

## Assessing the Efficiency of University Science Parks: From the Perspective of Value-Added Contribution

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### Abstract

As an important mechanism to stimulate technological spillovers from universities to firms, University Science Parks (USPs) provide a vital resource network for the survival of new venture, wealth creation and job generation. In this paper, we investigate the efficiency of USPs from the perspective of value-added contribution to analyze how to strengthen the rational allocation of resources and the skill of management of USPs under continuous extension scale and how to promote the value-added contribution of USPs, and we also expect to provide a new avenue for further research of USPs. Based on the data of 65 USPs in China, we apply an evaluation model to assess the efficiency of USPs. Using Stochastic Frontier Analysis, this study measures the efficiency of survival, wealth creation and job generation of USPs. Moreover, built upon the three dimensions of efficiency, this article conducts Cluster Analysis on the efficiency to categorize Chinese USPs into four typologies: multi-superior, incubation orientation, wealth orientation and job orientation. The results suggest that the overall efficiency of USPs is not high, mainly because of the lack of fund, the unreasonable usage of infrastructure, the shortage of service intermediaries and the low the level of management; the results also indicate the increase of survival rate relies on the increase of incubation fund, and the increase of wealth creation and job generation depends on the improvement of physical infrastructure; and the paper distinguishes the differences and the directions of promoting the value-added contribution of four types USPs.

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**Keywords:** USPs, efficiency, SFA, typology, value-added contribution.

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### INTRODUCTION

In order to access to the new scientific knowledge or resources of universities firms often develop formal and informal linkages with them (OECD, 1981). Malecki(1991) claimed that establishing links with universities could enhance wealth creation and job generation. Establishing USPs can transform talents and technologies advantages in universities into industrial and economic advantages. The first USP in China is DongBei USP, which was established in 1990. By the end of 2010 there were 86 NUSPs in China. These USPs occupy 8.15 million square meters of space area and owned 6617 tenants with total revenues \$661.7 billion. The accumulated number of graduated tenants is 4363. The tenants possessed 128 million employees, \$4867.36 million incubation fund, 1317 service intermediaries and \$821.03 million fixed asset.

Chinese USPs are deemed to play an important role in innovation. However, during the Economic Transitional Period, entrepreneurial and innovative activities of new ventures are often handicapped by institutional voids (Li and Zhang, 2007). Although China's emerging economy provides a rich context to test the proposition that USPs can contribute to new

ventures' survival, wealth creation and job generation. there are still a lot of problems avoid the development of USPs, for example, the shortage of fund, the lack of supporting policy, the deficiencies of infrastructure, etc, which all lead to the inefficiency of USPs. The two question how to strengthen the rational allocation of resources and the skill of management of USPs under continuous extension scale and how to increase the efficiency of USPs become hot spots in theory and practice.

### LITERATURE REVIEW

#### The University Science Park

According to the United Kingdom Science Park Association (UKSPA, 1996), SPs are designed to foster the formation and growth of high-tech firms, provide a favorable environment that enables large companies to develop relationships with new ventures, and promote formal and informal links between firms, universities, and other higher education institutions. As special science parks, USP are university-based technology initiatives that are designed to facilitate knowledge transfer from the university to industry. They also own management teams that actively struggle to promote technology transfer (IASP, 2001).

The universal purpose of incubator activities including establishing USPs is to increase the survival of new ventures (Allen, 1985), there is no doubt about that new ventures play important roles in the development of economies—they are major sources of sales, new jobs, and innovations in most economies (Peña, 2004; Phan et al., 2005). USPs are expected to offer their tenants the geographical and organizational advantages for knowledge interaction with the local high education institutions (Storey and Tether, 1998), as a result, USPs were often considered to be a solution to complex political and economic issues in society, for example, regional industry problems, the under-commercialization of research, the shortage of new product development, and unemployment (Autio and Klofsten, 1998; Hansson et al., 2005).

### The Value-Added Contribution of Science Parks

Mian (1996) noted that value-added, corresponding to the provision of the three major groups of elements (business, technical and social inputs), has become a part of the lexicon of the technology business incubation industry. Mian (1997) documented there are two main categories of services for value-added: (1) typical incubator services including shared office services, business assistance, access to capital, business networks, and rent breaks; and (2) the university-related which include services faculty consultants, student employees, university image conveyance, library services, labs/workshops and equipment, mainframe computers, related R&D activity, technology transfer programs, employee education and training, and sports and other social activity. Allen and Bazan (1990) claimed that value added refers to those specific ways that incubator programs enhance the ability of their tenants to survive and growth in SPs. From the perspective of value-added contribution, Mian (1997) stated a new framework to assess the performance of incubator under three performance dimensions including program sustainability and growth, tenant firm's survival and growth and contributions to the sponsoring university's mission.

### ECONOMETRICS MODEL

We use the stochastic frontier analysis (SFA) to assess the efficiency of USPs in China. We say that an USP is efficient if, when compared to another USP with similar amounts of inputs, it could produce more outputs without increasing its inputs usage, or, equivalently, it is one which, when compared to another USP with similar levels of outputs, could produce the current levels of outputs with fewer inputs (Thursby, 2002; Siegel, 2003). In SFA model, a production function of the following form is estimated:

$$Y = X_i\beta + \varepsilon_i \quad (1)$$

Where the subscript  $i$  denotes the  $i$ th USP,  $Y$  the output,  $X$  the vector of inputs,  $\beta$  the unknown parameter vector, and  $\varepsilon_i = V_i - U_i$ . The distributions of  $U_i$  and  $V_i$  are presented as follows:

$$U_i \sim i.i.d.N^+(0, s_u^2), U_i \geq 0$$

$$V_i \sim i.i.d.N(0, s_v^2)$$

That is, the inefficiency term ( $U_i$ ) is assumed to have a half-normal distribution, i.e., USPs are either “on the frontier” or below it. In this study, we set the SFA model as follows

$$\ln Survival_i = \beta_0 + \beta_1 \ln Staffs_i + \beta_2 \ln Fund_i + \beta_3 \ln Space_i + V_i - U_i \quad 2$$

$$\ln Tax_i = \beta_0 + \beta_1 \ln Staffs_i + \beta_2 \ln Fund_i + \beta_3 \ln Space_i + V_i - U_i \quad 3$$

$$\ln Employees_i = \beta_0 + \beta_1 \ln Staffs_i + \beta_2 \ln Fund_i + \beta_3 \ln Space_i + V_i - U_i \quad 4$$

Where *Survival*, *Tax* and *Employees* denote the survival rate of tenants, the taxes of tenants and job creation respectively, *Staff*, *Fund* and *Space* denote the personnel, the incubation fund and the space area respectively.

### EMPIRICAL RESULTS

#### Efficiency in Three Dimensions

Phan et al. (2005) and Siegel et al. (2003) suggested it is difficult to assess the impact and effectiveness of SPs because of the differently expected objectives of stakeholders and the lack of relevant performance criteria. As noted by Peña (2004), profitability is not a good index to measure performance because the firms in USPs were in the initial stages, firms often lacked profits. Phan et al. (2005) suggested survival per se versus wealth creation or job generation should be considered as the relative importance of performance dimensions may be closely associated with the different objectives of USPs.

As a new thing, the main purpose of Chinese USPs is to assist the formation and growth for new ventures, create wealth and generate jobs, so, we set the survival rate, the tax and job generation as output variables. The output in the dimension of facilitating the survival rate of tenants is measured by the number of tenants. The tax of tenants reflects the economic contribution of USPs. The personnel of USPs and the employee of tenants constitute the job generation. The input variables contain three aspects which are widely used to estimate the performance of USPs (Yin et al., 2010). The first variable is the labor input which is calculated in terms of the number of personnel. The second is the capital expressed as the total value of incubation fund. The third is material resources or infrastructures represented by the rental space of USPs (Dai and Sun, 2012; Zhang and Yin, 2010).

All of the data stems from the “2011 China torch statistical yearbook” and the homepage of every USP. Because the data of some USPs is unavailable, the

object of this study is 65. Descriptive statistics for the output variables and input variables are presented in table 1

Table 1 Descriptive Statistics

|                         | Minimum | Maximum | Mean      | Standard error | Standard deviation |
|-------------------------|---------|---------|-----------|----------------|--------------------|
| Survival rate (%)       | 2.13    | 80.56   | 27.603    | 0.02           | 15.854             |
| tax of tenant (1000¥)   | 400     | 249070  | 18669.492 | 4680.191       | 37732.905          |
| Job generation (person) | 256     | 7405    | 1478.723  | 150.5802       | 1214.016           |
| personnel (person)      | 8       | 90      | 27.369    | 2.109          | 17.001             |
| Incubation fund (1000¥) | 20      | 634627  | 59303.723 | 15696.869      | 126552.21          |
| Space area (sq.m)       | 10000   | 1350000 | 88883     | 23026          | 185640             |

Putting (2), (3) and (4) together, we use the FRONTIER 4.1 statistical package to assess efficiency, the empirical results are presented in the next section

Table 2 the result of efficiency from the perspective of value-added contribution.

| SFA                  | Model 1     |         | Model 2     |         | Model 3     |         |
|----------------------|-------------|---------|-------------|---------|-------------|---------|
|                      | coefficient | t-ratio | coefficient | t-ratio | coefficient | t-ratio |
| $\beta_0$            | 5.621***    | 6.999   | 4.287***    | 2.497   | 3.895***    | 5.132   |
| $\beta_1$            | -0.008      | -0.045  | -0.003      | -0.077  | 0.175       | 1.137   |
| $\beta_2$            | 0.061**     | 2.057   | 0.027       | 0.413   | 0.029       | 0.913   |
| $\beta_3$            | -0.272***   | -2.528  | 0.517***    | 2.884   | 0.283***    | 3.438   |
| $\sigma^2$           | 1.049***    | 4.53    | 2.798***    | 2.904   | 0.793***    | 2.959   |
| $\gamma$             | 0.952***    | 24.047  | 0.706***    | 3.177   | 0.871***    | 6.175   |
| Log likelihood       | -58.852     |         | 105.851     |         | 56.493      |         |
| LR test for one side | 12.926      |         | 0.865       |         | 1.442       |         |
| mean efficiency      | 0.533       |         | 0.431       |         | 0.569       |         |

Notes: N=65; \* Significant at the 10% level; \*\* at the 5% level; \*\*\* at the 1% level. LR is likelihood ratio test statistic, where it is subject to mixed chi-square distribution

According to table 2, all the correlation coefficients between output and input variables have the expected signs, despite some results are not significant. From model 1, under the 0.1 level of significant,  $\gamma = 0.952$ , so, it is necessary to use SFA to accessing the efficiency. The results show that  $\beta_1$  doesn't pass the significant testing, while  $\beta_0$ ,  $\beta_2$  and  $\beta_3$  pass. The empirical results  $\beta_2=0.061$  indicate that the improvement of the ability of incubating new venture needs the increasing of fund, however, the fund lack of Economic of Scale. And  $\beta_3=0.272$  notes that space area has negative impact on the survival rate. The overall efficiency of incubating new venture is low (0.533 on average), lacking of fund and unreasonable site planning is the reason why the efficiency of survival rate is low. From model 2,  $\beta_0$  and  $\beta_3$  are positive, and they all pass the testing under the 0.1 level of significant.  $\beta_1$  and  $\beta_2$  don't pass the testing of significance, what' more,  $\beta_1$  is negative, meaning the input of personnel has unconscious impact on wealth creation.  $\beta_3=0.517$  indicates that wealth creation needs the pull of space area, however, space area also lack of Economic of Scale. The mean efficiency of wealth creation is 0.431, which relates to the imperfection and the low usage of infrastructure in USPs. From model 3,  $\beta_0$  and  $\beta_3$  are positive, and they all pass the significant testing,  $\beta_1$  and  $\beta_2$  don't pass the testing of significance.  $\beta_3=0.283$  reveals the results that the

increase of job depends on the increase of space area, but space area is Economic of Scale too. The overall efficiency of job generation is also low.

The last row of table 2 presents the average efficiency in each of the three dimensions. The empirical results show that the efficiency in terms of job generation (Job-efficiency) is the highest on average (0.569), in addition, the efficiency in terms of facilitating the surviving rate of USPs (Survival-efficiency) ranks second (0.533 on average). Finally, promoting local economic development (Wealth-efficiency) is the lowest (0.431). In general, all of the efficiency is not high. One possible interpretation is that the USPs in China are still lacking fund and the infrastructure is unreasonably used. Another interpretation is that the shortage of service intermediaries and the low level of management constrain the development of USPs in China.

#### Four Typologies of USPs

Built upon the efficiency scores of individual USPs, we adopt SPSS 16.0 as a tool to make the K-mean cluster analysis (K=4) to investigate the differences and directions of promoting the value-added contribution of USPs. Table 3 and Table 4 are analysis results

Table 3. ANOVA

|                     | Cluster     |    | Error       |    | F      | Sig. |
|---------------------|-------------|----|-------------|----|--------|------|
|                     | Mean square | df | Mean square | df |        |      |
| Survival-efficiency | 0.737       | 3  | 0.017       | 61 | 43.601 | 0    |
| Wealth- efficiency  | 0.325       | 3  | 0.02        | 61 | 16.506 | 0    |
| Job- efficiency     | 0.439       | 3  | 0.017       | 61 | 27.886 | 0    |

Table 3 (ANOVA) shows the result of cluster analysis passes the significance testing, and all the efficiency of three dimensions makes significant contribution to the classification

Table 4 final cluster center

| Typology            | multi-superior | incubation orientation | wealth orientation | job orientation |
|---------------------|----------------|------------------------|--------------------|-----------------|
| Survival-efficiency | 0.705          | 0.698                  | 0.674              | 0.328           |
| Wealth- efficiency  | 0.536          | 0.337                  | 0.910              | 0.452           |
| Job- efficiency     | 0.743          | 0.365                  | 0.395              | 0.636           |

Table 3 is the final cluster centers, and we can identify four typologies of USPs in China, they are multi-superior, incubation orientation, wealth orientation and job orientation. The first type is termed as the “multi-superior”, its main characteristic is that the efficiency in all dimension is disproportionately high (i.e., Survival-efficiency is 0.705 on average, Wealth-efficiency is 0.536, and Job- efficiency is 0.743), with the reason of reasonable Input-Output resource allocation, and there are 14 incubators belonging to the first type. Multi-superior USPs pay more attention to all round development, other types of USPs can learn from multi-superior on the management. Nevertheless, the value-added of multi-superior USPs can be improved by adjusting the number of people, rational using funds and reasonable planning area.

The second typology is called the “incubation orientation”, whose Survival-efficiency is markedly higher (0.698 on average) than those of other dimensions, with a total number of 19. The development of these USPs relates to USPs’ core function, supporting the formation and growth of firms and cultivating entrepreneur. Considering that high survival rate mainly depends on more fund in the Chinese context, it is advisable that the government should set up more innovation fund and special fund to create a favorable atmosphere.

The third type is characterized by the high efficiency scores in wealth creation (0.910 on average), which we call “wealth orientation”. There are only three USPs belong to this type. The main reason for there are only 3 USPs belonging to this type is that USPs mostly incubate new ventures, and new product of these firms haven’t realized profits in their early stage, so they paid less taxes to wealth creation. Therefore, these USPs should lay more emphases on

expanded reproduction to improve the sales of new products. What’s more, in the process of their

development, the government should give more support on cutting tax for USPs.

The fourth type “job orientation”, the majority samples belonging to this type, is efficient in job generation. Why “job orientation” does well in creating jobs and occupying the largest number in the samples? The reason is that when USPs incubates ventures, they also increase the High-tech industry's share in the industry, expanding the scope of employment consequently. As the above noted, job growth depends on the increase of space area, but space area lack of Economic of Scale. Therefore, it is necessary for USPs to configure infrastructure reasonably and entrust the universities to make USPs as the training base. At the same time, to enhance management quality, the training of local talents and strongly absorption oversea talents should be strengthened.

## CONCLUSION

The efficiency in terms of job generation is the highest on average (0.569), more than the dimension of survival rate and wealth creation, what’s more, the ability of incubating new venture is mainly promoted by the increasing of fund, and the creation of wealth and job mostly depends on the increase of space area. In general, the average efficiency in each of the three dimensions is not high; the possible reasons are the lack of fund, the unreasonable usage of infrastructure, the shortage of service intermediaries and the low the level of management.

We can identify four typologies of USPs in China. They are multi-superior, incubation orientation, wealth orientation and job orientation. Multi-superior USPs pay more attentions to all round development, so their efficiency in all dimensions is relatively high; incubation orientation USPs perform noticeably on incubating new ventures, which is related to USPs’ core function that is to support the foundation and growth of firms and cultivate entrepreneur; there are only 3 USPs belonging to wealth orientation, mainly

because the firms in USPs haven't realized profits in their early stage; job orientation USPs do well in job generation and occupy the largest number in the sample, therefore they should take advantage of absorbing a large number of talents during the process of development.

#### **LIMITATIONS**

This study has three limitations, which may provide avenues for further researches. Firstly, the sample of this study is cross-sectional in nature across USPs and is not longitudinal, allowing only for analysis at one point in time rather than over the course of time. Given that there are lags involved, our results must be considered with caution. Secondly, the outputs of the USP in other dimensions are not considered, such as research commercialization (Allen and McCluskey, 1990; Bergek and Norrman, 2008; Siegel et al, 2001), training entrepreneurs (Grimaldi and Grandi, 2005; Allen and McCluskey, 1990), although these aspects are also important for the USP. Finally, the paper is studied in Chinese USPs. It is therefore desirable to extend our study to examine other USPs in other economies.

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