodt, 2003; Hollenstein, 2003; Gu and Tang, 2004; Robertson and Langlois, 1995; Shefe and Frenkel, 1998).

However, urban scientific expenditure was used as the independent variable to explore whether or not the empirical findings that affect the urban manufacturing productivity only passed the test in the CCR model (Table 4). So the third hypothesis of this study "Innovation input affects the production efficiency of the industrial park and the city" can only be partly verified.

6. Conclusions and Suggestions

This article regards the city and industrial park as a spatial unit of economic output. Inputting various production elements applicable to a particular space supplies the features of greater input and greater output. Applying DEA and TOBIT models, the production efficiency of 221 cities and 53 high-tech development zones are tested and the impact of innovation input on production efficiency is explored.

The empirical findings show that only three provincial capital cities, Changchun, Kunming, Lanzhou, and the municipality of Chongqing have optimum scale efficiency. As to the other big cities, such as Beijing (CCR and BCC), Shanghai (CCR), and Xi'an (CCR and BCC), the production was not as efficient as initially expected. Small cities such as Jinzhong, Liancheng, Tonghua and other manufacturing production areas are not necessarily inefficient. Crucially, production efficiency calculations must consider input and output at the same time. Additionally, the technical efficiency and scale efficiency of the BCC mode can reveal that big cities with excessively large scale may result in excessive input or less efficient use of elements, leading to decreasing

returns-to-scale or production without efficiency (such as most of the provincial capital cities).

The high-tech development zones have the same production efficiency situation. In the CCR model, the zones in Beijing, Guiyang, Xiamen, Huizhou, Foshan, and Shenzhen show the greatest efficiency and the production efficiency value is 1 (Shanghai, 0.965). The production efficiency of high-tech development zones in Tianjin and Chongqing were lower than expected (CCR were only 0.335 and 0.313, and BCC was 0.496 and 0.377). However, considered from the point of view of scale efficiency, we find that in municipalities and provincial capitals, only high-tech industrial zones in Beijing and Guiyang indicate optimal production scale and zones in Tianjin and Chongqing have the same relatively large scale. The Yangling High-Tech Development Zone is the newest and its production efficiency was the lowest. Having used input to conduct the tests, policy suggestions are focused on the factors of production input. When the test results show increasing returns-to-scale, it indicates insufficient input of production elements, and policies should be implemented to enhance investment in production elements. Evidence for decreasing returns-to-scale indicates that input of production elements is excessive relative to output, and in terms of policy, the inputs of production elements should be carefully reviewed.

The production efficiency of urban manufacturing industry, as measured by the BCC model test, is affected by high-tech industrial park development but the p value only reached 10% significance level. The overall fit is not high, and enhancement of urban production efficiency via the industrial park setting was not verified. This shows that there should be other factors that influence urban production efficiency. In order to understand whether or not urban production efficiency is susceptible to production efficiencies of high-tech park zones, this study also focused on 53 cities in proximity to high-tech development zones to test for correlation between urban production efficiency and production efficiency of high-tech development zones. The Pearsonvu correlation is only 0.259 (CCR model) and 0.325 (BCC model), which shows that neither are highly correlated. Therefore, the question remains as to whether or not the industrial park development policy can rely on the parent city to establish industrial parks in order to achieve a balance between industrial demand and investment supply. The results of this study can serve as references and as evidence useful to future policymakers.

Considering the impact of innovation input on the industrial park and urban production efficiency, although the scientific research expenditure has a role as an indicator of urban innovation input, its enhancement of urban manufacturing production efficiency is not verified. The impact of three innovation input variables, including the R&D expenditures, science and technology employees, and manufacturer's scale (employees at year-end / number of enterprises) on the efficiency of high-tech development zone are all statistically valid. The higher the R&D expenditure, the greater the production efficiency of high-tech parks. And the larger the manufacturer's scale, the greater the contribution will be toward enhancing production efficiency of high-tech development zones. Diseconomies prevail at the initial stage of R&D personnel input, but as the R&D personnel input reaches a certain scale it will positively correlate with the production efficiency of high-tech parks. This indicates that future research must focus on relevant scaling. For policymakers aiming to encourage technology-intensive and knowledge-intensive industries, the results of this investigation can help administrators and planners to develop a management framework.

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Notes

Note 1. Sveikauskas (1975) used Hicks-neutral transform variables and found in each population doubling, the urban productivity would increase by 5.98%; Segal (1976) found that the city of population over 2 million in comparison with the city of population less than 2 million had urban productivity increased by 8%.

Note 2. When Shefer (1973) tested returns-to-scale in the industry, he found that most of the manufacturing industries had localized economic effects; Segal's (1976) aggregate data from using Cobb-Douglas (referred to as CD) production function testing found that the manufacturing industry has external effects, but the external economic effect in the city is not very important; Greytak and Blackley (1985), through cross-sectional data of urban manufacturing industries using CD production function to test localized economies, found that Hicks-neutral localized economy factor has relevance; and Henderson (1986) examined urban manufacturing industries of both Brazil and the United States as examples. Using the flexible production function to test the urbanized economy and the localized economy, he concluded that external economies arose from the localized economy rather than from the urbanized economy.

Note 3. Sveikauskas (1975), assuming that the industry has a constant returns-to-scale, uses urban scale as the shift variable to test the external economy of the manufacturing industry and found urbanized economy elements. Nakamura (1985) used the secondary Transcendental Logarithmic (referred to as Translog) production function to test urbanized or localized economies in Japan and found that light industry possesses traits of the urbanized economy, while heavy industry is aligned with localized economy features; Louri (1988), using the Translog production function, found the urbanized economy plays an important role in manufacturing industries in Greece.

Note 4. When China was actively promoting economic reform, in science and technology development there were so-called three levels and six projects. Six projects are "on June 5, July 5, August 5 research project", "863 project", "Spark Project", "Torch Project", "Basic Research Project" and "National Scientific and Technological Achievements Key Point Promotional Project", the six projects are closely related to industrial park development.

Note 5. "Seminar minutes on the coastal part of the city" edited by the China Development Association, "China Development Zone Events", 1984.

Note 6. In this study, production cost data are lacking, so the setting efficiency is not calculated.

Note 7. On basis of Norman and Stoker's (1991) classification on the strength of the overall efficiency value, when efficiency is calculated by either constant returns-to-scale (CRS) or variable returns-to-scale (VRS) = 1, it indicates the city realized the optimal scale efficiency. An increasing returns-to-scale status (irs) with scale efficiency (SE) of <0.9 is judged as excessive small scale; scale efficiency (SE) <0.9, and Decreasing returns-to-scale status (drs), with scale efficiency (SE) <0.9 is judged as too large; scale efficiency of $0.9 \leqq SE \leqq 1$ and technical efficiency (TEVRS) if less than 0.9, then reflects ineffective production. When the scale efficiency is $0.9 \leqq SE \leqq 1$ and technical efficiency is $0.9 \leqq TEVRS \leqq 1$, efficiency can be improved in the short-term.

Note 8. SEZ: special economic zone.

Table 1.The descriptive statistics table of prefecture-level city variables

Variables	DEA Model			TOBIT Model		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Domestic Co. GDP (RMB10 million)	2100.943	22.318	31234.651	---	---	---
HKG, Macao, Taiwan Co. GDP (RMB 10 million)	458.299	0.053	14982.538	---	---	---
Foreign Co. GDP (RMB 10 million)	743.620	0.043	34133.115	---	---	---
Average annual employees (10 thousand)	13.985	0.210	204.620	---	---	---
Fixed assets paid up (RMB 10 million)	998.397	30.066	21696.800	---	---	---
Actual spending foreign capital in a contemporary year (USD million)	217.116	0.010	5073.340	---	---	---
No. of corporate (units)	399.972	18	9760	---	---	---
High-Tech Park (Yes or no)	---	---	---	Dummy variable, 1=Yes, 0=No		
Economic Technological Development Zone (Yes or no)	---	---	---	Dummy variable, 1=Yes, 0=No		
Science Expenditure (RMB 10 thousand)	---	---	---	2077.954	0	96100

Table 2. The descriptive statistics table of High-tech Development Zone variables

Variables	DEA Model			TOBIT Model		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Industrial GDP (USD 100 million)	309.182	17.936	1236.153	---	---	---
Tax paid (RMB 100 million)	19.759	0.384	120.086	---	---	---
Accumulated completed floor area (square kilometers)	2.924	0.509	9.098	---	---	---
No. of corporate (100) units	6.199	0.460	120.300	---	---	---
Employees at year-end (1000)	74.596	8.838	488.561	---	---	---
Assets at year-end (RMB 100 million)	498.693	61.922	5243.893	---	---	---
R&D Expenditure	---	---	---	77.956	0	1286.414
Science and Technology employees (person)	---	---	---	111.204	4.520	1433.050
Science and Technology employees (square) (person)	---	---	---	495.636	0.204	20536.323
Employees at year-end (1000) / No. of corporate (100) units	---	---	---	24.476	3.715	74.402

Table 3. Empirical results of the production efficiency of urban manufacturing industry

	CCR model				BCC model				Scale				Efficiency increasing or decreasing	
	Efficient	Ratio in total ratio (%) ratio in total	Inefficient	Ratio in total ratio (%)ratio in total	Efficient	Ratio in total ratio (%)ratio in total	Inefficient	Ratio in total ratio (%)ratio in total	Efficient	Ratio in total ratio (%)ratio in total	Inefficient	Ratio in total ratio (%) ratio in total	Efficiency increasing	Efficiency decreasing
Total prefecture -level cities	31	14.03%	190	85.97%	45	20.36%	176	79.64%	32	14.48%	189	85.52%	52	137
Coastal area	6	2.71%	51	23.08%	12	5.43%	47	21.27%	6	2.71%	51	23.08%	27	26
Inland	25	11.31%	139	62.90%	33	14.93%	129	58.34%	26	11.76%	138	62.44%	25	111
Mean efficiency	0.521				0.614				0.849				---	
Standard deviation	0.262				0.261				0.183				---	
Minimum	0.132				0.173				0.196				---	
Maximum	1				1				1				---	

Table 4. TOBIT model empirical findings of production efficiency of urban manufacturing industry

Independent variables	CCR model		BCC model	
	Coefficient value	P-Value	Coefficient value	P-Value
Constant	0.624	0.000***	0.513	0.000***
High-Tech Park (Yes or no)	0.105	0.108	0.098	0.094*
Economic and Technological Development Zone (Yes or no)	-0.029	0.672	0.015	0.799
scientific expenditure	0.0000053	0.074*	-0.0000002	0.939
Fit	0.396		0.031	

Note: * indicates 10% significance level was reached; *** indicates that 1% significance level was reached.

Table 5. Empirical findings of production efficiency in High-tech Development Zones

	CCR model				BCC model				Scale				Efficiency increasing or decreasing	
	Efficient	Ratio in total ratio (%)	Inefficient	Ratio in total ratio (%)	Efficient	Ratio in total ratio (%)	Inefficient	Ratio in total ratio (%)	Efficient	Ratio in total ratio (%)	Inefficient	Ratio in total ratio (%)	Efficiency increasing	Efficiency decreasing
Total High-tech Zones	6	11.32%	47	88.68%	9	16.98%	44	83.02%	6	11.32%	47	88.68%	11	36
Coastal area	4	7.55%	13	24.53%	6	11.32%	11	20.75%	4	7.55%	13	24.53%	2	11
Inland area	2	3.77%	34	64.15%	3	5.66%	33	62.26%	2	3.77%	34	64.15%	9	25
Mean efficiency	0.504				0.593				0.859				---	
Standard Deviation	0.247				0.250				0.173				---	
Minimum	0.165				0.25				0.165				---	
Maximum	1				1				1				---	

Table 6. TOBIT model empirical findings of production efficiency of High-Tech Industrial Development Zones

BCC model

Variables	Coefficient value	P-Value
Constant	0.754	0.000***
R&D expenditure	0.026	0.000***
Science/Technology employees	-0.086	0.000***
Science and technology employees^2	0.031	0.000***
Employees at year-end / No. of corporate	0.044	0.045**
Fit	0.150	

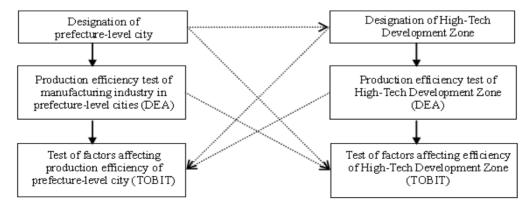Note: ** indicates 5% significance level was reached; *** indicates that 1% significance level was reached.

Figure 1. Research framework diagram