The Research on the Operating Efficiency Difference among Technology Business Incubators of Southwest China

--- Based on the Study of 28 Business Incubators in DEA Method

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Abstract

This paper uses DEA and cluster analysis method to make research on operating efficiency difference among 28 national business incubators of Southwest China with the data of 2010 to 2012 years. The results show that the operating efficiency of business incubators in Southwest presents the downtrend in dynamic fluctuation. The integral operating efficiency is relatively low and the efficiency difference is significant. Ineffective business incubators hold a relatively large proportion. The main factor is unreasonable resource allocation and low scale level.

Keywords: business incubators, operating efficiency difference, DEA, cluster analysis

1. The Introduction

Business incubator which provides facility and preferential policy for venture enterprises plays an important role in the development of modern science and technology enterprises. The number of Chinese business incubator has already reached 896 in 2011(including 346 national business incubators), and the income of incubating enterprise has reached 3750 billion yuan (Note 1). The rapid development of incubating enterprise becomes a new highlight of science and technology industry growth in the economic circumstance of weak domestic demand growth and foreign trade technical barriers. Southwestern China is Chinese important center of science and education, the raw material base and the economic hinterland. Sitting on abundant natural resources and human resources, Southwestern China which has characteristics of late beginning, great potential, fast development owes its unique in the national incubator industry competition. The national enterprise incubators of Southwestern China had increased to 28, the income of enterprise incubators and total incubation fund respectively were 2.17 billion yuan and 2.44 billion yuan in 2012 (Note 2). Southwestern China enterprise incubators have been initially showing the development of functional specialization, investment diversification, diversification of forms and organization networking. However, following suit blindly and without long-term planning makes the operating situation of Southwestern China enterprise incubators show the trend of the polarised. The incubators whose operation mechanism is not complete and competitive advantage is not obvious start to highlight the drawbacks. Incubating enterprises' fatigue innovation and continued falling survival rate shake the prospect of incubators and it brings tremendous industry risk for the healthy growth of small and medium technology companies in Southwestern China. Therefore, to evaluate the efficiency of science and technology business incubators in Southwestern China objectively and give the corresponding countermeasures and suggestions has double meaning of theory and practice to enhance the level of incubators operation, inspire the SMEs innovation vigor, and improve the efficiency of enterprise incubators.

What exactly is the cause of differences in the operation efficiency of business incubators? How to ensure high-efficient operation of business incubators? Foreign scholars mainly research these issues on the evaluation index system and econometric models. Sarfraz A.Mian analyzed the elements of university image, facilities and human resources to the incubating enterprise value growth contribution, and established efficiency evaluation system

of technology business incubators from the aspect of the continuity and growth of the projects, the survival and development of incubating enterprises, influence on university image, the completement of facilities and service of business incubators (Sarfraz A. Mian, 1997). K.F.Chan and Theresa Lau (2005) constructed incubator evaluation system (including resource gathering advantages, resource sharing, consulting services, public image, the network advantages, the cluster effect, location advantages, the cost of subsidies and financial support), and made an empirical research on the incubation process of a start-up business in Hong Kong Science and Technology Parks. Sung et al (2003) collected seven Korea business incubators data and applied statistical analysis of the "linear model" and "non-linear model" to the evaluation of business incubators.

Chinese scholars focus more on applying different methods of evaluation of the incubator efficiency on the basis of construction the index system. Liu Ninghui & Wang Xiaomin (2007) constructed performance evaluation system of science and technology business incubators, and made performance evaluation on the basis of the grey system theory with the data of five of Nanjing science and technology business incubator. Li Hengguang (2008) used AHP and fuzzy evaluation method to establish an evaluation model of comprehensive capacity of science and technology business incubators and it provided the basis for comprehensive ability evaluation of science and technology business incubators. Dai Bibo & Sun Dongsheng (2012) used DEA method to do empirical research on the operation efficiency of science and technology business incubators in Northeast China. Yin Qun & Zhang Jiao (2010) estimated the operation efficiency of business incubators in Yangtze River Delta region with DEA method, and put forward the efficiency improvement strategy of controlling inputs and output resource. Wang Jing & Wang Keyi (2012) made a technical efficiency evaluation on 140 national science and technology business incubators with DEA method, and drew a conclusion that the efficiency of business incubators are mainly affected by economic development, regional innovation level, the government public expenditure and intellectual support levels. Huang Hong (2013) did deep research on the operation efficiency and regional differences of 260 national science and technology business incubators with stochastic frontier analysis method, and put forward the countermeasures and suggestions of improving efficiency of business incubators .

In general, the existing literatures on cluster research of operation efficiency of regional incubators are relatively small, the research on the operation efficiency of Southwest regional incubator remains to be complete in particular, and the reasons of operation efficiency differences need to be fully revealed. Therefore, this paper build a DEA mode to do empirical research on Southwest business incubators operation efficiency, explore the reasons of the difference of operation efficiency and improvement approaches from the angle of DEA validity, and provide technical basis for managers and policy constitutors.

2 Methods and Models

2.1 DEA Method and BCC Models

Data Envelopment Analysis (DEA) was put forward by the operations researcher Charnes in 1978, it is a new overlapping field of operations research, management science and mathematical economics, this method has its unique advantages on the evaluation of decision-making units of multiple inputs and multiple outputs. It divides efficiency into pure technical efficiency, scale efficiency, overall efficiency for more comprehensive evaluation of effectiveness of decision-making units. DEA model is divided into two kinds of input-oriented and output-oriented models according to different point of efficiency evaluation. Input-oriented model is to reduce input as much as possible in order to optimize the allocation of resources under the same output; while output-oriented model is to maximize output in order to improve efficiency of resource use under the same input. According to whether the returns to scale are variable, DEA basic model is divided into constant returns to scale model (CCR) and variable returns to scale (BCC) model. This paper adopts input-oriented BCC model to evaluate the efficiency in order to optimize the allocation of resources from the input perspective. Business incubators are decision-making units of multiple inputs and multiple outputs, assuming that there are n decision-making units, each unit has m kinds of investment decision and s kinds of output, x_{ij} represents the i-th input of j-th decision-making unit inputs DMUs and y_{rj} represents the r-th output of j-th decision-making unit, s_i^- and s_r^+ respectively represent slack variables of i-th input and r-th output. BCC model as follows:

$$\min \theta - \varepsilon(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+)$$

$$s.t. \begin{cases} \sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta x_{i0}, i = 1,2...m \\ \sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{r0}, r = 1,2...s \\ \sum_{j=1}^{n} \lambda_j = 1 \\ \lambda_j, s_i^-, s_r^+ \geq 0; j = 1,2...n \end{cases}$$

The decision-making unit for DEA is valid when $\theta = 1,\ s_i^- = 0,\ and\ s_r^+ = 0$; the decision-making unit is DEA invalid when $\theta < 1$.

2.2 Cluster Analysis

Cluster analysis is an important statistical data classification method, which classifies clustering objects according to the characteristics of things. Hierarchical clustering method and fast clustering method (also known as K-means clustering) are more common among clustering analysis. K-means clustering has better clustering effect for relatively large-scale samples. The basic idea of K-means clustering method is: first, select K objects for the initial cluster centers according to certain methods, the next, calculate the distance of each object with each initial cluster center, and then, assign each object to its nearest cluster center to form an initial cluster, last, adjust them to form final clusters according to the similarity of the objects and the principles of the shortest distance.

3. The Selection of Indicators and Data Sources

Index selection is the premise and basis for the evaluation of operation efficiency of business incubators, and choosing the right input and output indicators has a crucial impact on the DEA efficiency evaluation. Foreign scholars mainly constructed incubators efficiency evaluation system from the perspective of incubators and incubating enterprises. The incubators aspects are consist of incubator facilities, management services and financial support, and the incubating enterprises aspects mainly related to business growth capacity, the persistence and growth of projects, and the graduation rate of incubating enterprises. The domestic scholars mainly built incubator efficiency evaluation systems based on the inputs and outputs of resource. Cui Qi'en, Liu Shuai & Qian Shiru (2011) built the evaluation input index of incubators operation efficiency in terms of management personnel, the total incubation funds, the value of fixed assets and equipment, and site area. They formed output indicators in view of the number of cumulative graduation enterprises, the number of incubators employees and the taxes of incubating enterprises. Yin Qun and Zhang Jiao (2010) constructed input indicators from the human resources (total staff), financial resources (investment funds) and material resources (site area) aspects. They established output index from hatching efficiency (cumulative graduation enterprises) and social efficiency (jobs and paid taxes) angle. Huang Hong (2013) selected input indicators from site area of incubators, employees of business incubators, and chose the number of graduated incubators, incubating enterprises, employees of incubating enterprises, and the income of employees of incubating enterprises as output indicators. The paper constructed the input and output indexes system of Southwest business incubators on the basis of the summary of previous research results (Table 1).

Table 1. The input and output indicators of technology business incubators

Indicators categories	The secondary indicators	Specific indicators (unit of measurement)
Input indicators	Human input	Employees of business incubators(pc)
	Financial input	Total incubation funds (thousand yuan)
	Material input	Site area(square meter)
Output indicators	The incubation effect	Cumulative graduated enterprises(pc)
		Annual graduation rates of incubating enterprises
	Economic benefits	The average graduate income (thousand yuan)
	Social benefits	New jobs of business incubators(including total number of incubator staff and total number of incubating enterprises staff) (pc)

Talents are the core part of the incubators competitiveness, the enterprise incubators which are dedicated to providing technical guidance and management service to the incubating enterprises need various aspects of professional technical personnel and management personnel to maintain daily operation. Thus, the paper selected "employees of business incubators" as the human input indicators of the index system. Incubation fund is mainly constituted by the government support, finance and tax subsidies and entrepreneurial venture investment fund. The technology commercialization process of science and technology enterprise incubators can't without incubation fund support. Therefore, "incubation fund" is undoubtedly the best financial indicators of measuring operating efficiency of science and technology business incubators. As a space carrier of office space and basic facilities for the incubating enterprises, incubator space is the material basis for the operating efficiency. Thus the paper selects "site area" of incubators as an indicator of material resources.

Annual graduation rates of incubating enterprises reflect the ability of technology business incubators pushing incubating enterprises to the market. Thus, the paper chooses "graduation rates of incubating enterprises" and "cumulative graduated enterprises" to measure the effect of incubation. As a venture platform for SMEs, benefits from guidance and service of technology business incubators are not only visually reflected in the addition of graduated enterprises income, but also in the creation of employment opportunities, promotion of industries upgrading, stimulation of economic growth and improvement of social benefits. Thus, the paper picks out "the average graduate income" and "new jobs of business incubators (including total number of incubators staff and total number of incubating enterprises staff)" as the output indicators on behalf of economic and social benefits of the business incubators.

Considering the continuity and authority of original data, the paper removed incubators of lower level and incubators of missing data, and finally selects 28 national business incubators in Southwest China from "China Statistical Torch Yearbook (2010-2012)", then the paper classifies the annual data for the empirical analysis.

4. An Empirical Analysis of the Operating Efficiency

4.1 Descriptive Statistics

The paper makes descriptive statistics with annual data of incubator samples from 2010 to 2012 years (Table 2). The results shows: there are large differences among the efficiency of 28 business incubators. The maximum comprehensive efficiency is 1.000, the minimum one is 0.128 and the mean one is 0.700. From the input point of view, the standard deviation of site area, total incubation fund and employees of business incubators are relatively large, that means the difference of construction input into Southwest incubators is relatively large. From the output perspective, cumulative graduated enterprises, annual graduation rates of incubating enterprises, new jobs of business incubators, the average graduate income and other indicators have low mean value, that indicates the potential output of the incubators have to be further explored.

Table 2. The descriptive statistics results of indexes data

Variables	Mean Value	Standard Error	Standard Deviation	Minimum Value	Maximum Value	Observation Numbers	Degree of Confidence(95%)
TE	0.700	0.029	0.268	0.128	1.000	84	0.058
PTE	0.828	0.025	0.225	0.170	1.000	84	0.049
SE	0.838	0.021	0.189	0.348	1.000	84	0.041
Employees of business incubators	29.738	2.017	18.486	6.000	90.000	84	4.012
Site area	51280.833	8110.775	74336.477	2394.000	478740.000	84	16132.004
Total incubation fund	10151.583	1819.559	16676.535	500.000	100000.000	84	3619.030
Cumulative graduated enterprises	77.298	11.092	101.658	4.000	370.000	84	22.061
Annual graduation rate of incubating enterprises	0.088	0.009	0.080	0.011	0.421	84	0.017
New jobs of business incubators	2514.468	241.381	2212.290	138.000	12345.000	84	480.096
The average graduate income	11196.238	1599.159	14656.539	200.000	89681.000	84	3180.664

Note: TE= the overall efficiency, PTE= pure technical efficiency, SE= scale efficiency. The same as below.

4.2 DEA Efficiency Analysis

The paper measures the operating efficiency of 28 Southwest business incubators with Deap2.1 software, and summarized efficiency of 2010-2012 years by province in Table 3, and then draws the radar charts for analysis (Chart 1). From the vertical perspective, it is not hard to find the efficiency of Southwest incubators showing a downward trend in the overall dynamic fluctuations. It indicates that some aspects of the incubators run sluggish during operation, its crux is: the input of business incubators increase in recent years, while the extent of marginal output increase is relatively limited and the decrease of input-output efficiency drives down the overall operating efficiency of business incubators. From the three years average horizontal data to analyze, the overall efficiency level of Southwest is relatively low and regional differences is quite significant. The data shows the highest efficiency is Tibet, followed by Chongqing, Yunnan, the bottom of rankings are Sichuan and Guizhou. The reason maybe: there is only one national science and technology business incubator in Tibet, so the input of incubator is relatively concentrate. Besides, national policy support is comparatively great. All of them push up operating efficiency of Tibet to a certain extent; the overall efficiency is not high in Sichuan. It primarily roots in multi-point and wide surface. On the one hand, large difference of the efficiency of 11 business incubators pull down the overall operating efficiency level; on the other hand, scattered distribution, poor information and overlapping construction of business incubators lead to unobvious cluster effect. Business incubators of Guizhou failed to establish a market operation mechanism of modern technology incubators organizations. In addition, the market positioning of some incubating enterprises have a large deviation. The business incubators are over-reliance on government preferential policies and lack of mechanism to attract capital and talents. They are maybe the reasons that the enterprise graduation rate is not high and the operating efficiency continues to decline.

Table 3. Business incubators operating efficiency from 2010 to 2012 years by province

Zone	The number of business incubators	2010 year			2011 year			2012 year			the mean value of 2010-2012 years		
		TE	PTE	SE	TE	PTE	SE	TE	PTE	SE	TE	PTE	SE
All	28	0.694	0.785	0.872	0.745	0.834	0.878	0.661	0.864	0.764	0.700	0.828	0.838
Sichuan	11	0.585	0.701	0.835	0.584	0.698	0.813	0.618	0.808	0.768	0.596	0.736	0.805
Yunnan	7	0.646	0.704	0.877	0.871	0.992	0.876	0.732	0.955	0.758	0.750	0.884	0.837
Guizhou	2	0.932	0.998	0.933	0.522	0.582	0.896	0.476	0.837	0.556	0.643	0.806	0.795
Chongqing	7	0.802	0.906	0.891	0.900	0.938	0.961	0.662	0.848	0.789	0.788	0.897	0.880
Tibet	1	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

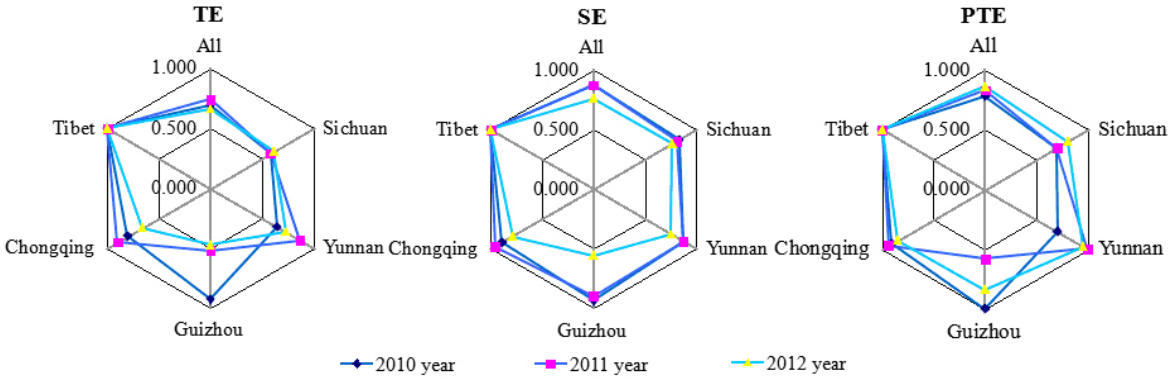

Chart 1. The chart of operating efficiency in Southwest China from 2010 to 2012 years

4.3 K-means Clustering Analysis

To further dissect the operating efficiency differences among Southwest technology business incubators, the paper makes K-means clustering analysis on the DEA efficiency results of 2012 year. BCC model decomposes efficiency into overall efficiency, pure technical efficiency and scale efficiency. The overall efficiency is equal to the product of pure technical efficiency and scale efficiency, and there is no direct correlation between pure technical efficiency and scale efficiency. Therefore, this paper selects pure technical efficiency and scale efficiency as clustering variables, sets K = 4, and does clustering analysis with SPSS18.0 software platform (Table 4).

Table 4. Cluster centers table

Cluster variables	Initial cluster centers				Final cluster centers			
	I	II	III	IV	I	II	III	IV
PTE	1.000	0.760	0.390	1.000	1.000	0.870	0.530	0.890
SE	1.000	0.700	0.750	0.380	0.980	0.740	0.910	0.460

As it can be seen from Table 4, pure technical efficiency and scale efficiency of Class I business incubators are maintained at a high level, and the overall efficiency is undoubtedly the highest grade of all; pure technical efficiency and scale efficiency of Class II business incubators are in "double-low" state; the pure technical efficiency of Class III business incubators is significantly lower than scale efficiency, while the scale efficiency of Class IV business incubators is significantly lower than the pure technical efficiency. The overall efficiency of Class II, III and IV incubators need to be further improved.

Table 5. The table of K-means clustering variance analysis

Clustering variables	Between groups		Within the groups		The F value	Significance level
	Mean variance between groups	Degrees of freedom between groups	Mean variance within the group	Degrees of freedom within the group		
PTE	0.198	3	0.006	24	30.869	0.000
SE	0.367	3	0.006	24	59.363	0.000

The Table 5 shows that the significance level of clustering variables is 0.000. All the clustering variables pass the test of significance, therefore the above clustering results can be the basis of clustering analysis of the efficiency differences of business incubators.

Table 6. The efficiency classification of Southwest business incubators

Categories	The names of business incubators	TE	PTE	SE	Categories	The names of business incubators	TE	PTE	SE
I	F1	1.000	1.000	1.000	II	F15	0.778	1.000	0.778
I	F2	1.000	1.000	1.000	II	F16	0.631	0.795	0.793
I	F3	1.000	1.000	1.000	II	F17	0.585	0.760	0.769
I	F4	0.836	1.000	0.836	III	F18	0.626	0.631	0.992
I	F5	1.000	1.000	1.000	III	F19	0.559	0.590	0.948
I	F6	1.000	1.000	1.000	III	F20	0.291	0.388	0.751
I	F7	1.000	1.000	1.000	III	F21	0.494	0.517	0.956
I	F8	1.000	1.000	1.000	IV	F22	0.377	1.000	0.377
II	F9	0.745	0.902	0.826	IV	F23	0.264	0.757	0.348
II	F10	0.573	0.858	0.668	IV	F24	0.373	0.885	0.421
II	F11	0.531	0.760	0.698	IV	F25	0.452	0.884	0.512
II	F12	0.746	0.914	0.816	IV	F26	0.554	1.000	0.554
II	F13	0.626	0.923	0.678	IV	F27	0.326	0.751	0.434
II	F14	0.602	0.941	0.639	IV	F28	0.544	0.923	0.590

Note: F1-F28 represent the Tibet Autonomous Region Science and Technology Innovation Service Center, Chengdu Hi-tech Innovation Service Center, Chengdu Hi-tech Zone Innovation Service Center, Chengdu Hi-tech Zone Education Technology Park Incubator Co., Ltd., Kunming High-tech Innovation Service Center, Kunming Economic and Technological Development District of Emerging Industries Incubator Management Ltd., Science and Technology Development co., LTD of Sea turtles Pioneer Parks in Yunnan, Science and Technology Management Institutions in Yuzhong District, Chengdu Digital Entertainment Software Park Management Investment Co., Ltd., Chengdu Wuhou Hi-tech Innovation Service Center, Mianyang High-tech Zone Innovation Service Center, Kunming Innovation Park Technology Development Co., Ltd., Guiyang High-tech Innovation Service Center, National University Science and Technology Park Innovation Service Center in Chongqing, Chongqing Hi-tech Innovation Center (Chinese International Business Incubator in Chongqing), Business Incubator Co., Ltd. in Jinqu, Fuling District of Chongqing, Chongqing Wulidian Industrial Design Center, Chengdu Tianhe Chinese and Western Medicinal Technology Conservation co., Ltd, Sichuan University Science and Technology Park Development Co., Ltd., Hi-tech Innovation Service Center in Zigong City, Chongqing High-tech Industrial Development Zone Innovation Service Center, Mianyang High-tech Zone Biomedical Incubator Ltd., Sichuan Zhongwu Technology Co., Ltd, Science and Technology Incubator Ltd. of North Institute in Kunming, Kunming Wuhua High-tech Science and Technology Park Innovation Service Center, An Incubator of New Materials in Yunnan Province, Software Park in Guizhou Guiyang, Chongqing Nan'an Technology Innovation Development Co., Ltd..

(1) The relatively efficient business incubators. The business incubators of relatively efficiency is the Class I incubators in clustering analysis, its pure technical efficiency and scale efficiency are close to or equal to 1. The Class I has 8 business incubators and accounts for 28.6% of Southwest business incubators. Sichuan and Yunnan each have three business incubators, Chongqing and Tibet each have one business incubator. In addition to the scale efficiency of F4 business incubator, the pure technical efficiency, scale efficiency and the overall efficiency of the Class I business incubator is 1, that means the pure technical efficiency and scale effeciency of the Class I are effective.

Efficient pure technical efficiency is the business incubator which has reached the best level of resources utilization without considering variation of return to scale, namely changing any input can not increase output, or the existing level of output by using the input has met the lowest level. Concretely speaking, the relatively efficient business incubators can't change the output such as cumulative graduated enterprises, annual graduation rate, average income of graduation through the variation of input such as incubation fund and employees of business incubators. Efficient scale efficiency owns the scale of business incubator which can achieve the best returns under the existing incubator configuration, and any scale change will decrease the efficiency. The scale efficiency of relatively efficient business incubators is 1 which represents effective scales. They should be maintained for continuing operations.

Class I business incubators has obvious advantages in terms of efficiency. Both the scale level and resources allocation have reached the optimum state. They should maintain the existing scale and continue to make breakthroughs and technological innovation. As the highest operating efficiency of Southwest business incubator, the scale level, resources allocation and management experience of Class I business incubators can be the reference for other incubators.

(2) Relatively inefficient business incubators. Relatively inefficient business incubators are Class II business incubators in the clustering analysis. Their comprehensive efficiency are relatively low, and the scale efficiency are lower than the pure technical efficiency. There are 9 relatively inefficient business incubators, which hold 32.1% of Southwest business incubators. There are 4 in Chongqing, 3 in Sichuan, 1 in Yunnan and 1 in Guizhou.

To enhance the operating efficiency of Class II business incubators must adjust the scale and optimize resources allocation according to the return to scale. It can match the scale with the existing inputs and outputs and exploit the advantages of talents and capital to the full. The business incubators can improve the efficiency preferably in this way.

(3) Business incubators of inefficient configuration. Class III refers to the business incubators of inefficient configuration, and it takes the overall proportion of 14.3%. Three of them are located in Sichuan, and one of them is situated in Chongqing. The pure technical efficiency and scale efficiency of Class III are relatively low. The pure technical efficiency is obviously lower than scale efficiency, indicating that Class III need adjust the resource configuration and scales, especially the resources allocation. As it can be seen from table 7, and there is much redundancy in Class III business incubators (F18-F21), such as the number of employees, site area and total incubation funds, the site area is the worst. Such business incubators need to be improved as following: First, the incubators should be appropriate to reduce the area, improve efficiency of utilizing site area and avoid a huge waste of space resources; Secondly, the incubators should streamline institutions, cut down on overstaffing, improve staff skills and quality, make proper jobs rotation, enhance jobs adaptability of employees and enhance human resources efficiency; Finally, controlling incubation fund properly and accelerating turnover of incubation fund will be helpful to improve capital efficiency.

(4) Inefficient scale business incubators. They are Class IV incubators in clustering analysis, and their scale efficiency are obviously lower than pure technical efficiency. They hold 14.3% of all. They distribute over Yunnan, Sichuan, Chongqing, and Guizhou. Class IV business incubators are in the stage of increasing return to scale (Table 7). On one hand, the cause of the inefficient scale is that the scales of the business incubators are unable to achieve scale effect with smaller scales; on the other hand, the scales of business incubators don’t match the input and output of business incubators, and there is a conflict between increasing returns to scale and input redundancy. It may be due to irrational structure of input and output in business incubators, which cause structural imbalance between the incubators input and resources requirements. So they have redundant inputs (including site area, personnel, total fund), while other resources are relatively scarce, such as poor infrastructure, lack of scientific and technological personnel, short of management experience, low incubators awareness, and insufficient policy support.

Thus, the business incubators should be improved as follows: for one thing, they should revise their scales to gain scale effect and cost advantages; for another, incubators could adjust input structure according to the market and their own needs, cut redundant input and add insufficient input. At the same time, business incubators should actively

introduce talents, improve the independent innovation capability, establish their brand image, strengthen their soft power, absorb advanced management experience from outstanding business incubators, and take advantage of preferential policies to attract more potential enterprises which can improve the scale effiency.

Table 7. The inputs and outputs adjustment of invalid business incubators

	Input 1	Input 2	Input 3	Output 1	Output 2	Output 3	Output 4	
The names of business incubators	Employees of business incubators (person)	Site area (square meters)	Total incubation fund (thousand yuan)	Cumulative graduated enterprises (person)	Annual graduation rates of incubating enterprises	New jobs of business incubators (person)	The average graduate income (thousand yuan)	Returns to scale
F9	-2.461	-2918.546	-354.360	82.284	0.000	238.916	62716.898	Increasing
F10	-3.689	-4785.171	-425.639	32.463	0.011	0.000	17581.984	Increasing
F11	-6.228	-10129.664	-924.602	0.000	0.033	874.334	63582.104	Increasing
F12	-8.653	-2896.065	-256.895	54.957	0.000	0.000	909.948	Increasing
F13	-2.453	-5289.346	-2836.316	124.203	0.091	0.000	0.000	Diminishing
F14	-0.821	-972.537	-2607.623	0.000	0.222	1379.675	0.000	Increasing
F16	-8.414	-5221.286	-1026.075	101.745	0.060	0.000	0.000	Increasing
F17	-8.862	-5988.108	-1380.379	94.292	0.052	0.000	0.000	Increasing
F18	-53.335	-18264.445	-1844.446	0.000	0.000	0.000	0.000	Increasing
F19	-11.474	-5972.517	-9424.899	0.000	0.033	1838.842	669.068	Increasing
F20	-23.267	-15062.297	-11021.193	2.580	0.113	0.000	0.000	Increasing
F21	-16.908	-47231.743	-4347.719	0.000	0.009	0.000	0.000	Diminishing
F23	-37.912	-4844.832	-1522.453	123.666	0.061	607.300	481.635	Increasing
F24	-2.522	-2329.733	-563.776	12.936	0.021	24.323	0.000	Increasing
F25	-2.556	-3787.995	-348.610	0.000	0.026	514.932	34506.054	Increasing
F27	-10.690	-8626.448	-870.103	74.828	0.019	523.492	9500.5	Increasing
F28	-10.551	-2101.447	-230.928	78.519	0.053	213.047	0.000	Increasing

5. Conclusions and Recommendations

5.1 Conclusions

This paper adopts DEA method to estimate the overall efficiency of 28 national science and technology business incubators in Southwest China with the data of 2010-2012 years, analyze the provincial differences among operating efficiency of science and technology business incubators in Southwest China, and dissect the operating efficiency differences and the improvement direction with K-means clustering analysis. The results show as below:

(1) The overall operating efficiency of the science and technology business incubators in Southwest displays a downward trend in the dynamic fluctuations. It shows the development trend of "low-high-low" in 2010-2012.

(2) The mean value of operating efficiency (0.700) of the business incubators in Southwest is low, and regional differences in operating efficiency are significant. The operating efficiency of Tibet and Chongqing are relatively high, while Sichuan and Guizhou are comparatively low. This is consistent with conclusions of research on the operational performance of Chinese business incubators (Huang Hong, 2013), which indicating that the level of regional economic development is not the decisive affecting factor for the efficiency of business incubators.

(3) The proportion of invalid business incubators in Southwest which holds 71.4% is relatively large. The ineffective incubators in Southwest have large influence on the level of overall operating efficiency. Irrational resources allocation and low scale levels are the main factors leading to low operating efficiency of business incubators. The results validate the conclusions of previous studies in Northeast, the Yangtze River Delta and other regions ulteriorly(Dai Bibo & Sun Dongsheng, 2012; Yin Qun & Zhang Jiao, 2010; Wang Jing & Wang Keyi, 2012), and that points directions and ideas for further improvement of the Southwest incubators management.

5.2 Recommendations

We could improve the efficiency of business incubators from the angle of business decision, follow-up of incubators and government support in addition to a targeted response.

(1) Rational choice of enterprises. Decision makers should be familiar with the operating characteristics of business incubators, and leverage local government preferential industry policies to improve the running effectiveness of human, financial, and material resources under available level of technology. Enterprises need to investigate hardware and software environment of incubators before settling down, and focus on the support measures of gathering superior industries which are helpful for the development of enterprises. The combination of local industries is good for helping SMEs to grow rapidly and reduce uncertainty from blindly following suit. In addition, the decision makers of enterprises also need to pay attention to their own improvement of management level, establish reasonable development strategies of science and technology enterprises, abandon obsolete concepts of family business, apply modern management methods for enterprises and improve the market competitiveness to grow up with the incubators.

(2) Incubators take the initiative to follow up. The business incubators should recognize their locations and goals, and actively learn the advanced experience from successful incubators. They could attach importance to improve the efficiency of incubating and broaden the financing channels and product market. In this way, they can achieve the purpose of providing one-stop personalized service for enterprises. Then, business incubators could pay attention to the role of talents in the operation of science and technology incubators. A reasonable scale of incubator can reduce unnecessary losses. Furthermore, the business incubators should build strict accepted standards to ensure the quality and quantity of tenant companies and keep the optimal resources allocation. Last, they could provide superior and efficient business consulting services and talents according to different enterprises nature and staffings. In this way, they can build a good venture environment for technology professionals and management personnel at the same time.

(3) The government exerts support. First of all, government should define the strategic orientation of incubators, pay attention to the coordinated development of the whole incubators. Government could build university industrial parks development model of "industry-university-institute" through making full use of scientific research advantage in scientific research institutes concentrated regions such as Chongqing, while developping special industries based on local outstanding resources endowment (mineral, climate, medicine, etc.) in Yunnan, Guizhou, Tibet and other under-development regions. Besides, the government should also make effective evaluation of business incubators running state at each stage in time to ensure the scientificity of the incubators operation. At last, government should add support of talents, financial, goods to incubators. They should formulate relevant policy measures, control situation of business incubators and correct the new problems in time to ensure their efficient and smooth running. By taking these measures, business incubators can help competitive technology companies to stand out as soon as possible.

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Notes

Note 1. Data from the "twelfth five-year" development plan of national science and technology business incubators.

Note 2. Data from the Chinese statistical yearbook.