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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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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: 74) that "we will need to unpack the variables associated with the incubation process" to achieve advancement in theories of business incubation.

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

[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."

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; Henderson, 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 1,500 by 2015 and that they will nurture more than 100,000 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 the 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

The 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 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 space, 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 also be in the form of 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). While their average number of graduating firms remained relatively stable, around 6-8 per STBI per year, the average employment size of individual client firms also remained virtually the same, and their average value added increased from 2 million yuan to 3.2 million yuan during the period.

We will explore various factors associated with such a rapid growth of the STBIs in China, including increases in the input of resources to incubation activities, changes in the environment surrounding STBIs, and efficiency improvements in incubation activities. We are also interested in the question of how the performance of incubators can be measured. In practice, the number of firms graduating successfully from the incubation program is often used as a measure of incubation performance. We will investigate whether this measure is appropriate in the context of the STBIs in China. This paper also attempts to address the issue of the linkage between incubation and universities. STBIs are

[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.

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	6	6	6	8	7
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

supposed to assist tenant firms in carrying out R&D and in adopting technologies from abroad. In this respect, university-based STBIs may have an advantage over government-established STBIs. The former can match job-seeking alumni and job-offering firms that have graduated from incubation. In addition, 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 the linkage between incubation and universities is potentially important in China as well, there has been no attempt to study this issue empirically.

3 Factors Contributing to the Good Performance of STBIs

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 market space" (Hackett and Dilts 2004a: 43). In China, such a market failure problem is by no means less serious than in developed countries and, hence, it seems reasonable to assume that STBIs endeavor to correct such a market failure. More specifically, STBIs would target ventures that would not be viable without incubation services but that have the potential ability to compete with other firms in the market after receiving incubation services, and STBIs would be interested in nurturing as many such ventures as possible, as argued by Rice and Matthews (1995) among others. In what follows, we explore the factors associated with incubation performance measured by the number of successful graduates and then consider the relevance of this performance measure.

We begin by considering the major inputs to incubation, namely the services provided by incubation managers and the basic infrastructural support, such as the provision of offices and workshops. The quantitative aspects of these inputs may be captured by the number of incubation managers, which is denoted by M in Table 2 and the subsequent tables reporting the results of the regression analyses below, and by the site area, denoted by S. The effectiveness of the services provided by incubation managers, however, will not be determined by the number of managers alone. For example, the number of successful graduates will heavily depend on whether incubation managers can select ventures with high potential as tenant firms and on whether the managers can provide high-quality training and assistance to tenant firms. In China, however, few incubation managers are experts in engineering, marketing, or management, and few have distinguished careers at private of foreign firms. Harwit (2002) suspects that STBIs' business development services and technical assistance to tenant firms are not as good as expected. In other words, the incubation managers are poorly endowed with specific human capital. It is then likely that the effectiveness of their incubation activities depends on the extent to which the general human capital of these incubator managers makes up for their lack of specific human capital.

Our measure of the general human capital of an STBI is the proportion of incubation managers who have at least a master's degree. The number of successful graduates from an STBI is expected to be positively associated with this variable, denoted E. Moreover, the positive association between E and incubation performance may be strengthened by a side effect of education. To the extent that highly educated persons tend to have personal networks in various fields (Simon and Warner 1992; Montgomery 1991; Saloner 1985), STBIs with highly educated incubation managers will have an advantage in inviting competent lecturers to their programs and introducing their tenant firms to potential customers or sponsors.

Colombo and Delmastro (2002) emphasize that 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. The financial support that business incubators provide to their tenant firms is thus expected to be an important input for business incubation. Consistent with this expectation, every STBI establishes incubation funds, 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 such funds is the government, but there are also some private donations and investment. The amount of incubation funds established by an STBI is denoted F. Although STBIs have recently been allowed to invest in the equity of their client firms, financial assistance usually takes the form of incubation funds. We expect a positive association between the performance of an STBI and F.

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	Univ.	73	71.5
	incubator *i* in year *t*	Gov.	64	58.4
y_{3it}	Average value added generated by graduates	Univ.	9.1	13.3
	from incubator *i* in year *t* (million yuan)	Gov.	6.9	6.2
M_{it}	Three-year average number of managers of	Univ.	30.0	21.1
	incubator *i* in years *t*, *t*-1, and *t*-2	Gov.	21.4	11.5
E_{it}	Three-year average of the ratio of managers	Univ.	0.25	0.12
	with master's degrees	Gov.	0.15	0.08
S_{it}	Three-year average of site area (10,000 square	Univ.	6.2	6.3
	meters)	Gov.	5.8	5.7
F_{it}	Three-year average of incubation funds used to	Univ.	2.9	6.9
	financial support to client firms (million yuan)	Gov.	2.3	4.8
UT_{it}	Three-year average of the number of university	Univ.	23.3	13.4
	teachers in the host city (1,000 person)	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	Univ.	2.1	4.6
	population in the host city (million persons)	Gov.	2.3	7.8
UID_{it}	Three-year average of urban industrial diversity	Univ.	0.84	0.04
	index	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.

We have so far discussed factors within STBIs. We turn now to the environment surrounding STBIs, which may affect incubation performance. One such environmental factor may be foreign direct investments (FDIs) that have flowed into the neighborhood of an STBI. Learning from foreign ventures can be an important channel of technology transfer to incubators and incubatees. Indeed, a number of empirical studies have been conducted regarding knowledge spillovers from foreign ventures to domestic firms in general (e.g., Aitken and Harrison 1999; Barrel and Pain 1999; Saggi 2002; Keller 2004; Javorcik 2004), and to those in China in particular (Chen, Chang, and Zhang 1995; Todo, Zhang, and Zhou 2009; Ran, Voon, and Li 2007; Hu 2007). In view of this substantial body of literature, knowledge spillovers from foreign ventures to STBIs are worthy of consideration. Sources of knowledge spillovers, however, may not be limited to FDIs. Monck et al. (1988), Colombo and Delmastro (2002), and Lindelöf and Löfsten (2003) point out the importance of knowledge spillovers from universities to science parks in the UK, Italy, and Sweden, respectively. To capture knowledge spillovers from FDIs and universities, we use the stock of foreign direct investments, FDI, and the number of university teachers, UT, in the locality of each STBI. The details of these variables are explained in the next section.

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 other words, STBIs' tenant firms and graduate firms may profit from the cross-fertilization of ideas with other firms in different industries as well as the division of labor among firms located in the same city. We use the non-agricultural working population, *WP*, in order to control for the effect of the scale of urban industrial activities. We use the urban industrial diversity index, *UID*, which will be defined in the next section, in order to control for the effect of the diversity of urban industrial activities.

Detailed data on these factors are available from the Torch Center for the five years from 2002 to 2006. We are interested in whether these factors are positively linked with the number of successful graduates as we expect and how important each factor is. These questions are addressed by estimating a function explaining the number of successful graduates in terms of the observable factors. In so doing, it is desirable to control for the effects of unobservable factors as much as possible. For this purpose, we take advantage of the availability of panel data covering five years.

$$\begin{aligned}\ln y_{1it} = {} & \alpha \ln M_{it} + \beta \ln E_{it} + \gamma \ln S_{it} + \delta \ln F_{it} + \phi \ln UT_{it} + \eta \ln FDI_{it} \\ & + \mu \ln WP_{it} + \rho UID_{it} + u_i + \lambda_t + e_{it} . \qquad (1)\end{aligned}$$

where subscript i and t indicate an incubator and a year, respectively, y_1 is the number of firms that has successfully graduated from incubator i in year t, u_i is the time-invariant effect of an unobservable factor specific to incubator *i*, λ_t is a year effect common to all incubators, and e_{it} is a random error. We transform the data of the observable variables into logarithmic form in order to facilitate the discussion of the relative importance of the right-hand side variables.

Since an incubation process lasts usually for three years, y_{1it} should correspond to the incubation activities undertaken for the three years, *t*–2, *t*–1, and *t*. To maintain the simplicity of notation, we make each of the right-hand side variables denote the three-year averages instead of the values of year *t* alone. For example, M_{it} denotes the average number of incubator managers at incubator *i* in *t*–2, *t*–1, and *t*. In relation to this, it is worth noting that the endogeneity of the right-hand side variables is unlikely to be serious. It is true that causality runs from incubation performance to incubation inputs, as well as in the opposite direction, because incubation performance is evaluated by incubators and their regulators such as the local government and universities in order to adjust incubation inputs. Since such a reaction to the performance recognized in year *t* will occur later than year *t*, however, it will not affect our right-hand side variables, which are the averages over *t*–2, *t*–1, and *t*.

As mentioned earlier, a number of studies suggest the importance of the linkage between incubators and universities as a determinant of incubation performance (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 tenant firms receive technology transfer from universities (Siegel et al. 2003). In regression equation (1), the difference in performance between university-based STBIs and local government-based STBIs may appear in three ways. First, the two types of STBIs may differ in the observable variables, namely the variables representing the quantitative and qualitative aspects of incubation inputs and the environmental factors. Such differences can be seen from Table 2, which reports the means of the explanatory variables by incubator type. Second, the two types of STBIs may differ in unobservable factors. Suppose, for example, that university-based STBIs have an advantage over government-established STBIs in terms of access to university libraries and laboratories. Since such a difference is not captured by the explanatory variables, its effect on y_1 will be absorbed by the individual effect u_i. Third, the importance of an explanatory variable as a determinant of y_1 may be different for different types of STBIs. Such a difference will appear as a difference in the coefficient on the explanatory variable. Our approach to estimating the second and third differences will be discussed in the next section.

While we have implicitly assumed that the number of graduates is a natural measure of incubation performance, we should consider the possibility that incubation managers simply pick "winners" or firms that would be capable of meeting market competition even without incubation, so that the incubation program can produce a large number of graduates. In other words, the number of graduates can be a misleading measure of incubation performance to the extent that the selection and entry of ventures into the incubation program is not a random treatment. The non-random selection of tenant firms is not necessarily meaningless since it is a waste of resources to try to nurture hopeless ventures. The selection bias, however, may be excessive, especially when incubation managers' salaries are closely linked with the number of graduates. Ideally, their salaries should be linked with the purely additional effect of their incubation services. The evaluation of such an effect would involve counterfactual comparison, namely a count of the tenant firms that are graduating successfully but that would not become competitive in the market without receiving incubation services. Since such evaluation is difficult in practice, incubation managers may be given too strong incentives to increase the number of graduates, on the one hand. On the other hand, highly promising ventures may be uninterested in the incubation program or too large to be accommodated in incubation facilities and, hence, the selection bias toward capable ventures may not be very strong.

To what extent the selection bias is serious is an empirical question. Unfortunately, the data of tenant firms at the time of their entry into the incubation program are not available. The available data on tenant firms are limited to the mean values, aggregated up to the STBI level, of employment size (denoted y_2), value added (y_3), and labor productivity (y_3/y_2) at the time of their graduation. To make good use of these pieces of information, we propose to estimate functions that explain these variables in terms of the explanatory variables on the right-hand side of equation (1). Suppose that STBIs try to increase the number of graduates by biasing the selection of incoming ventures rather than by developing the capability of the ventures. In this case, an STBI has a large number of graduates because it has selected tenant firms with high growth potential, and an STBI has a small number of graduates because it has failed to select such tenant firms. Thus, in this case, the explanatory variables that have positive coefficients in equation (1) are expected to have positive coefficients in the equations explaining y_2, y_3, and y_3/y_2 as well. If the explanatory variables do not have significant coefficients in the former equations, the resources of STBIs may be used to nurture less capable tenant firms rather than for biased selection. We should add hastily that this is not the only possible interpretation and that this estimation exercise will not offer any definitive evidence. Nonetheless, the exercise will allow us to be more specific about the selection bias.

4 Data

We use the STBI data provided by the Torch Center for the period 2002-2006. The complete data necessary for the estimation of equation (6) are available for 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. Mainly for this reason, 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. As mentioned in the previous section, we suspect that these two types of STBIs have different coefficients in equation (1). This is another reason why we estimate equation (1) using the separate samples.

The sample means and standard deviations as well as the 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 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.

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 basic statistics of the city-level variables are presented toward the bottom of Table 2. The FDI stock is constructed based on the following formula:

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

where I is the annual real FDI in the host city and d is the 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,

$$UID_{it} = 1 - \sum_{m=1}^{M} \left[\frac{E_{mit}}{\sum_{m=1}^{M} E_{mit}} \right]^2, \tag{3}$$

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.

If the efficiency of incubation is improved by STBIs, the efficiency improvement will be captured by λ_t in equation (1) to the extent that the improvement is common to STBIs. The value of λ_t is estimated as the coefficients of four dummy variables representing year 2003 to year 2006 with year 2002 being the standard.

To examine possible differences between the two types of STBIs, we use a dummy variable that is equal to 1 if incubator *i* is a university-based STBI and 0 if it is a government-established STBI, which is referred to as the university dummy. The university dummy is included in equation (1) to capture the advantage of the university-based STBIs over the government-established STBIs that cannot be attributed to observable factors. Note, however, that such an effect cannot be estimated if the individual effect u_i in equation (1) is not a random effect but a fixed effect. We will also attempt to capture the difference between the two types of STBIs in the coefficients on the explanatory variables in equation (1). For this purpose, we add to equation (1) the interaction terms or the products of the university dummy and the explanatory variables such as *M* and *E*.

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. The intention behind splitting the period into two sub-periods is to see whether the determinants of the number of incubation graduates changed over time due to the introduction of equity investment by the incubators in their tenant firms or due to some other changes in the policies related to STBIs and in the environments surrounding the STBIs.

In each of these tables, the first three columns show the estimates of the fixed-effects model, and the last three columns show the estimates of the random-effects model. Whether the latter estimates are consistent is indicated by the results of the Hausman specification test shown toward the bottom of columns (iv) to (vi). Columns (i) and (iv) use the university-based STBI sample, while columns (ii) and (v) use the government-established STBI sample. Columns (iii) and (vi) use the pooled sample and report the coefficients on 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.

In Table 3, while the results of the Hausman specification test indicate that the random-effects model estimates are inconsistent, the two specifications yield the same qualitative results. That is, the estimated coefficients on the number of incubation managers, their education levels, site area, and the amount of funds are positive and highly significant for both university-based and government-established incubators, whereas the coefficients on the environmental variables, namely the number of local university teachers, FDI stock, urban labor force, and urban diversity index are insignificant for both the university-based and government-established incubators. These results indicate that the factors within STBIs, namely the inputs of human resources, land, and financial capital are far more important as determinants of incubation performance than the environmental factors or the characteristics of the location of the incubation program. In columns (i), (ii), (iv), and (v), the coefficients on the number of managers and their education are greater than the coefficients on the land and financial support, even though the difference is not statistically significant. Such a difference suggests that the input of human resources plays a particularly important role in incubation.

As shown in column (vi), the coefficient of the university dummy is statistically insignificant, which indicates that the university-based STBIs are not at an advantage, given the observable factors. The differences in the coefficients between the two types of incubators are also insignificant, as shown in columns (iii) and (vi). Thus, if the university-based STBIs and the government-established STBIs differ in performance, the reason lies primarily in the difference between them in observable variables, particularly the fairly large difference in the number of incubation managers with high education, as shown in Table 2. The coefficients on the year dummy variables are not significant, which indicates that there was no progress in the efficiency in incubation activities among the STBIs.

Turning to Tables 4 and 5, a major difference between them is that for both types of incubators, the estimated coefficient on the incubation managers' education level is clearly smaller in Table 4 than in Table 5. Although the coefficients on some other variables are also smaller in Table 4, the differences are not as large as the difference in the coefficient on the education variable. A possible explanation for this reduced importance of the quality of the human resource input is that incubation activities became standardized over time so that the ability to deal with new phenomena, which may be enhanced by education according to Schulz (1975), became less important.

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)
LnFDI	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)
Y2003	0.08 (0.04)	0.09 (0.06)	-0.01 (0.04)	0.01 (-0.01)	0.04 (0.07)	-0.03 (-0.08)
Y2004	0.02 (0.06)	0.04 (0.13)	-0.02 (-0.04)	0.02 (-0.02)	0.06 (0.17)	-0.04 (-0.15)
Y2005	0.07 (0.13)	0.04 (0.15)	0.03 (0.05)	0.07 (0.03)	0.08 (0.23)	-0.01 (-0.09)
Y2006	0.13 (0.10)	0.06 (0.09)	0.07 (0.51)	0.09 (0.07)	0.05 (0.13)	0.04 (0.27)
University dummy						2.22 (0.93)
Hausman Test	F(12, 112) = 28.41**	F(12, 172) =31.81***	F(24,285)=30.02***	Chi2 (12) = 18.65**	Chi2 (12) = 14.96**	Chi2(24) =17.01**
Wald Tests	0.69	0.61	0.64	0.57	0.49	0.53
Adj R-squared	0.69	0.61		0.57	0.49	
Sample size	125	185	310	125	185	310

The dependent variable is lny_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.

Another major difference between Tables 4 and 5 is that the variables related to urbanization economies, namely 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 the greater variation in the extent of urbanization for the government-established incubators explains why the urbanization variables have significant coefficients in their 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 environmental 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. Third, there is no discernible progress in the efficiency in incubation, as the insignificant coefficients on the year dummies indicate.

The estimated functions that explain the logarithm of employment size (ln_{y2}) and the logarithm of value added (y_3) of the firms graduating from the incubation programs are presented in Table 6. We also estimated a similar function explaining the logarithm of labor productivity ($ln_{y3} - ln_{y2}$) and obtained estimation results similar to those for y_2 and y_3; that is, no explanatory variables had significant coefficients. 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.

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)
lnFDI	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)
Y2003	0.07 (0.04)	0.09 (0.06)	-0.01 (0.03)	0.01 (-0.03)	0.04 (0.08)	-0.03 (-0.07)
Y2004	0.02 (0.05)	0.04 (0.12)	-0.02 (-0.06)	0.02 (-0.03)	0.06 (0.19)	-0.04 (-0.14)
University dummy						1.22 (0.42)
Hausman Test				Chi2 (10) = 9.28	Chi2 (10) = 20.21**	Chi2 (20) =47.13***
Wald Tests	F(10, 64) =22.11**	F(10, 100) =27.53***	F(20, 165) =24.32**	Chi2 (10) = 16.49**	Chi2 (10) =17.04**	Chi2(20) =16.87**
Adj R-squared	0.62	0.66	0.63	0.54	0.48	0.51
Sample size	75	111	186	75	111	186

The dependent variable is lny1. 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		
	Universit y	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)
LnFDI	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)
Y2005	0.05 (0.08)	0.03 (0.09)	0.02 (0.05)	0.06 (0.07)	0.08 (0.33)	-0.02 (-0.11)
Y2006	0.10 (0.12)	0.07 (0.09)	0.03 (0.33)	0.08 (0.17)	0.06 (0.23)	0.02 (0.07)
Universit y dummy						3.36 (1.06)
Hausman Test				Chi2 (10) =7.76	Chi2 (10) =22.21**	Chi2 (20) =26.49***
Wald Test	F(10, 64) =29.01**	F(10, 100) =37.42***	F(20, 165) =34.12***	Chi2 (10) =19.04**	Chi2 (10) =13.89**	Chi2(20) =15.21**
Adj R-squared	0.72	0.57	0.63	0.59	0.51	0.54
Sample size	75	111	186	75	111	186

The dependent variable is lny_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.

Although not reported in Table 6, we estimated the function explaining the logarithm of labor productivity ($ln_{y3} - ln_{y2}$) as well. The estimated coefficient on each explanatory variable 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.

If the incubators use their resources only to attract a large number of ventures with high growth potential rather than to provide truly effective incubation services, the variables associated closely with the number of graduates would have positive and significant coefficients in the equations explaining employment size, value added, and labor productivity. However, the results shown in Table 6 stand in stark contrast to the results shown in Tables 3 to 5, in which the resource variables concern the number of graduates. These results are more consistent with the view that while there may be the tendency of picking winners, the incubators allocate their resources more to relatively incapable tenant firms to develop their capabilities to the level of successful graduation. If this is the case, the number of graduates of STBIs will be correlated with the resources of STBIs but the size and productivity of the graduates from STBIs will not. It is also possible that the incubators had not been given strong incentive to increase the size and productivity of the graduates until some incubators were recently allowed to invest in their tenant firms.

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)
lnFDI	-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)
Y2003	0.02 (0.07)	0.01 (0.04)	0.05 (0.05)	0.02 (0.06)
Y2004	0.05 (0.07)	0.01 (0.05)	0.09 (0.07)	0.06 (0.13)
Y2005	0.02 (0.03)	0.08 (0.06)	0.17 (0.63)	0.07 (0.15)
Y2006	0.02 (0.10)	0.16 (0.09)	0.30 (0.10)	0.16 (0.09)
Hausman test	Chi2 (12)=9.03	Chi2 (12)=15.9	Chi2 (12)=7.38	Chi2 (12) =14.0
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.

6 Conclusions

This paper has examined the association between some possible indicators of incubatee success and the resources used by incubators in China. 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 but not with the variables characterizing the location of the incubator, such as the inflow of FDIs, proximity to universities, and the diversity and scale of industrial activities in the locality. Another finding is that there are no significant differences between university-based incubators and government-established incubators in the way in which their resource inputs contribute to incubation performance.

These results clearly indicate that whether government support to technology-oriented firms achieves an excellent outcome depends critically on the input of high-quality resources. To be sure, metropolitan environments with diverse and large-scale industrial activities may be helpful to business incubation, and favorable access to the facilities and alumni networks of universities may be advantageous to incubators. Compared with the input of resources itself, however, these environmental factors are of the secondary importance in China. The outcome of incubation can be improved by increasing the quantity and improving the quality of the input of resources.

Business incubation started in China in the late 1980s. It has become widespread, as the rapid increase in the number of incubation programs indicates. At each incubation program, the process of incubation has been repeated and become systematized over time, even though new programs have been established every year and started from scratch. In a sample that includes both long-established and new incubation programs, we find that the high education of incubation managers has become less important as a determinant of incubation performance. This result suggests that business incubation in China as a whole has become systematized and standardized. Subsequently, a question arises as to what additional challenges the incubation managers are trying to address. Our regression analyses find evidence neither for efficiency gains in the conventional incubation activities nor for the creation of new types of activities. Our results are consistent with the view that incubation managers continue to focus on the development of the capability of their tenant firms up to the level of meeting market competition and that they do not try to go beyond that level. These results suggest that business incubation in China has reached the level that the government-led approach, in which incubation managers are quasi government officials, can achieve.

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