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Business Incubators in China: An Inquiry into the Variables Associated with Incubatee Success

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Abstract This paper examines the association between the outcome of business incubation and the resources used by incubators, by using a small panel of science and technology business incubators (STBIs) in China. We find that while the number of firms graduating from an STBI is closely correlated with the infrastructure as well as the human and financial resources at the STBI's disposal, the graduates' firm sizes, in terms of employment and value added, as well as their labor productivity are unrelated to such resource inputs. We also find that the educational levels of incubator managers and the financial support given to their clients have significant impacts on the number of graduates. However, the number of graduates does not increase with the scale and diversity of the cities in which their STBIs are located or with the presence of foreign ventures and universities in the locality. We do not find that university-based and government-established STBIs differ significantly in their incubation performance.

JEL M13, O31, O32, O38

Keywords Business incubators; new firms; market failures; government policy; human resources; China

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BUSINESS INCUBATORS IN CHINA: AN INQUIRY INTO THE VARIABLES ASSOCIATED WITH INCUBATEE SUCCESS

1. Introduction

There has been growing interest in business incubation and, accordingly, a significant body of research has developed in recent years (Hackett and Dilts, 2004b). It is widely recognized that new technology-oriented firms often face difficulties arising from market failure problems (e.g., Colombo and Delmastro 2002; Link and Scott 2003; Hackett and Dilts 2004a). Because markets for knowledge are imperfect, such firms can appropriate only a part of the social benefits that they generate. Their access to finance is unfavorable because of imperfections of financial markets. The prevalence of these market failures justifies government support to new technology-oriented firms.

Some kinds of government support, however, may lead to inefficient resource allocation, since they may retard the selection process by which efficient firms survive market competition while inefficient firms disappear (e.g., North, Smallbone, and Vickers 2001; Colombo and Delmastro 2002).¹ Thus, careful investigation into the effectiveness of each policy tool is called for. Notable studies in this line include Merrifield (1987), Allen (1988), Sherman and Chappell (1998), Rice (2002), Siegel et al. (2003), Link and Scott (2003), Abetti (2004), and Rothaermel and Thursby (2005). The literature, however, does not have a systematic framework yet (Phan, Siegel, and Wright 2005). We agree with Hackett and Dilts (2004b p. 74) that “we will need to unpack the variables associated with the incubation process” for the advancement in theories of business incubation.

¹ According to MacDonald (1987), Massey et al. (1992), and Bakouros et al. (2002), government policies that are intended to promote the growth of high-tech industry are “high-tech fantasies.”

This paper examines the association between the outcome of business incubation and the resources used by incubators, by using a small panel of business incubators in China. Since the outcome of incubation is multifaceted, there are a variety of measures of incubation outcome, such as the number or proportion of firms graduating from the incubator and the growth of these firms. The association between each aspect of incubation output and the resources used by the incubator as inputs is not yet established empirically in the literature. This paper explores such associations while controlling for the effects of the local community or the environment of the incubators, especially the effects of knowledge spillovers from local universities and foreign ventures as well as the impacts of urban scale and diversity. According to the literature on economic development and geography, large cities are “virtual incubators” in the sense that they nurture new businesses by generating benefits of the so-called urbanization economies (e.g., Jacobs 1969; Hernderson, Kuncoro, and Turner 1995). This is why we are concerned about the urbanization variables.

While the number of business incubators began increasing substantially across the world in the 1980s (Link and Scott 2003), it was not until 1987 that science and technology business incubators (STBIs) were established in China, according to the Torch Center under the Ministry of Science and Technology. In China, almost all the STBIs are founded and operated by local governments and universities. Since most universities are state-owned, the STBIs are almost all government-supported incubators. The managers of the STBIs are quasi government officials appointed and paid by local governments or universities. The Torch Center predicts that the total number of STBIs will reach 1,000 by 2010 and that they will nurture more than 50,000 technology-oriented start-up firms. Despite the increasing presence of STBIs in China, empirical

research has yet to be carried out to assess their performance.

This paper attempts to identify what the STBIs intend to produce as well as the determinants of the output. In the literature on the incubator-incubation phenomenon, there have been few empirical studies examining the “incubator variables associated with incubatee success” (Hackett and Dilts 2004b). We find that while the number of STBI graduates is closely correlated with the infrastructure as well as the human and financial resources used by the STBI, the firm size, in terms of employment and value added, as well as labor productivity of the graduates are unrelated to such resource inputs. We also find that the educational levels of incubator managers and the financial support given to their clients have significant impacts on the number of graduates, a point consistent with the theoretical model developed by Hackett and Dilts (2004a).

While some authors argue that those incubators with strong ties with local universities are advantageous (e.g., Mian 1996; Abetti 2004; Hackett and Dilts 2004b), our data do not show that university-based and government-established STBIs differ significantly in performance. Probably this is because we control for the effect of the human resources of STBIs, which tend to be more abundant at the university-based STBIs, and because even the government-established STBIs have some ties with local research institutions. We do not find any evidence that the number of graduates from STBIs is affected by the scale and diversity of the cities in which they are located or by the presence of foreign ventures and universities in the locality.

Section 2 describes the development of the STBIs and their institutional characteristics. Testable hypotheses are formulated in Section 3, followed by the description of the data in Section 4 and the regression analysis in Section 5. The

summary of the findings and implications for future research are contained in Section 6.

2. Business incubators in general and in China

Clients of business incubation are usually start-up firms. For a start-up firm to enter a business incubator program, it has to apply for admission. Incubators usually provide their clients with basic infrastructural support, such as shared office facilities and workshops, as well as business assistance services (Smilor, Kozmetsky, and Gibson 1988; Mian 1996). Incubators also provide technology-related support including technology transfer programs to their tenant firms (Abetti 2004). Such value-adding support is expected to enhance the performance of the tenant firms and contribute to their successful graduation.

In China, the STBIs are granted privileges by the government, such as subsidies and exemptions from corporate income tax and real estate income tax. A typical STBI occupies several floors of a publicly owned office building and provides client firms with laboratories, workshops, and shared office floors, together with subsidized telecommunication network access, at low rents. Some clients have factories outside the STBIs' premises. Including such factories, the average floor area per STBIs is 32,653 square meters as of 2006. According to our interviews with a Torch Center official, the rent can be half of the market rate or less. The STBIs also provide financial assistance and management advice to their clients. Financial assistance usually takes the form of loans, but it can be gifts of small amounts of money. It is only recently that some STBIs have begun investing in their tenant firms on a trial basis.

When the STBIs screen incoming tenant firms, attention is paid to the applicants' technologies, business plans, and market potential. Some STBIs recruit tenant firms

from various industries, while others focus on a specific industry such as information technology and biotechnology. According to our interviews with some STBI managers, the STBIs admit 20 to 70 percent of the firms applying to an incubation program.² The period of incubation is usually three years. Tenant firms may be allowed to linger on in the STBIs, but they are required to pay the market-rate rents for offices and workshops. A tenant firm is regarded as successful if it has made a profit in the last year in the incubation period and can compete with other firms in the market without receiving any subsidy. An unsuccessful firm may go into liquidation or linger on in the STBI after the three-year incubation. The probability of failure is about 20 percent in the electronics equipment industry and about 60 percent in the internet industry and the biotechnology industry, according to our respondents.

Table 1 summarizes the national statistics for the STBIs in China. Between 2002 and 2006, the number of client firms under incubation increased from 20993 to 41434, and their real value added increased from 41 billion yuan to 133 billion yuan (at the 2000 price).³ Behind such rapid growth of the STBIs has been the strong support provided by the government. The government increased the number of STBIs from 378 to 548 or by 45 percent during the period 2002 - 2006. Individual STBIs increased the average number of tenant firms from 55 to 76 or by 38 percent and their average number of graduating firms from 40 to 54 or by 35 percent. While the average employment size of individual client firms remained virtually the same, their average value added increased from 2 million yuan to 3.2 million yuan during the period.

Such rapid growth of the STBIs in China has been government-led. A question arises as to whether incubation managers are provided the right incentives to carry out

² We conducted interviews with managers at STBIs in Beijing and Qingdao in April 2007.

³ The nominal values are deflated by using the GDP deflator.

their tasks. While their performances are evaluated by local governments or universities, does such evaluation provide sufficient incentive to incubation managers? As mentioned above, some STBIs have begun investing in the equity of tenant firms on a trial basis. Such trials may be an indication that incubation managers are considered to lack sufficient work incentive. It is also unclear how the employers of incubation managers can evaluate incubation performance, which is multifaceted. According to the incentive contract literature (e.g., Milgrom and Roberts 1992; Laffont and Martimort 2002), the problem of providing incentives is complicated when the principle (such as local governments and universities) cannot be sure that the agent (such as incubation managers) allocate their time and efforts correctly among the various activities that need to be carried out. To our knowledge, there have been few empirical studies exploring these issues.

Similarly, a question arises as to the ability of incubation managers. Usually, they are not experienced in management or marketing. They are not businessmen running enterprises. As Harwit (2002) attests, their business development services may not be as good as expected. It is also questionable whether the STBIs can provide high-quality assistance to tenant firms in carrying out R&D and adopting technologies from abroad. In these respects, university-based STBIs may have advantages over government-established STBIs. The former can match job-seeking alumni and job-offering firms that have graduated from incubation. Faculty members can act as consultants. Moreover, university-based incubators can use university research facilities such as laboratories and libraries. If universities provide business incubation services more efficiently, university-based incubators should prevail and the resources should be reallocated away from government-established incubators to university-based

incubators. University-based STBIs, however, remain much fewer in number than government-based STBIs, as shown in Table 1. Siegel et al. (2003) and Rothaermel and Thursby (2005) discuss the relative efficiency of university-based incubators and the other types of incubators in the context of developed economies. While the issue of linkage between incubation and university is potentially important in China as well, there has been no attempt to study this issue empirically.

3. Hypotheses

According to the literature on management incentives and executive compensation, the behaviors of managers are strongly affected by the way in which their performances are evaluated as well as by the elasticities of the compensation with respect to their measured performances (e.g., Jensen and Murphy 1990; Murphy 1999). Empirical studies presenting evidence in favor of this theory abounds the literature, including a number of case studies of state-owned enterprises (SOEs) in China (e.g., Groves et al. 1995; Lin, Cai, and Li 1998; Liu and Otsuka 2004; Mengistae and Xu 2004). According to Kato and Long (2006), an increasing number of China's listed firms have recently linked executive compensation with the shareholder value of the firm. Since the STBIs are unlisted, however, compensation to incubator managers cannot be linked with the value of the STBIs. Another possibility is that incubators are allowed to invest in the equity of their client firms so that they have a profit motive for producing competitive graduates. As we mentioned earlier, however, such equity investments have just begun recently on a trial basis. Thus, it is likely that the behaviors of incubator managers are influenced by the way in which their performances are evaluated by their employers, i.e., local governments or universities.

The next question concerns the measure of incubator-incubation performance. STBIs are supported by the government probably because they are expected to contribute to job creation and income generation through nurturing entrepreneurship and stimulating innovation. However, the evaluators' motivation and ability to monitor incubator managers are unlikely to be high. The competitiveness of graduates is difficult to measure. The evaluators may check the average firm size and average labor productivity based on the data submitted by incubator managers. These variables, however, may be difficult to interpret because efficient firm size depends on what a firm produces and because labor productivity may reflect the capital-labor ratio and may not necessarily reflect efficiency. The evaluation of incubator-incubation performance is likely to depend on a simpler and more clear-cut indicator than these variables. The number of graduates from an incubator in a given period of time is a natural measure of the incubator's performance, even though it may not be an ideal measure.

Careful consideration should also be given to market failures. Business incubators exist at least partly because "they are able to select and nurture ventures that have a greater likelihood of failure in proportion to upside potential than either a venture capitalist, or a firm engaging in corporate venturing would be willing to select, thereby resolving market failure in the intermediate potential venture marketspace" (Hackett and Dilts 2004a, p. 43). Such weak-but-promising ventures with "a greater likelihood of failure" are unlikely to have particularly large firm sizes or high productivity. It is more likely that business incubators are interested to nurture such ventures so that they are viable (e.g., Rice and Matthews 1995). This line of argument seems to lead to the same conclusion that the number of graduates is a natural measure of incubator-incubation performance.

To translate these arguments into a testable hypothesis, we employ a function

$$y = Af(x), \tag{1}$$

where y is the output of an incubator, A is the productivity shifter, x is a vector of resource endowments of the incubator, and f is an increasing concave function. Since the output of business incubation may be multi-faceted, y in equation (1) should read a vector of outputs (y_1, y_2, \dots, y_n) , and the right-hand side should correspondingly read $(A_1f_1(x), A_2f_2(x), \dots, A_nf_n(x))$. Vector y includes possible outcomes of the incubator-incubation process, such as the number of graduating clients, firm sizes in terms of employment and value added, and productivity. On the right-hand side, vector x includes measures of the human and material resources of the incubator as well as financial inputs such as low-interest loans that the incubator provides to client firms. Human resource input may be measured by the number of incubator managers and their education levels. Material resource input may be measured by the floor area size. We will later discuss what the shifter A is.

Note that functions $f_1(x), f_2(x), \dots, f_n(x)$ share the same x and do not specify how resource endowments x are allocated to the production of y_1, y_2, \dots, y_n . This is because the allocation of x is unobservable to us. If the incubator managers are motivated to increase, say, y_1 as much as possible but not y_2 , then y_1 will increase with x whereas y_2 will not. In this case, while the elasticities of y_1 with respect to the elements of x are positive, those of y_2 are much smaller or zero. Our previous argument translates into the following hypothesis:

Hypothesis 1: The number of graduates from incubators has a greater elasticity with

respect to incubator resources than the graduates' average firm size and productivity do.

In China, many incubator managers without expertise in technology or management organize technology transfer programs and business development programs for their client firms. It is likely that the effectiveness of such incubation activities depends much on the extent that the general human capital of these incubator managers makes up for their lack of specific human capital. In this sense, it seems reasonable to hypothesize that the education level of incubator managers and their performance are positively related. Another source for the positive relationship between the education and performance of incubator managers is that highly educated persons tend to have personal networks in various fields (Simon and Warner 1992; Montgomery 1991; Saloner 1985). In the case of business incubators, personal networks may help them invite competent lecturers to their programs and introduce their clients to potential customers or sponsors.

As Colombo and Delmastro (2002) emphasize, new technology-oriented firms often face unfavorable access to finance. Banks generally lack the technical expertise required to assess the quality of a new high-technology business. New firms do not have track records on which banks may base their lending decisions. Banks may well therefore be reluctant to finance investments undertaken by new, technology-oriented firms. Financial support that business incubators lend to their clients is thus expected to be an important input for business incubation. Based on these considerations, we advance the following hypothesis:

Hypothesis 2: Among the major determinants of the number of incubation graduates are

the education level of incubator managers and the amount of financial support given to their clients.

Another possible determinant of incubation performance is the linkage between incubators and universities (e.g., Mian 1996, 1997; Siegel et al. 2003; Link and Scott, 2003; Hackett and Dilts 2004b; Rothaermel and Thursby 2005). Universities have abundant human resources and research-related infrastructure such as laboratories. Moreover, the university-incubator linkage may help incubatees receive technology transfer from universities (Siegel et al. 2003). If university-based incubators take full advantage of this linkage, they will make significant contributions to the development of incubates (Mian 1996). The question arises, however, as to whether incubators have to be founded and operated by universities. Government-established incubators and other incubators may also benefit from linkages with local universities. In the case of China, for example, a number of business incubators have some kinds of ties with local universities and research institutes even if they are not university-based. The following hypothesis may facilitate an inquiry concerning whether university-based incubators have an intrinsic advantage:

Hypothesis 3: University-based STBIs do not perform significantly better than government-established STBIs once the effects of the human and other resources of STBIs are controlled for.

4. Empirical Methodology and Data

We assume that functions f_k ($k = 1, 2, \dots, n$) have constant elasticities; i.e.,

$$y_k = A_k M^{\alpha_k} E^{\beta_k} S^{\gamma_k} F^{\delta_k} , \quad (2)$$

where M is the number of managers of the incubator, E is an indicator of their education level, S is the site area available to this incubator, and F is the funds that this incubator uses to support its clients financially. To estimate the elasticities α_k , β_k , γ_k , and δ_k , we take the logarithm on both sides of equation (2) for each output y_k ,

$$\ln y_{kit} = \ln A_{kit} + \alpha_k \ln M_{it} + \beta_k \ln E_{it} + \gamma_k \ln S_{it} + \delta_k \ln F_{it} , \quad (3)$$

where subscripts i in year t indicate incubators and years.

While y_k can represent any aspect of incubation outcomes, we focus on the number of graduates from incubator i in year t , which is denoted y_{1it} , the average employment size (i.e., the number of workers) of the graduates, which is denoted y_{2it} , and the average value added of the graduates, which is denoted y_{3it} . Note that $\ln y_{1it} + \ln y_{2it}$ is equal to the logarithm of employment created by the incubator i in year t , that $\ln y_{1it} + \ln y_{3it}$ is equal to the logarithm of value added (i.e., contribution to GDP) generated by the graduates, and that $\ln y_{3it} - \ln y_{2it}$ is equal to the logarithm of labor productivity.

Since an incubation process lasts usually for three years, output y_{kit} should correspond to the incubation activities undertaken for the last three years, $t - 2$, $t - 1$, and t . To maintain the simplicity of notation, we make the right-hand side variables M_{it} , E_{it} , S_{it} , and F_{it} denote the three-year averages instead of the values of year t alone. For

example, while y_{1it} denotes the number of graduates in year t , M_{it} denotes the average number of incubator managers in $t - 2$, $t - 1$, and t .

These right-hand side variables are admittedly endogenous because they may be affected by an unobservable third factor $\ln A_{kit}$. If we treat $\ln A_{kit}$ as a random error term and run an OLS regression, the estimates of the elasticities will be biased.⁴ To mitigate the estimation bias, we take two measures. First, we decompose $\ln A_{kit}$ into three components: a fixed effect u_i , a time-variant and common effect or the year effect λ_t , and the remaining part B_{kit} , which is time-variant and specific to incubator i ,

$$\ln A_{kit} = u_i + \lambda_t + B_{kit}. \quad (4)$$

By applying the fixed-effects model, we can eliminate the bias due to the correlation between u_i and the right-hand side variables. The effect of λ_t can be controlled for by adding year dummy variables to the controls. Note, however, that the use of the fixed-effects model is not effective if the right-hand side variables are correlated with B_{kit} .

Therefore, second, we add four controls which are time-variant, specific to incubator i , and observable to us. They are the number of teachers affiliated with local universities (UT), the stock of foreign direct investments (FDI), the non-agricultural working population (WP), and the urban industrial diversity (UID) in the city in which

⁴ One may think the right-hand side variables are endogenous because the local government or university allocates more resources to incubator i if incubator i performs better. Without such repercussion, the evaluation of performance will be meaningless. Hence repercussion is likely to exist. It may not cause serious estimation bias, however. The reaction of the local government or university to y_{kit} occurs in year $t + 1$ or later, whereas the right-hand side variables are the averages of the values taken in $t - 2$, $t - 1$, and t . Because of this difference in timing, the endogeneity problem due to repercussion may not be as serious as the problem due to a third factor.

the incubator is located. With these variables, B_{kit} in equation (4) is written as

$$B_{kit} = \phi_k \ln UT_{it} + \eta_k \ln FDI_{it} + \mu_k \ln WP_{it} + \rho_k UID_{it} + e_{kit}, \quad (5)$$

where e_{kit} is a random error. The number of local university teachers, UT , and the stock of foreign direct investment, FDI , are intended to capture knowledge spillovers from universities and foreign ventures, respectively, in the locality to the incubator and incubatees. The possibility of such spillovers from universities is pointed out by Monck et al. (1988), Colombo and Delmastro (2002) and Lindelöf and Löfsten (2003) among others. There is a substantial body of literature on spillovers from foreign ventures to domestic firms in general (e.g., Aitken and Harrison 1999; Barrell and Pain 1999; Saggi 2002; Keller 2004; Javorcik 2004), and those in China in particular (Chen, Chang, and Zhang 1995; Todo, Zhang, and Zhou 2009; Ran, Voon, and Li 2007; Hu 2007). According to Jacobs (1969), Glaeser, et al. (1992), and Henderson, Kuncoro, and Turner (1995) and many other authors, new firms, especially technology-oriented firms, will benefit from urbanization economies, which arise from the scale and diversity of urban industrial activities. In order to control for the effects of urbanization economies, we include non-agricultural working population, WP , and the urban industrial diversity index, UID , which will be defined below.

Substituting equations (4) and (5) back into equation (3), we obtain the regression equation,

$$\begin{aligned} \ln y_{kit} = & \alpha_k \ln M_{it} + \beta_k \ln E_{it} + \gamma_k \ln S_{it} + \delta_k \ln F_{it} + \phi_k \ln UT_{it} + \eta_k \ln FDI_{it} \\ & + \mu_k \ln WP_{it} + \rho_k UID_{it} + u_i + \lambda_t + e_{kit}. \end{aligned} \quad (6)$$

In order to test Hypothesis 3, we add a “university dummy,” a variable that takes value 1 if incubator i is university-based and value 0 otherwise, to the right-hand side of equation (6). Since this dummy variable is time-invariant, its coefficient cannot be estimated in the fixed-effects model specification. Thus, we attempt to use the random-effects model as well, even though the consistency of the random-effects estimate is not guaranteed.

Detailed data of the STBIs are provided by the Torch Center for the period 2002 - 2006. However, the complete data necessary for the estimation of equation (6) are available for only 62 STBIs. In this small sample, 37 STBIs are government-established and 25 are university-based. Since university-based STBIs account for only about 10 percent of the STBI population, university-based STBIs are overrepresented in this sample. Thus, we run regressions separately for the university-based STBI sample and the government-established STBI sample, and when the two samples are pooled, we use sampling weights. The data of the variables regarding the cities that host the STBIs, such as foreign direct investment and local university teachers, working population, and industrial diversity, are taken from the *Chinese Statistical Yearbook* and the *China Urban Statistical Yearbook*.

The sample means and standard deviations as well as definitions of the variables are reported in Table 2. The government-established incubators tend to produce a greater number of graduates y_1 than the university-based incubators. Both the average employment size y_2 and the value added y_3 of graduating firms are greater for the university-based incubators than for the government-established incubators. While the standard deviation of y_1 is much smaller than the mean, the standard deviations of y_2

and y_3 are as large as their means. The relatively large standard deviations of y_2 and y_3 indicate that there is no nationally common standard size of employment or value added required for graduation.

The education level of incubation managers, E , is measured here by the proportion of managers with a master's degree or higher in the STBI. Incubation funds, F , are specialized funds established by each STBI, which are required to be used exclusively for the development of tenant firms and usually take the form of low-interest loans. The main source of funds is the government, but there are also some private donations and investment. The university-based incubators tend to have higher education levels E , larger site areas S , and greater amounts of funds F than the government-established incubators.

Toward the bottom of Table 2 are the basic statistics of the city-level variables. To construct FDI stock, we use the following formula:

$$FDI_{it} = (1 - d)I_{t-1} + (1 - d)^2I_{t-2} + \dots + (1 - d)^3I_{t-n} , \quad (7)$$

where I is the annual real FDI in the host city and d is a depreciation rate. Following Ran et al. (2007), we have applied a depreciation rate of 15 percent and three-year lags ($n = 3$) to the regressions discussed in the next section. For the robustness check, we have also run regressions assuming that $d = 0.1$ and $n = 5$, and obtained results which are qualitatively the same and thus not reported in this paper.

The index of urban industrial diversity (UID) is equal to one minus the Herfindahl index in terms of the employment in two-digit industries in a city,

$$UID_{it} = 1 - \sum_{m=1}^M \left[\frac{E_{mit}}{\sum_{m=1}^M E_{mit}} \right]^2, \quad (8)$$

where E_{mit} is the three-year average of the number of workers in a two-digit industry m in the host city of incubator i in years t , $t - 1$, and $t - 2$, and M is the total number of two-digit industries which include agriculture, manufacturing, mining, public utility, wholesale and retail, real estate, construction, finance, and education. The value of UID falls between zero and one, and a greater value indicates greater diversity.

5. Estimation Results

The estimated function that explains the number of graduates from incubators (y_1) is presented in Table 3 for the entire sample period and in Tables 4 and 5 for the two overlapping periods, 2002-2004 and 2004-2006. In each of these tables, the first three columns show the fixed-effects model estimates, and the last three columns show the random-effects model estimates. Columns (i) and (iv) use the university-based STBI sample. Columns (ii) and (v) use the government-established STBI sample. Columns (iii) and (vi) use the pooled sample and include the interaction terms multiplying the university dummy by each right-hand side variable, in order to examine the differences between the two types of STBIs. These two columns report only the coefficients on the university dummy variable and the interaction terms.

The results of the Hausman specification test are shown toward the bottom of columns (iv) to (vi). In Table 3, the test results indicate that the random-effects model estimates are inconsistent. The fixed- and random-effects model estimates, however, are qualitatively similar. The coefficients of the number of incubator managers, their

education levels, site area, and the amount of funds are positive and highly significant for both university-based and government-established incubators. By contrast, the coefficients of local university teachers, FDI stock, urban labor force, and urban diversity index are insignificant for both the university-based and government-established incubators. While the two types of incubators differ in the coefficients, the differences are statistically insignificant as shown in columns (iii) and (vi). The coefficient of the university dummy, i.e., the difference in intercept, is also insignificant, as shown in column (vi). These results are highly consistent with Hypotheses 2 and 3.

The regressions reported in Tables 4 and 5 are intended to inform us as to whether there was any change in the determinants of the number of incubation graduates over time due to the introduction of equity investment by the incubators in their client firms. A major difference between the two tables is that for both types of incubators, the coefficient on the education level of the incubator managers is much smaller in Table 4 than in Table 5.⁵ Another major difference is that the variables related to urbanization economies, i.e., the urban population and the urban diversity index, have positive and significant effects on the number of graduates from government-established incubators in Table 4 but not in Table 5. Reviewing the descriptive data, we find that the government-established incubators are located not only in highly urbanized areas but also in less diversified and smaller cities, whereas the university-based incubators tend to be located in metropolitan areas. Probably because of this variation in the extent of

⁵ This is not to say that the effect of managers' high education on the number of graduates is no longer significant. On the contrary, the fixed-effect model estimate of the effect of $\ln E$ in column (ii) is significant at the 10 percent level. While the fixed-effect model estimate in column (i) is insignificant, the random-effect model estimate in column (iv) is highly significant, and the latter is consistent according to the result of the Hausman specification test.

urbanization for the government-established incubators, the urbanization variables had positive effects in the 2002-2004 sample. Regional gaps in economic development, however, have been decreasing in recent years, as the empirical studies of regional growth convergence by Wang and Ge (2004) and others attest. Such convergence may have weakened the effects of the urbanization variables of the number of graduates from the government-established incubators over time.

Despite these differences, the results shown in Tables 4 and 5 are similar to those in Table 3 in general and in two respects in particular. First, in both sample periods, the variables representing the incubator's human resources, infrastructure, and financial resources are closely and positively associated with the number of graduates, whereas the city-level variables are much less closely associated with the number of graduates. Second, in both sample periods, the university-based and government-established incubators do not differ significantly in the relationship between these resources and the number of graduates. Moreover, the coefficient on the university dummy is insignificant in each of these tables. From these similarities, it seems fair to conclude that the recent introduction of equity investment has not yet exerted any impact on the way in which incubation-incubator performance is determined.

The estimated functions that explain the average firm size of the graduates in terms of employment (y_2) and value added (y_3) are presented in Table 6. As shown toward the bottom of the table, the results of the Hausman test indicate that the random-effects model estimates are consistent in all cases. Thus, the table reports only the random-effects model estimates, which are more efficient than the fixed-effects model estimates. In this table, no regressors have significant coefficients, and some coefficients are negative. For example, the coefficient on $\ln M$ is negative in columns

(i) and (ii). Note that the elasticity of the total employment of the graduates with respect to M is given by the sum of the coefficients on $\ln M$ in column (i) or (ii) in Table 6 and the corresponding column (i) or (ii) in Table 3, since the logarithm of the total employment is given by $\ln y_1 + \ln y_2$. While the coefficient in Table 3 is positive and significant, the one in Table 6 is negative, and their sum is positive but insignificant.

Similar results are obtained for the relationship between the total employment ($\ln y_1 + \ln y_2$) and the education level of incubator managers ($\ln E$) and for the relationship between the total value added of the graduates ($\ln y_1 + \ln y_3$) and the number of incubator managers ($\ln M$). Although not reported in Table 6, we estimated the function explaining labor productivity ($\ln y_3 - \ln y_2$) as well. The estimated coefficient on each regressor is equal to the corresponding coefficient in column (iii) minus that in column (i) for the university-based incubators, and the coefficient in column (iv) minus that in column (ii) for the government-established incubators. The estimation result is that none of these differences is significant.

These results stand in stark contrast to the results concerning the number of graduates as shown in Tables 3 to 5, in which the resource variables, i.e., $\ln M$, $\ln E$, $\ln S$, and $\ln F$, have positive and highly significant coefficients. This contrast lends strong support to Hypothesis 1 and suggests that while the incubators focus their attention on increasing the number of graduates to the limit of their resources rather than on improving the quality of the graduates in terms of employment size, value added, and productivity.

6. Conclusions

This paper has examined the association between some possible indicators of incubatee

success and the resources used by incubators. A major finding is that the number of graduates from an incubator is closely associated with the human resources, infrastructure, and financial resources of the incubator, whereas the average employment size and value added of the graduates are not as closely related with these resources of the incubator. The second half of this finding, however, may be attributed to the small size of our sample. Our results warrant a considerable compilation of similar studies in China and in other countries.

The estimation results also indicate that there are no significant differences between university-based incubators and government-established incubators. A possible interpretation of this finding is that while the linkage between incubators with research institutes may be important, it does not follow that universities provide more efficient incubation service than local governments. Further investigation is called for if the source of advantage of university-based incubators over government-established or other types of incubators is to be identified.

There is growing interest in the business incubator-incubation phenomenon. For example, researchers working on industrial development in developing countries are curious about what the role incubators play in a nascent industry (e.g., Sonobe and Otsuka 2006). Schmitz (2000) and Sonobe, Hu, and Otsuka (2002), for example, argue that traders coming from urban areas serve as virtual incubators for the development of rural industries. They also argue, while referring to the special economics literature, that large cities may be virtual incubators because new firms and industries tend to emerge there. This paper, however, has found no indication that incubators or their clients benefit from urbanization economies or from knowledge spillovers from foreign ventures. These results also call for further investigation.

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Table 1
Growth of Science and Technology Business Incubators, 2002-2006

	2002	2003	2004	2005	2006
Total number of STBIs	378	431	464	534	548
Total number of university-based STBIs	40	42	46	49	62
Total number of tenant firms (1,000 firms)	21.0	27.3	33.2	39.5	41.4
Total number of tenant firms that graduated	2,213	2,774	2,737	4,097	4,081
Total real value added of tenant firms (billion yuan)	41.6	57.0	66.8	102.7	133.3
Total No. of employees in tenant firms (1,000 persons)	363.4	482.5	552.4	717.3	792.6
Number of tenant firms per STBI	55	63	72	74	76
Number of tenant firm employees per STBI	6608	7659	7672	9693	10429
Number of employees per tenant firm	17	18	17	18	19
Number of graduates per STBI	40	44	38	55	54
Real value added per STBI (million yuan)	110.0	132.3	144.0	192.4	243.2
Real value added per tenant firm (million yuan)	2.0	2.1	2.0	2.6	3.2

Source: *The Annual Statistics Report of the Torch Center, 2002 – 2007.*

Note: Real value added is calculated

Table 2
Definitions and Basic Statistics, 2002-2006

Variable	Definition	Type	Mean	S.D.
y_{1it}	Number of graduates from incubator i in year t	Univ.	11	4.0
		Gov.	19	12.6
y_{2it}	Average employment size of graduates from incubator i in year t	Univ.	73	71.5
		Gov.	64	58.4
y_{3it}	Average value added generated by graduates from incubator i in year t (million yuan)	Univ.	9.1	13.3
		Gov.	6.9	6.2
M_{it}	Three-year average number of managers of incubator i in years t , $t-1$, and $t-2$	Univ.	30.0	21.1
		Gov.	21.4	11.5
E_{it}	Three-year average of the ratio of managers with master's degrees	Univ.	0.25	0.12
		Gov.	0.15	0.08
S_{it}	Three-year average of site area (10,000 square meters)	Univ.	6.2	6.3
		Gov.	5.8	5.7
F_{it}	Three-year average of incubation funds used to financial support to client firms (million yuan)	Univ.	2.9	6.9
		Gov.	2.3	4.8
UT_{it}	Three-year average of the number of university teachers in the host city (1,000 person)	Univ.	23.3	13.4
		Gov.	13.2	11.9
FDI_{it}	FDI stock of the host city (million yuan)	Univ.	181	177
		Gov.	141	157
WP_{it}	Three-year average of non-agricultural working population in the host city (million persons)	Univ.	2.1	4.6
		Gov.	2.3	7.8
UID_{it}	Three-year average of urban industrial diversity index	Univ.	0.84	0.04
		Gov.	0.78	0.10

Source: *The Annual Report of the Torch Center*, 2002-2007, the *Chinese Statistical Yearbook*, and the *China Urban Statistical Yearbook*, various years.

Table 3
Estimated function explaining the number of graduates (y_1), 2002-2006

	Fixed-effects model			Random-effects model		
	University	Government	Interaction terms in pooled data	University	Government	Interaction terms in pooled data
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
$\ln M$	0.35** (2.39)	0.27*** (3.30)	0.08 (0.46)	0.23** (2.11)	0.24*** (3.06)	-0.01 (-0.02)
$\ln E$	0.18** (2.14)	0.21*** (4.38)	-0.03 (-0.47)	0.26*** (3.51)	0.20** (4.29)	0.06 (0.67)
$\ln S$	0.25** (2.25)	0.19*** (3.76)	0.06 (0.51)	0.14* (1.92)	0.21*** (4.23)	-0.07 (-0.73)
$\ln F$	0.16*** (2.88)	0.23*** (5.47)	-0.07 (-1.00)	0.11** (2.24)	0.21*** (5.19)	-0.10 (-1.53)
$\ln UT$	0.39 (1.36)	0.18 (0.86)	0.21 (1.02)	0.03 (0.38)	0.01 (0.17)	0.02 (0.14)
$\ln FDI$	0.04 (0.59)	0.06 (1.43)	-0.02 (-0.28)	0.02 (0.43)	0.03 (0.87)	-0.01 (-0.15)
$\ln WP$	-0.04 (-0.29)	-0.19 (-1.00)	0.15 (0.62)	-0.01 (-0.12)	0.08 (0.70)	-0.09 (-0.59)
UID	0.09 (0.06)	0.86 (1.52)	-0.77 (-0.55)	0.07 (-0.26)	0.55 (1.13)	-0.48 (-0.57)
University dummy						2.22 (0.93)
Hausman test				Chi2 (12) = 21.24**	Chi2(12) = 46.83***	Chi2 (24) = 40.56***
Sample size	125	185	310	125	185	310

The dependent variable is $\ln y_1$. Five year dummies and an intercept are included in the regression. Their coefficients are not reported in this table but provided upon request. Columns (iii) and (vi) report the estimated coefficients on the interaction of the *UNI* dummy and each regressor. Numbers in parentheses are t statistics in the fixed-effects models and z statistics in the random-effects models. *, **, and *** indicate the 10 percent, 5 percent, and 1 percent significance levels, respectively.

Table 4
Estimated function explaining the number of graduates (y_1), 2002-2004

	Fixed-effects model			Random-effects model		
	University	Government	Interaction terms in pooled data	University	Government	Interaction terms in pooled data
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
$\ln M$	0.38* (1.71)	0.27*** (2.68)	0.11 (0.79)	0.20* (1.65)	0.26*** (2.70)	-0.05 (-0.30)
$\ln E$	0.50*** (3.53)	0.29*** (4.91)	0.21 (1.49)	0.41*** (4.13)	0.26*** (4.53)	0.15 (1.38)
$\ln S$	0.38** (2.65)	0.38*** (4.50)	0.01 (0.08)	0.16* (1.74)	0.32*** (4.35)	-0.16 (-1.41)
$\ln F$	0.20*** (2.78)	0.32*** (4.45)	-0.12 (-1.04)	0.14** (1.99)	0.28*** (4.29)	-0.14 (-1.53)
$\ln UT$	-0.38 (-0.53)	-0.27 (-1.45)	-0.11 (-0.32)	-0.06 (-0.45)	-0.22 (-1.05)	0.15 (0.88)
$\ln FDI$	0.07 (0.56)	-0.05 (-0.84)	0.13 (0.98)	0.01 (0.14)	-0.06 (-1.18)	0.07 (0.82)
$\ln WP$	0.01 (0.06)	0.68* (1.96)	-0.67 (-1.61)	0.03 (0.17)	0.46*** (3.19)	-0.43** (-2.07)
UID	-0.08 (-0.05)	1.17* (1.70)	-1.25 (-0.92)	0.43 (0.36)	0.90 (1.56)	-0.47 (-0.55)
University dummy						1.22 (0.42)
Hausman test				Chi2 (10) = 9.28	Chi2 (10) = 20.21**	Chi2 (20) = 47.13***
Sample size	75	111	186	75	111	186

The dependent variable is $\ln y_1$. Two year dummies and an intercept are included in the regression. Their coefficients are not reported in this table but provided upon request. Columns (iii) and (vi) report the estimated coefficients on the interaction of the *UNI* dummy and each regressor. Numbers in parentheses are t statistics in the fixed-effects models and z statistics in the random-effects models. *, **, and *** indicate the 10 percent, 5 percent, and 1 percent significance levels, respectively.

Table 5
Estimated function explaining the number of graduates (y_1), 2004-2006

	Fixed-effects model			Random-effects model		
	University	Government	Interaction terms in pooled data	University	Government	Interaction terms in pooled data
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
$\ln M$	0.27** (2.36)	0.25** (2.06)	0.02 (0.06)	0.24** (2.01)	0.19* (1.68)	0.05 (0.24)
$\ln E$	0.11 (0.89)	0.16* (1.91)	-0.05 (-0.33)	0.25*** (2.93)	0.12 (1.56)	0.13 (1.13)
$\ln S$	0.21** (2.03)	0.15* (1.90)	0.06 (0.51)	0.16* (1.71)	0.13* (1.76)	0.04 (0.31)
$\ln F$	0.18* (1.86)	0.25*** (4.08)	-0.07 (-1.00)	0.15* (1.72)	0.21*** (3.73)	-0.06 (-0.93)
$\ln UT$	0.56 (1.05)	0.02 (0.13)	0.54 (1.03)	0.06 (0.40)	0.02 (0.18)	0.04 (0.43)
$\ln FDI$	0.07 (0.67)	0.09 (1.05)	-0.01 (-0.09)	0.04 (0.67)	-0.00 (-0.02)	0.05 (0.76)
$\ln WP$	-0.19 (-0.68)	-0.41 (-1.41)	0.22 (0.68)	-0.05 (-0.34)	0.10 (0.68)	-0.15 (-0.48)
UID	-1.14 (-0.34)	0.40 (0.31)	-1.54 (-0.45)	0.71 (0.44)	0.04 (0.05)	0.66 (0.35)
University dummy						3.36 (1.06)
Hausman test				Chi2 (10) = 7.76	Chi2 (10) = 22.21**	Chi2 (20) = 26.49***
Sample size	75	111	186	75	111	186

The dependent variable is $\ln y_1$. Two year dummies and an intercept are included in the regression. Their coefficients are not reported in this table but provided upon request. Columns (iii) and (vi) report the estimated coefficients on the interaction of the *UNI* dummy and each regressor. Numbers in parentheses are t statistics in the fixed-effects models and z statistics in the random-effects models. *, **, and *** indicate the 10 percent, 5 percent, and 1 percent significance levels, respectively.

Table 6
Estimated random-effects models for the functions explaining employment size (y_2) and value added (y_3) of graduates, 2002-2006

	$\ln y_2$		$\ln y_3$	
	University	Government	University	Government
	(i)	(ii)	(iii)	(iv)
$\ln M$	-0.17 (-1.05)	-0.14 (-1.25)	-0.22 (-1.54)	-0.13 (-1.17)
$\ln E$	-0.12 (-1.25)	-0.08 (-1.16)	0.02 (0.18)	-0.07 (-1.00)
$\ln S$	0.18 (1.41)	-0.04 (-0.52)	0.05 (0.44)	-0.00 (-0.06)
$\ln F$	0.06 (0.73)	0.05 (0.64)	0.04 (0.49)	-0.05 (-0.88)
$\ln UT$	0.17 (1.01)	-0.14 (-1.38)	0.20 (1.23)	-0.08 (-0.78)
$\ln FDI$	-0.10 (-1.15)	-0.05 (-0.84)	0.01 (0.11)	0.04 (0.66)
$\ln WP$	-0.04 (-0.23)	0.15 (1.07)	-0.00 (-0.02)	-0.08 (-0.59)
UID	-2.30 (-1.31)	0.86 (1.26)	-1.02 (-0.61)	-0.24 (-0.35)
Hausman test	Chi2 (12) = 9.03	Chi2 (12) = 15.91	Chi2 (12) = 7.38	Chi2 (12) = 13.97
Sample size	125	185	125	185

Five year dummies and an intercept are included in the regression. Their coefficients are not reported in this table but provided upon request. Numbers in parentheses are z statistics. *, **, and *** indicate the 10 percent, 5 percent, and 1 percent significance levels, respectively.

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