Incentive Regulation Study about Improving the Operation Efficiency of Scientific and Technological Enterprise Incubator

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ABSTRACT: Scientific and technological enterprise incubator is a complex system that has both high input and high output. Its operation efficiency is affected by many factors. Using data envelopment analysis (DEA), this paper compares and analyses the operation efficiency of 243 national level scientific and technological enterprise incubators from 22 provinces. Based on the result of analysis and scientific and technological enterprise's characters from the point of view of incentive regulation, this paper also proposes some policy suggestions about how to improve the efficiency of the incubator.

KEYWORDS: Scientific and Technological Enterprise Incubator, Operation Efficiency, Data Envelopment Analysis (DEA), Incentive Regulation.

1. Introduction

As new socio-economic organizations to support the growth of science and technology venture enterprises and to promote the transformation of scientific and technological achievements , science and technology enterprises incubators are able to reduce entrepreneurial costs and risk by providing a series of services and resources support based on the different needs of the business growth process, which can help the growth and development of venture enterprises. Practice has proved that, as specialized service institutions of innovation and entrepreneurship, science and technology enterprises incubators have shown their unique features and potential in many aspects. It is because of the prominent role of science and technology enterprises incubators in promoting the development of high and new technology industries, supporting the growth of venture enterprises, promoting employment and the transformation of scientific and technological achievements, cultivating regional economy growth point and so on, they caused a high degree of attention of governments around the world, and then they have been widely adopted in many

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countries and regions, thus they have got rapid development worldwide. China's science and technology enterprise incubators originated in the late 1980s, in the development course of 20 years, from nonexistence to existence, from small to large, the number is growing year by year and the incubation ability is enhancing continuously. According to the statistics of the torch high technology industry development center of national Ministry of science and technology, until the end of 2010, China has totally 896 science and technology enterprises incubators, number after the United States, ranking second in the world, and they have made important contributions to our country's technological and economic development.

However, with the deepening of China's reform and opening up, from the point of view of the practical development of science and technology enterprises incubators, the quantity and quality of China's science and technology enterprises incubators still far can not meet the needs of innovation and entrepreneurship development, the ability of linking and integrating social resources is not strong, the service level is not high, the operation efficiency of science and technology enterprises incubators is low, and also the enterprises incubators are lack of a virtuous cycle of self-development and sustainable development capacity. Investigating its reason, the paper argues

that as a kind of quasi-public goods with positive externalities, the science and technology enterprises incubators have got strong support of the Chinese government in as long as more than 20 years of development and construction process. In our country, the vast majority of enterprises incubators are set up by all levels of government , the phenomenon that the government is both the provision of public services and production operators has not been completely changed, thus it leads to an inevitable low efficiency. Meanwhile, it exists the uncoordinated interests target and asymmetric information between the government and science and technology enterprises incubators. And also the current regulatory policy and institutional arrangement are missing or malfunctioning, therefore resulting to low services quality and low operational efficiency of enterprises incubators. Many empirical studies on various policy effects of regulation conducted by British, U.S. economists show that: Incentive regulation has obvious effects in solving the problem of information asymmetry, promoting enterprises to reduce costs, improve quality and ameliorate services, and also in achieving Pareto improvements.Learning from the successful experience of developed Western countries, combined with China's specific situation, the introduction of incentive regulation in science and

technology enterprises incubator industry has certain positive significance in improving the incubators' operation efficiency.

2. Review of Incentive Regulation Theory

Chinese word "GuiZhi" came from English word "Regulation" or "Regulatory Constraint". Its meaning is regulation management, or rules and regulations restriction. In some related Chinese writings, it is also translated to control. In Economics, regulation generally refers to that government treats controlling market failures as its responsibility, and with its legal right, government makes a series of administrative regulations to microeconomic subject, or direct economic control and intervention. The purpose of regulation is to overcome allocation of resources with low efficiency which is caused by "market failure", and to reach the maximization of social welfare. Regulation is originated from market failure. It is to say that market failure is the logical starting of regulation, which means that the theory basis of regulation is market failure. Basic types of market failure are natural monopoly, externality and information asymmetry and public goods. Because the government or the regulatory organization has some special advantages, likes the government's tax ability, punishment force, compelling force and so on, when there is market failure, which damages the allocation of resources efficiency or public welfare, the government will react to it, in order to ensure the orderly operation and economic growth and to achieve the maximization of social welfare. Chinese scholar Wang Junhao said that the government regulation is actually a special goods which is provided by the government, and the demand of this special public goods comes from the natural monopoly and externality, and the supply is mainly depends on the government's understanding and conditions of the new regulation policy. Only when the government has a depth understanding on the new regulation, there will provide the motivation of regulation. Actually, the history of the regulation is a dynamic process of the constantly changing of the government behavior's force and focus. Generally, the development of the western regulation theory mainly goes through five stages: The Public Interest Theory of Regulation, The Capture Theory of Regulation, The Economic Theory of Regulation, The Theory of Contestable Markets, The Incentive Theory of Regulation.

The incentive theory of regulation was developed from a western regulation economics branch in the 1980s, and with game theory, information economics, principal-agent theory and other emerging theory and analysis method was introduced to regulation theory research, a new

regulation theory, that is incentive regulation theory was developed. Market failure is the reason that regulation exists, and information asymmetry is the premise of the application of the incentive regulation. Incentive regulation is from the point of view of information asymmetry, and then the incentive schemes are designed. Free agency is given to the regulated in some degree, in order to induce and incentive the regulated using information advantages correctly, and choosing behaviors that regulators expected. They hope the regulated could improve internal efficiency, reduce cost, meet a wide range of social interests, and make the regulated's objectives and social goal to converge. Famous Japanese regulation economist Masu Uekusa consists that the incentive regulation is to incentive the regulated to improve internal efficiency, under the original governance structure conditions. The positive incentive to pressure of competition and efficiency of production is given to the regulated. In the incentive regulation, regulators just focus on the regulated's output performance and external effect, but less control the regulated's specific behavior. To encourage the regulated to achieve a certain goal, higher degree of autonomy is given to them.

This property of incentive regulation makes it different from traditional administrative imperative regulation mode.

Incentive regulation is the application of incentive theory in regulation economics. It solves the problem successfully that both sides' information asymmetry in traditional regulation mode which leads to low efficiency. Traditional regulation theory is based on the assumptions that both sides of regulation have common information. However, in regulation practice, the information owned by regulators and the regulated is often not symmetrical. That is to say that regulators do not have complete information about the regulated's production cost, service quality, technology and effort level. In order to solve the low efficiency due to information asymmetry of both sides of regulation, Laffont , Tirole and other scholars apply the game theory and incentive theory in information economics in regulation theory. They analyze the regulatory organizations with incomplete information under the condition of incentive mechanism design problem, and put forward the standard theory framework of the inventive regulation theory. Along with the development of incentive regulation theory and practice, the modern western countries have many category of incentive regulation, and some important types are Franchise Bidding, Yardstick Competition, Social Contract and Price Cap Regulation. The incentive regulation theory is developed and perfected in the natural monopoly industries (such as telecommunication,

electric power and other utility), and now its research and application has been extended to insurance, banking supervision and other fields. However, using incentive regulation theory in the new and high technology industries and enterprise incubation is rare. The theory of externality and public goods in economics offers theoretical basis for the science and technology enterprise incubation industry, and market failure and the information asymmetry theory is the use of incentive regulation of that industry's logical starting. In this paper, the inventive regulation research of the science and technology business incubator begins from the analysis of the operation efficiency.

3. Operation efficiency analysis of science and technology enterprise incubator

The science and technology enterprise incubator is a complex input-output system with multi-input and multi-output, its operation efficiency primarily reflects the relativities between inputs and outputs in the business activities. However data envelopment analysis (DEA) method has the special advantage in dealing with a complex system of multi-input and multi-output. Mainly using mathematical programming methods, with obtained sample data, the method carries out relative effectiveness or efficiency evaluation of the same type to be assessed object with multi- input and multi-output namely decision unit (Decision Making Unit, Abbreviation DMU).The input and output weight

in this method is the optimal weight obtained according to the actual data, so it has high objectivity; This method does not need to assume a specific functional relationship between the input and output, so it has the characteristics of the black box type of research method. This analysis method can reflect objectively input and output efficiency of to-be-assessed object. Also it can analyze comprehensively the current level as well as improvement direction. Therefore, following the principle of advanced method and effective model, this paper chooses the data envelopment analysis method to evaluate and comparison analyze the operation efficiency of the science and technology enterprises incubators.

3.1 Establishment of evaluation index system and data acquisition

（1）establishment of evaluation index system

To establish a rational input and output index system is the premise and basis of applying DEA method to evaluate and analyze. The establishment of evaluation index system firstly needs to launch analysis, discussions and expert interviews, meanwhile it needs to take into account the characteristics of the science and technology enterprises incubators and analyze the needs of their operation efficiency, as well as some principles such as the purpose, comprehensiveness, representativeness of indicators selection and data availability. On this basis, a reasonable evaluation index system can be built.

The input and output indices of DEA analysis method are corresponding to the input-output

relationship of science and technology enterprises incubators. The investment of science and technology enterprises incubators is various types of hatch resources inputs, including two major categories of hardware and software resources. Incubation, by its very nature, is just incubation object-oriented allocation of resources. Based on the index selection principles, this paper select human, financial and material resources as the investment of science and technology enterprises incubators, and then human resources should view the number of practitioners in the incubator as index; financial resources view the total financial resources of the incubator as index, including the total incubator fund and accumulated public technology service platform investment amount; material resources view the total hatching area of the incubator as index. The science and technology enterprises incubators are a kind of multi-output organization, and its output is reflected in the incubator itself and the benefits created by incubator enterprises, including the economic and social benefits, which are reflected in several aspects such as incubation achievements, social outcomes, economic outcomes, and science and technology innovation achievements of the enterprises incubators. Based on the index selection principles, in this paper, incubation achievements view the accumulated number of graduation enterprises and annual graduation rate(the number of graduation enterprises / the number of incubated enterprises the same year) as evaluation index, social outcomes view the number of provided social employment personnel (including the number of the incubators employees and the number of incubated enterprises employees the same year) as evaluation index, economic outcomes view the gross economic income (including the gross income of incubators and the average income of incubated enterprises at graduation) as evaluation index, science and technology innovation achievements view the number of incubated enterprises that are approved to get intellectual property rights the same year as evaluation index. The operation efficiency evaluation index system of science and technology enterprises incubators established by this paper is shown in Table 1.

Table 1 operation efficiency evaluation index system
of science and technology enterprises incubators

index family		evaluation index	index calculation
input index	human resources	the number of the incubators employees	
	financial resources	total financial resources of the incubators	incubation fund amount + accumulated public technology service platform investment amount
	material	gross area of the incubation site	

Output index		resources	
	incubation achievements	the accumulated number of graduation enterprises	
		annual graduation rate	the number of graduation enterprises / the number of incubated enterprises the same year
	social outcomes	the number of provided social employment personnel	the number of the incubators employees + the number of incubated enterprises employees the same year
	economic achievements	the gross economic income	the gross income of incubators+ the average income of incubated enterprises at graduation
	science and technology innovation achievements	the number of incubated enterprises that are approved to get intellectual property rights the same year	

（2）data acquisition

This paper chooses the national science and technology enterprises incubators of 2010 year as study sample. Having removed a part of data-missing sample, this paper finally chooses 243 national science and technology enterprises incubators in 22 provinces (autonomous regions and municipalities directly under the central government) as decision-making unit of efficiency evaluation. The input and output index data of the decision-making units are all derived from official statistics. And then they are sorted out mainly according to the 《2011 China Torch Statistical Yearbook 》 that is compiled by the ministry of science and technology torch high technology industry development center.

3.2.the measure and analysis of technology business incubator operational efficiency

（1）the result of efficiency measure

The essay calculate the data of collection by using EMS and C^2R model and get the result of technology business incubator operational efficiency. Because the calculation results data is in large quantities, each incubator operation efficiency value no longer given, below are

only province calculation results. As shown
in Table 2.

Table 2   summary sheet of each regional state level
technology business incubator operational efficiency measure in 2010

Province	Number of incubated tenants sample	Efficiency mean	Relative effective number of incubator	Ineffective number of incubator	Effective incubator proportion
Beijing	22	70.29%	5	17	22.73%
Tianjin	4	59.95%	0	4	0.00%
Hebei	8	62.62%	1	7	12.50%
Liaoning	13	61.72%	1	12	7.69%
Jilin	4	59.54%	1	3	25.00%
Heilongjiang	7	54.97%	0	7	0.00%
Shanghai	14	56.99%	0	14	0.00%
Jiangsu	40	52.26%	3	37	7.50%
Zhejiang	19	68.92%	3	16	15.79%
Anhui	8	61.86%	0	8	0.00%
Fujian	4	58.66%	0	4	0.00%
Shandong	25	58.54%	3	22	12.00%
Henan	8	58.19%	2	6	25.00%
Hubei	13	72.06%	3	10	23.08%
Hunan	6	58.83%	1	5	16.67%
Guangdong	16	71.37%	4	12	25.00%
Guangxi	4	48.43%	0	4	0.00%
Sichuan	9	59.26%	2	7	22.22%
Yunnan	4	56.67%	0	4	0.00%
Shanxi	11	72.87%	4	7	36.36%
Gansu	2	49.43%	0	2	0.00%
Xinjiang	2	46.87%	0	2	0.00%
Total	243	60.01%	33	210	13.58%

Table 2 reflected the total level of technology business incubator operational efficiency in our country based on the sample of 243 state level technology business incubators. According to population mean, efficiency level is only 60.01%. In the measuring and analysis of the 243 technology business incubators

reach a hundred percent only 33 which are belonged to relative effective incubator, effective incubator accounted for the proportion of the total sample only 13.58%, the other 86.42% are ineffective incubator. All above state that total level of technology business incubator operational efficiency in our country is not optimistic. It has a large space of improvement, the government should give high attention about the effect of enterprise incubator resources input and output.

According to the Table 2, the differences of technology business incubator operational efficiency in each province are obvious. The average value of technology business incubator operational efficiency in Beijing, Hubei, Guangdong and Shanxi are more than 70%, on the contrary, that in Guangxi, Gansu and Xinjiang are below 50%, that is to say the differences of technology business incubator policy formulation and internal management in each districts deserves further study.

（2）the analysis and adjustment of ineffective incubator

In order to further analysis the factor of technology business incubator operational efficiency, find the main factors led to ineffective operational efficiency and identify the improvement direction of science and technology incubators to improve operation efficiency. We need to further projection analysis of the non DEA efficient technology business incubator. When evaluated decision unit is non DEA efficient, There must be input redundancy or insufficient output, and then we can analysis the non DEA efficient evaluated decision unit by using projection analysis method, calculated to make non DEA efficient decision making units into the effective decision units, adjust the input and output to ensure the main factors. According to the technology business incubator operational efficiency calculated result, we can learn that Jiangsu province has 40 technology business incubators, DEA efficient are only 3, the others are non DEA efficient. We can projection analysis about Jiangsu province 37 non DEA efficient incubator by using projection theory, get the analysis results as shown in Table 3.

Table 3　summary sheet of inefficient incubator

input and output index adjustment analysis results in Jiangsu province

Input-output index		Actual value	Target value	Adjusted value	Adjustment ratio
Input indexes	Number of employees of incubated	731	720	-11	-1.37%

	tenants				
	Incubator total financial resources	1598685.00	1142254.05	-456430.95	-28.55%
	Incubation site total space area	2104787.00	1996187.51	-108599.49	-5.16%
Output indexes	Accumulated number of graduated tenants	2520	3184	664	26.34%
	Annual graduation rates	13.15%	15.93%	2.78%	21.18%
	Provide social employment	66939	70029	3090	4.62%
	Economic gross income	820274.00	866746.88	46472.88	5.67%
	Number of incubated tenants approves intellectual property	1916	2571	655	34.21%

According the index adjustment ratio from Table 3, we can learn that index "Number of incubated tenants approves intellectual property" adjustment range maximum, that is to say technology business incubator in Jiangsu province science and technology innovation achievements relative shortage , that is the main factor of technology business incubator operational efficiency. Secondly, index "Incubator total financial resources" adjustment range more, that is to say the incubator financial resources input are redundant and waste, that is also the main factors.

Thirdly, index "Accumulated number of graduated tenants" and "Annual graduation rates" adjustment range over 20%, that is mean the graduated from incubator incubation enterprise quantity relative shortage ,they are the important factors. The factors all above are the main reasons which lead to the lower incubator operational efficiency. It is the key improved aspects to improve the technology business incubator operational efficiency in Jiangsu province.

4.Forth, the incentive regulation policies and proposals to improve the

operational efficiency of the technology enterprise incubators

The above analysis shows that China's science and technology enterprise incubators as the quasi-public goods with positive externalities needs to further improve its operational efficiency. Combined with the above analysis and characteristics of technology enterprise incubators, this paper put forward the following policy recommendations to improve the operational efficiency of the technology business incubators from the view of the incentive regulation.

（1）The introduction of yardstick competition. Incentive regulation theory provides us with many specific measures for reference and new ideas to solve the problem, and using incentive regulation needs to select a specific embodiment according to the actual situation of different industries reasonable. The earlier analysis shows that the operational efficiency of technology business incubators in various regions of China is different, so we can try to introduce yardstick competition.。 The basic idea of using this regulatory is using operational efficiency and service quality indicators which other regions similar to the region's technology business incubators as a reference, and formulating the reasonable operational efficiencies and service standards in the region's technology business incubators. It can inspire the region technology business incubator to reduce costs, improve service and increase operational efficiency. This method provides a convenient channel to access industry information for regulation. If the conditions of different regions are closing, we can use the information from other areas of science and technology business incubator to regulate the incubators in the region in theory. This method by comparison with business incubators' similar conditions can reduce the information asymmetry and lower the cost of access to information. With this method, it can regulate the technology business incubators nationwide effectively. Government or regulatory agencies use the operational efficiency and other indicators different levels of "benchmark incubator "as measures, and considering regional differences. On this basis, the development of regulatory standards, prompting the region's technology business incubators indirect competition between regions to improve operational efficiency and expand.

（2）The gradual implementation of franchise bidding. Many of our technology business incubators are building by all levels of government, the government is both the incubator provides operators, resulting in a low efficiency can not be avoided. For these government-owned science and technology business incubators can be gradually introduced to the concession tendering system, select the appropriate vendor contracted lease

operation. Franchise bidding is the introduction of a number of vendors through a competitive tender earns the franchise of technology business incubator. This method can guarantee the successful of the most efficient tech business incubator with more low-cost manufacturers to provide more quality services, and also be able to make the business successful manufacturers to meet the intent of the government regulation. Franchise bidding in the bidding stage of the competition instead of regulation, the Government's role is to act as the auction rather than regulation. Franchise usually has a specified number of years, under the pressure of a potential competitor, the current franchise vendors in order to prevent the loss of the right to operate in the next operating period, they must constantly improve the quality of service, and further improve the operations of the incubator efficiency. Franchise bidding by bidders' competition not only improves the operational efficiency of the incubator, but also reduces the burden on the government or regulatory agencies. Bidders competition for concession eliminate government regulation which are difficult to solve the information asymmetry problem,, and the competition decided concession rather than regulation to decide concession

（3）The rational use of other types of regulatory tools. Because there are positive externalities in technology business incubator, its social benefits outweigh the private benefits, leading to a lack of economic dynamism of private sector business incubator. Maintain incubator normal operation, it is necessary for the incubator conducted to support, as long as an incubator to hatch the project in line with the government in the high-tech on to encourage direction, the government should make rational use of the various regulatory tools, such as giving incubators financial subsidies, tax relief, subsidized loans, and so on, to ensure its continuing operations. To make regulatory tools play a stimulating, the regulatory programs should be rational designed. Financial subsidies, for example, the amount of it can be determined by the incubator's actual contribution in order to play the role of the financial subsidies incubator incentive, specifically, the actual contribution of the incubator can be reflected by the quantity and quality of incubator companies. The amount of the subsidy can be divided into two parts, the basis of subsidies and benefits of subsidies, respectively linked to the quantity and quality of the graduation enterprise. The number of qualified graduate enterprise reflects an important indicator of the operational efficiency of the incubator, the government can be given as the number of qualified graduate enterprise incubator basis for subsidies, the more the number of firms qualified graduation, the greater the basis of the

amount of subsidies. Created in the incubated enterprises and graduated corporate tax revenue reflects incubators generate the part of the social benefits, Tax incubated enterprises and graduated enterprises create, within a certain number of years, according to a certain proportion from the annual tax return replenishment business incubators as effective subsidy incubator. In this way, it can inspire incubator to make a large number of qualified graduating enterprise' enthusiasm, and link the government subsidies to the operational efficiency of technology business incubators. Thus, it can improve the operational efficiency of the incubator, and achieve the sound development of the incubator.

（4）Improve the institutional basis of the incentive regulation. Incentive Regulation is based on the environment of market economy and the rule of law. To incentive regulation on the implementation of the technology business incubator, the first task is to improve the institutional basis of incentive regulation. Strictly regulate administrative procedures for the implementation of incentive regulation to the regulated sector, the only clear procedural requirements to ensure that the incentive regulation policy formulation and implementation. The same time, in order to meet the requirements of the development of market economy, it is necessary to constrain and limit the permissions of the

regulation, government regulation must be appropriate, especially in the decisive role of the market mechanism for allocation of resources can not be shaken. The market mechanism as the basis for allocation of resources is a guarantee of efficiency, and government regulation have to go through the market mechanism to implement and work. In view of the characteristics of the technology business incubators quasi-public goods, irrespective of incentive regulation measures the incubator management requires both government intervention, but also give full play to the role of the market mechanism. Only incentive regulation and market mechanisms parallel, to jointly promote the sustainable development of the technology business incubators.

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