

## Study on the Independent Innovation Capability of Innovative Pilot Enterprises: A Case in Fujian Province of China

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**Abstract** Possessing independent intellectual property rights, independent brand and continuous innovation ability is the overall requirements of innovative enterprise in our country. In this paper, we take the first batch innovative pilot enterprises in Fujian province as the research object, using the factor analysis, the paper discusses the internal factors of independent innovation in different types of enterprises, and the paper has different characteristics analysis for all kinds of enterprises. We found that the difference of internal factors influence of different kinds of large enterprises were tiny, in different kinds of small and medium-sized enterprises, high-tech enterprises and private enterprise the influence was different. The conclusion provides practical guides for local government to further promote innovative enterprise pilot job.

**Keywords** Innovative pilot enterprise; Independent innovation capability; Inner impact factor; Fujian Province

### 1 Introduction

Fierce international competition and the reality of China's economic development that make our government recognize that enhancing China's economic competitiveness greatly depends on our ability to create a group of innovation-oriented enterprises with independent intellectual property rights, independent brands and sustained innovation capability. July 2006, Ministry of Science and Technology, the State Council, the SASAC, China Federation of Trade Unions three ministries start pilot innovative enterprises, thereafter, many cities, including Fujian province also start pilot innovative enterprises and the experimental work. Due to the independent innovation achievements of innovative pilot enterprise mainly comes from internal factors, some external factors can through the internal factors play a role. At present, there are many research literatures at home and abroad, but they are mainly based on the comprehensive evaluation of innovation inputs and outputs. Foreign economic circles often use R & D investment and patent activity index as an approximation when they measure innovation inputs and outputs<sup>[1]</sup>. To innovation inputs, most part of scholars inspect only from the perspective of R & D costs<sup>[2][3][4][5][6][7]</sup>, but using R & D costs and R & D personnel (usually the quantity of scientists and engineers engaged in research) two indicators is still occupying the mainstream<sup>[8][9][10]</sup>. Innovation output quantitative index have a development process, due to the close relationship with innovation, data accessible, and slowly, the patent standard is objective, slowly changeable, since the 1970s patent as a measure of innovation output level index has been widely applied<sup>[11]</sup>, patent quality has become the enterprises' independent innovation ability, and the main factor of the core competitiveness. Of course, in recent years, along with the people's further understanding of the innovation process, Relevant research has gradually involved in the education and training of enterprise R & D personnel, and innovation strategy, incentive mechanism and innovative culture, etc. Domestic related research mainly focuses on national emphasis in independent innovation, Innovation evaluation index mainly refers to R&D costs, R&D personnel, innovation output, innovation management, innovation strategy, and innovative environment, etc<sup>[13][14]</sup>. Some scholars usually adopt R&D index for innovative research<sup>[12][13]</sup>, China's science and technology development strategy research group use the traditional index to study Chinese regional innovative ability. But, the discussion of influence factors of independent innovation ability for Innovative pilot enterprises is still relatively lacking, the research that combining with the enterprise characteristics is also rare. So, it provides a good study space for this paper.

Usually, the independent innovation capability of enterprises mainly studies whether the enterprises achieve a breakthrough in core technology and obtain independent intellectual property rights. Because the patents are the most important and intuitive intellectual property products<sup>[14]</sup>, they are often used to measure innovation capacity<sup>[15][16][8]</sup>. Of course, which patented type can embody the core technology best is the invention patent right. Therefore, this paper emphasizes on discussing the patent of independent innovation, especially in the output (patent for invention has important influence factors).

## **2 Inner Impact Factors' Selection and Data Source of Enterprises Independent Innovation**

### **2.1 The inner impact factors' selection**

Based on the related research achievements at home and abroad, according to the overall requirements of innovative enterprise, and enterprise development in Fujian province, we absorb two indexes commonly used in traditional research of R&D costs and R&D personnel. Secondly, due to the innovation practice proves that enterprise innovation output not only depends on whether the enterprise with R&D personnel, but also depends on the enterprise later input for education and training<sup>[17]-[19]</sup>, because only the human capital increase to a higher level of innovation can produce positive effects<sup>[21]</sup>. At present, the elasticity of scientific research personnel input to innovation output is 1.201<sup>[11]</sup>. Therefore, we incorporated the worker education, training, learning expenditure indexes into the evaluation system. After that, the development of enterprise independent innovation needs a complete innovation system's support, so enterprise technology R&D institution construction index is indispensable. In addition, the patent output and its growth rate of modern enterprise depend on its innovative management level, especially the feasible innovation strategy and effective incentive mechanism is the most important<sup>[21]</sup>. Therefore, this article mainly chose six internal elements for research; there are enterprise R&D input intensity, R&D personnel proportion in enterprise employees, education, training and learning expenses proportion in main business gross income, enterprise technology R&D institution construction condition, enterprise innovation development strategy construction condition and the innovation incentive mechanism condition.

### **2.2 Data source**

This paper takes the first pilot enterprise in Fujian province as research samples, including large enterprise (31), small and medium-sized enterprises (30), state-owned enterprises (15), private enterprise (46), high-tech enterprise (51) and traditional enterprise (10). The sample data mainly comes from the first batch of 61 innovative pilot enterprises' "innovative enterprise self-evaluation report" that jointly collected by the federation of Fujian Provincial Science and Technology Department, Economic and Trade Commission, the SASAC, trade unions (not including the commentary on the state-level innovation-oriented enterprises, and those have been included or recommended by the national pilot innovative enterprise). Since this paper mainly verified the independent innovation situation of these companies after two years' pilot period, therefore this paper also uses the annual examination data for research (i.e. the 2008).

## **3 Independent Innovation Inner Factors Analysis for Innovative Pilot Enterprises**

This paper mainly uses factor analysis method to analyze the main inner impact factors. Firstly, we standardizes the original data (due to the sample data are positive indicator, so we ignore whether isolated treatment), Then we do factor analysis for six types of sample unit index, according to the principle of more than 1 Eigen value to select common factors, and through the maximum rotation matrix load and variance of rotation matrix. According to the results of data processing, and submit the materials and typical business enterprise research, we extracted from different types of enterprise's main innovation inner impact factors (need to explain, because there is no need to use common factor to do the analysis and evaluation, so in the process we ignore the fitness test):

### **3.1 Inner factors of large enterprises**

For large enterprises, we can get to two indexes that are innovation strategy and incentive mechanism of innovation which makes greater contribution for the first common factors, enterprise technology R & D institution-building status indicator makes a bigger contribution for the second factor. Therefore, there are three input elements that have a greater impact on large enterprises. It illuminates that innovation management is even more important after enterprise gets bigger. At the same time, it also needs to strengthen enterprise technology research and development institutions, which can provide a complete innovation system for enterprises' independent innovation.

### **3.2 Inner factors of small and medium enterprises**

For small and medium enterprises, according to the factor analysis output results, we get three male factors, Through the load analysis, we can elicit two indexes that are R&D input intensity and R&D personnel proportion which make greater contribution for the first male factors, education, training and learning expenses of main business operation proportion indicator makes the bigger contribution for the second factor, innovation incentive mechanism indicator makes the bigger contribution for the third factor. Therefore, there are four input elements that have a greater impact on small and medium

enterprises. Lack of funds, talent shortage and personnel quality is small is the fatal crux of small and medium enterprises' development, this is also the common problem of small and medium enterprises in general. Moreover, because the scale is small, Enterprise mechanism, system is not perfect, so we need an effective incentive mechanism for innovation and development.

### **3.3 Inner factors of High-tech enterprises**

For High-tech enterprises, we get three main factors, Through the load analysis, we can elicit two indexes that are R&D input intensity and R&D personnel proportion which make greater contribution for the first main factors, innovation incentive mechanism indicator makes the bigger contribution for the second factor, enterprise technology research and development institutions indicator makes the bigger contribution for the third factor. Therefore, there are four input elements that have a greater impact on High-tech enterprise. High-tech enterprise with high investment, high risk, high difficulty etc. Therefore, it requires a higher input for R & D funding and personnel, and in order to stimulate R & D personnel an arduous study for independent innovation, we need more effective incentive system and measures.

### **3.4 Inner factors of traditional enterprises**

For Traditional enterprises, we get two main factors, through the load analysis, we can elicit two indexes that are R&D input intensity and R&D personnel proportion which makes greater contribution for the first main factors, innovation incentive mechanism indicator makes the bigger contribution for the second factor. Therefore, there are three input elements that have a greater impact on traditional enterprise. . The main reason for traditional enterprises' backward is that lack of traditional input elements (R&D input intensity and R&D personnel proportion). There also exists lag phenomenon in the innovation management, especially the incentive mechanism, system for independent innovation. Therefore, independent innovation is relatively weak.

### **3.5 Inner factors of the state-owned enterprises**

For the state-owned enterprises, we get two main factors, through the load analysis, we can elicit two indexes that are R&D input intensity and R&D personnel proportion which makes greater contribution for the first main factors, innovation incentive mechanism indicator makes the bigger contribution for the second factor. Therefore, there are three input elements that have a greater impact on state-owned enterprise. Due to the inflexible mechanism of state-owned enterprises and the relatively poor efficiency, the funding is insufficient, and brain drain problem is serious. Therefore, only these three areas were resolved through great effort can enhance the strength of independent innovation of the state-owned enterprises.

### **3.6 Inner factors of private enterprises**

For private enterprises, we get three main factors, Through the load analysis, we can elicit that R&D input intensity makes greater contribution for the first main factors, enterprise technology research and development institutions indicator makes the bigger contribution for the second factor. R&D personnel proportion indicator makes the bigger contribution for the third factor. Therefore, there are three input elements that have a greater impact on private enterprise. Due to the limitations of their private enterprise, lack of capital investment is the biggest problem in the process of independent innovation. Secondly, it is a common phenomenon that the enterprise technology research and development institutions are not perfect, but this is the main factor for independent innovation lag of private enterprises. In addition, most private enterprises' development is not stable, led to a serious R & D personnel flow.

## **4 Comparison Different Kinds of Enterprises' Different Characteristics Based on the Main Inner Factors of Independent Innovation**

### **4.1 The different characteristics between High-tech enterprise and traditional enterprise, state-owned enterprise and private enterprise in the large enterprises**

There are high-tech enterprise, traditional enterprise, state-owned enterprise and private enterprise in the large enterprises, in order to further understand the main inner impact factors, such as "Innovation strategy", "Innovation incentive mechanism", and "Enterprise technology research and development institution construction condition" have different influence to different types of enterprises, we did correlation assumption test.

For "Innovation strategy" elements, we can do comparison between high-tech enterprise and traditional enterprise.

Assumption 1: Because of high and new technology enterprise mainly carries on the precise and advanced innovation, the risk is very high, they need more strategy and planning for future development than traditional enterprise planning.

Table1 have Listed the three major input elements of the statistical data and the patent license of 2008 annual examination of large enterprise and traditional enterprise high-tech enterprise, state-owned enterprises and private enterprises (considering the current intellectual property products of enterprise is relatively poor, the invention patent, the patent for utility model or design patent and the software copyright are clinching in the patented product evaluation. And, given autonomy mainly authorized, therefore this patent doesn't use patent application as foreign economic usually used, but use patent license to measure the data).

**Table 1 Mean Value of the Main Inner Impact Factor of Large Enterprises in Annual Review**

	classification	amount	innovation strategy	innovation incentive mechanism	technology R&D institution construction condition	invention Patent	three patent sum
large enterprises	High-tech	27	7.22	7.41	91.49	0.89	9.19
	Traditional	4	7.75	7.25	41.687	0.25	2
	state-owned	10	7.4	7.5	68	0.60	3.7
	private	21	7.24	7.33	93.2	0.91	10.43

In order to analyze the difference of the enterprises, we have done the inspection (in table 2 and 3). In table 2(a), calculation results show that the means of traditional enterprise and high-tech enterprise are highly approached. In table 2(b), the corresponding t is 0.214, higher than the significant level $\alpha$  ( $\alpha = 0.05$ ), we should not refuse to zero assumption, think of the influence of "innovation strategy" elements to traditional enterprise and high-tech enterprises have no significant difference in the level of 5%.

**Table 2(a) Descriptions**

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Traditional	4	7.7500	.50000	.25000	6.9544	8.5456	7.00	8.00
High-tech	27	7.2222	.80064	.15408	6.9055	7.5389	6.00	9.00
Total	31	7.2903	.78288	.14061	7.0032	7.5775	6.00	9.00

**Table 2(b) ANOVA**

	Sum of Squares	df	Mean Square	Sig.
Between Groups	.970	1	.970	.214
Within Groups	17.417	29	.601	
Total	18.387	30		

Due to the influence of the factors under different types of enterprise internal differences are compared using the same method, in order to save space omitting the calculation process, this paper calculated results and analysis.

Calculation analysis revealed that "innovation strategy" elements of state-owned enterprises and private enterprises in the level of 5% did not differ significantly. "Innovation incentive mechanism" elements have no significant difference in the level of 5% to high-tech enterprise and traditional enterprise, state-owned enterprises and private enterprises. "Enterprise technology R&D institution construction condition" elements have no significant difference in the level of 5% to high-tech enterprise and traditional enterprise, state-owned enterprises and private enterprises, too. That means during pilot period the large enterprises in various enterprises for independent innovation within three

main influence factors paid more attention to the average investment in enterprises (Just in the enterprise technology R&D institution construction of some gaps), these inner impact factors for different types of enterprises have different influence. The gaps of different types of enterprise innovation output (patent, especially invention patent), we think this is due to the original foundation of different types of enterprises, namely of inner impact factors affect difference is not big, but different base will inevitably lead to different output.

#### 4.2 The different characteristics between High-tech enterprise and traditional enterprise, state-owned enterprise and private enterprise in the small and medium-sized enterprises

**Table 3 Mean Value of the Main Inner Impact Factor of Small and Medium-sized Enterprises in Annual Review**

	classification	amount	R & D input intensity (%)	R&D personnel proportion (%)	education expenses proportion (%)	Innovation incentive mechanism	invention Patent	three patents sum
small and medium-sized enterprises	High-tech	24	5.72	22.07	1.23	6.75	0.17	4.58
	Traditional	6	16.97	32.25	0.76	6.5	0.17	4.17
	state-owned	5	23.32	60.14	1.08	7.4	0.2	2.6
	private	25	4.89	17.62	1.15	6.56	0.16	4.88

There are also high-tech enterprise, traditional enterprise, state-owned enterprise and private enterprise in the small and medium-sized enterprises. Calculation results show that “R&D input intensity” elements have significant difference in the level of 5% to high-tech enterprise and traditional enterprise, state-owned enterprises and private enterprises. “R&D personnel proportion” elements have significant difference in the level of 5% to state-owned enterprises and private enterprises. In addition, “R&D personnel proportion” elements have no significant difference in the level of 5% to high-tech enterprise and traditional enterprise. “Education expenses proportion” elements have no significant difference in the level of 5% to high-tech enterprise and traditional enterprise, state-owned enterprises and private enterprises. “Innovation incentive mechanism” elements have no significant difference in the level of 5% to high-tech enterprise and traditional enterprise, state-owned enterprises and private enterprises.

According to the calculation result analysis, high-tech enterprise and traditional enterprise have difference in “R&D input intensity”, because this batch of small and medium-sized traditional enterprises after incorporated into pilot, they have greater pressure, so they increased “R&D input intensity”. We can see from the table 3 of their efforts, State-owned enterprises and private enterprises, “R&D input intensity” differences in state-owned enterprises, mainly due to the fund relative abundance than private enterprise, and easy to get all support, table 3 shows the difference of their capital investment, State-owned enterprises and private enterprises ", "R&D personnel in proportion, current differences in private enterprises in R&D talents cultivation absorb, is relatively backward.

In addition, the high-tech enterprise and the traditional enterprise in R&D personnel proportion have no significant differences, we think that the main reason is two kinds of enterprises are more attention R&D talents cultivation, absorbing work (see chart 3), also shows that traditional enterprise in the pilot R&D personnel so close to actively expand the scale of talented high-tech enterprise; high-tech enterprise and the traditional enterprise in “education expenses proportion” have no significant differences means that two kinds of enterprises pay attention to the investment of personnel training, we can be seen from the table 3 traditional enterprise investment is already close to high-tech enterprise. State-owned enterprises and private enterprises in “education expenses proportion” have no significant differences, that’s because private enterprises for their own interests, pay more attention to the investment of personnel training than state-owned enterprises. From the table 3 we can see that the investment of private enterprises is a little higher than state-owned enterprises. High-tech enterprise, traditional enterprise, state-owned enterprise and private enterprise have no significant differences in “innovation incentive mechanism”, that’s because they all noticed that “innovation incentive mechanism” have incentive effect to innovation, especially to independent innovation. We can see from table 3.

Due to the main inner factor have greater influence to state-owned enterprise and private enterprise than high-tech enterprise and traditional enterprise. So their innovation output (patent, especially invent patent) was very different (Table 3).

#### 4.3 The different characteristics between large enterprise, small and medium-sized enterprises, state-owned enterprise and private enterprise in High-tech enterprises

Table 4 Mean Value of the Main Inner Impact Factor of High-tech Enterprises in Annual Review

	classification	amount	R & D input intensity (%)	R&D personnel proportion (%)	Innovation strategy	Technology R&D institution construction condition	invention Patent	three patents sum
high-tech enterprises	large	27	4.34	16.99	7.22	91.49	0.89	9.19
	Small and medium-sized	24	5.72	22.07	6.67	115.5	0.17	4.58
	state-owned	11	5.89	22.02	7.18	87.41	0.46	3.09
	private	40	4.74	18.66	6.9	107.02	0.58	8.1

There are also large enterprises and small and medium enterprises, state-owned enterprises and private enterprises in high-tech enterprises. Calculation result show that "R & D input intensity" elements have significant difference in the level of 5% to large enterprise, small and medium-sized enterprises. Besides, "R&D input intensity", "Innovation development strategy" elements have no significant difference in the level of 5% to state-owned enterprises and private enterprises. "R&D personnel proportion" elements have no significant difference in the level of 5% to large enterprise small and medium-sized enterprises, state-owned enterprises and private enterprises. "Enterprise technology R&D institution construction condition" elements have no significant difference in the level of 5% to large enterprise, small and medium-sized enterprises, state-owned enterprises and private enterprises, too.

According to the calculation result analysis, large enterprise, small and medium-sized enterprises have differences in "R&D input intensity" is because small and medium-sized enterprise condition congenital deficiency, survival crisis is great, once they realize innovation investment can create good development prospect, they will pay more attention on R&D input than large enterprise. We can see it from the table 4, large enterprises; small and medium-sized enterprises have differences in "innovation development strategy" is because once enterprises become larger, they will establish a set of innovation development strategy, and equipped with detailed measures, and earnestly implement. We submit through the enterprise materials and an investigation, and validate it.

In addition, according to the material analysis, we found during the trial of small and medium-sized enterprises in R&D personnel the important influence factors on the inner increasing investment. And from the table 4 we can see small and medium-sized enterprises have more than mean large enterprises, But in the enterprise technology research and development institutions, enterprises are in the high-tech enterprise, basically established R&D institutions at various levels, and therefore to large enterprises and small and medium-sized enterprises in "R&D personnel proportion" and "enterprise technology R&D institution construction condition" little difference.

For state-owned enterprises and private enterprises in high-tech enterprise, Calculation results show that in the four major inner impact factors, we have no significant differences in the conclusion is, although the state-owned enterprise in "R&D input intensity", "R&D personnel proportion" and "innovative development strategy" aspects of private enterprise, over private enterprise in "enterprise technology R&D institution construction condition" on a slightly higher state-owned enterprises (see table 4), but not enough to constitute the significant differences between the degree of efforts.

Therefore, the main influence factors of the internal due to large enterprises and small and medium-sized enterprises than the influence of state-owned enterprises and private enterprises affect difference before two kinds big, innovative enterprise in China (patent output, especially after the invention patent) than the difference of two large (see table 4). But state-owned enterprises and private enterprises in the innovation of output gap, we think are mainly due to the original foundation of two kinds of enterprises.

#### 4.4 The different characteristics between large enterprise, small and medium-sized enterprises, high-tech enterprises and traditional enterprises in private enterprise

There are large enterprises and small and medium-sized enterprises, and also hi-tech enterprise and traditional enterprise in private enterprises. Calculation results show that "Innovation development

strategy”, “Innovation incentive mechanism” elements have significant difference in the level of 5% to large enterprise, small and medium-sized enterprises. Besides, “Innovation development strategy”, “Innovation incentive mechanism” elements have no significant difference in the level of 5% to high-tech enterprises and traditional enterprises. “Enterprise technology R&D institution construction condition” elements have no significant difference in the level of 5% to large enterprise, small and medium-sized enterprises; high-tech enterprises and traditional enterprises. “R&D personnel proportion” elements have no significant difference in the level of 5% to large enterprise, small and medium-sized enterprises, too.

**Table 5 Mean Value of the Main Inner Impact Factor of Private Enterprises in Annual Review**

	classification	amount	Innovation strategy	Innovation incentive mechanism	Technology R&D institution construction condition	R&D personnel proportion (%)	Invention patent	Three patents sum
private enterprises	large	21	7.24	7.33	93.19	17.83	0.91	10.43
	Small and medium-sized	25	6.68	6.56	121.12	17.62	0.16	4.88
	high-tech	40	6.9	7	107.02	18.66	0.58	8.1
	traditional	6	7.17	6.33	117.37	11.45	0	2.83

According to the calculation result analysis, large enterprises and small and medium-sized enterprises have difference in “Innovation development strategy” and “Innovation incentive mechanism” is because in innovation management, large enterprise is better than small and medium-sized enterprise. However, we should also notice this kind of small and medium-sized enterprises in these two factors have close to large enterprises (see table 5), as for “Enterprise technology R&D institution construction condition” and “R&D personnel proportion”, there is no significant difference between large enterprise and small and medium-sized enterprise. We think that’s because these two factors have relatively close in large enterprises and small and medium-sized enterprises of this batch private enterprises. (The actual data in table 5 although display in “enterprise technology r&d institution construction condition”, two kinds of enterprise still have certain disparity). Therefore, it is because the two kinds of enterprises have differences in input factors which caused the innovation output gaps (patent, especially invention patent) (see table 5).

For the high-tech enterprise and traditional enterprise in private enterprises, Calculation results show that in the four main influence factors within there were no significant differences, according to the actual material and research results, we think this kind of traditional during the pilot is in four elements on the input, already close to high-tech enterprise, and even some elements on the reason of slightly more than high-tech enterprise (see chart 5). However, two kinds of enterprise innovation output gap still, we think is mainly due to the original foundation of two kinds of enterprises.

In addition, because of the first batch of innovative pilot enterprises in Fujian province in the traditional enterprise, state-owned enterprises for 10, 15, sample size too small, so we have to these two types of enterprise variance analysis.

## 5 Conclusions

Based on the subject of the first batch of innovative pilot enterprise evaluation data in Fujian province, this paper has made some attempt to the main investment elements of quantitative research for independent innovation of enterprises, and we has explored and analyzed the different role of input factors in different types of enterprises, but the sample size of the first batch of enterprises is not big enough, maybe it will have some impact on the results of quantitative research, there still much to be desired.. But we can have a view on regional innovative pilot enterprises of independent innovation reflected in the effectiveness, and provide inspiration for the work of pilot innovative enterprises.

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