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# How is Innovation Performance Under the Restriction of Industry Cluster: Evidence from a Survey on High-Tech Firms

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## Abstract

*Under-development of high-tech industry cluster hampers the strategy of innovation-driven for less developed regions. While prior studies has demonstrated innovation difference among regions, little attention has been paid to innovation heterogeneity at firm-level. An conceptual model is adopted to evaluate innovative activities of high-tech firms in under-development regions. Using unique firm survey, an investigation was thoroughly conducted on high-tech firms. Based on survey data of 142 high-tech firms, some interesting results emerge. Lack of support from industry cluster, depression effect of technological innovation is not obvious. SMEs have more inclination to innovate, asymmetry exist between occupation of innovative resources and innovation ability, and weak innovation agglomeration effect shows in two development zones. Further analysis on input-output efficiency of innovation indicate that, input-output efficiency of R&D funding is relatively good, but R&D personnel and innovation management are insufficient, which lead to low effective conversion effect.*

**Keywords:** Technological innovation; Heterogeneity; Resources and Environmental Constraints; Depression Effect

## 1 Introduction

China are becoming a innovation superpower. In 2018, China's R&D expenditure totaled 1.97 trillion yuan, accounting for 2.18% of GDP, and technological progress reached up to 58.5%. High-tech firms are the most active group of scientific and technological innovation activities. With intense enthusiasm for technological innovation, they are not only the major driving force behind innovation, but also achieve self-growth and development through innovation. Since 2012, high-tech firms have actively involved in the process of innovation-driven development. In 2018, 181,000 high-tech firms achieved 1.7 trillion yuan turnover of technology contracts. Technology innovation focuses on whether or not bring long-term economic growth. Both technology and products of high-tech firms are time-bound and short in cycle, featured by higher knowledge and capital intensity, strong resource mobility and fast growth, which makes innovation behavior also demonstrate certain characteristics that in turn influence innovation performance. However, innovation heterogeneity among regions in China mustn't be neglected in the transformation stage of high-quality development. It is especially true for developing western regions in China, competitiveness of high-tech firms active on markets became increasingly determined by innovation. On the contrary, Innovation-driven pattern has been strongly supported by 125,112 high-tech firms in eastern China. By 2018, there has been 599 high-tech firms in Xinjiang, about 50 percent of them in growing stage. To be worse, Xinjiang's fiscal R&D expenditure has been deducted significantly in the last two years, accounting for less than 1% of government spending, far from demands of scientific and technological progress and development.

Innovation output depends largely on innovations input. Hans and Almas (2002) have proposed, lack of technological information hampers innovation investments, while a lack of external financial sources positively affects innovation efforts. Information asymmetry and high self-innovation heterogeneity may lead to the dislocation of the financing role of the government and the market<sup>[1]</sup>. A scientific evaluation model of high-tech innovation ability is conducive to solving problems such as information asymmetry among firms, governments and financial institutions. A large number of literature have focused on innovation and performance evaluation of high-tech industry in developed regions, especially listed companies, while little attention to less developed regions. In this paper we focus on the role that innovation ability plays as an importance to performance heterogeneity among high-tech firms. Our definition of performance heterogeneity is related to the differences in innovation

output among firms. We take advantage of the unique survey opportunity supported by government institutions. We will then try to establish the existence of a relationship between innovation ability and performance.

The innovation survey of firms grew up around the 1970s, gradually formed a normative survey in the 1980s. OECD and member states have successively launched the *Oslo Manual* since 1992, the third edition of which has been published so far<sup>[2-3]</sup>. It becomes an internationally recognized guide to innovation survey. The United States Census Bureau conducts innovation surveys, and the statistics on government science and technology activities are assigned to the National Science Foundation<sup>[4]</sup>. In addition, many academic institutions specialize in innovation survey and analysis, such as the 4,800 innovation surveys of SPRU in the UK and the innovation surveys on 8,000 commodities conducted by the US Small Business Management Association<sup>[5]</sup>. Since 1980s, China has been actively carrying out surveys on firm innovation, such as the innovation survey on 105 firms with output beyond 1 million yuan conducted by National Research Center for Science & Technology for Development in 1989, the “Industry Survey” in 1994, “the innovation survey on large and medium-sized industrial firms of six provinces and cities” in 1996, the “innovation surveys conducted by the Development Research Center of the State Council and National Bureau of Statistics on large and medium-sized firms of two provinces, Fujian and Gansu, in 1994-1995, the annual survey on firm innovation conducted by National Bureau of Statistics throughout the country from 2007 to 2017<sup>[6-8]</sup>. These innovation surveys drew lessons from the approach of OECD, and involved R&D input, innovation output, innovation model, innovation policy and institutional environment at firm level. Currently, innovation surveys on high-tech firms is at the stage of catching-up development in China, raising new issues for formulating innovation policies and requiring to obtain comprehensive innovation survey data<sup>[9-10]</sup>. In 2012, the National Innovation Conference specified the objectives and tasks of constructing the national innovation survey system. In April 2017, the Ministry of Science and Technology and the National Bureau of Statistics issued the *Measures for the Implementation of the National Innovation Investigation System* (hereinafter referred to as the *Implementation Measures*) and established a national innovation survey system in China<sup>[11]</sup>. Zhang Chidong (2013) looked into and analyzed major technology innovation projects of innovative firms, evaluated characteristics and tendencies of technological innovation<sup>[12]</sup>.

Characteristics of innovation activities of high-tech firms reflect their survival state. It is important to find correlation between innovation activities with actual performance. Previous assessment on innovation performance of high-tech firms focuses on constructing index systems and evaluation methods. Major of evaluation models involves innovation input-output, innovation behavior process and innovation benefit, etc., among which input-output level has been widely used. In terms of selecting the evaluation methods, DEA method, factor analysis method, neural network method and regression analysis method all have advantages and limitations respectively. In contrast to other methods, results form DEA are more objective and accurate from the perspective of innovation efficiency. Xu Xia (2016) , Chen Yingwen, et.al. (2018) have used two-stage DEA model to evaluate the innovation efficiency of China's high-tech industry. Little literature has focused on innovation performance from micro perspective of firms<sup>[13-14]</sup>. Zhang Yuchen and Zhou Jie (2013) took sales revenue of new product as the indicator of innovation performance, analyzed factors impacting on innovation performance of foreign high-tech firms in Shanghai<sup>[15]</sup>. The results have shown positive correlation between R&D capital, R&D personnel and research institutions with innovation performance. Zhao Xiyang and Liu Yaqin (2016) employed the factor analysis method to assess innovation performance of high-tech firms in Hubei Province. They have concluded that economic development played a great role in improving innovation performance of high-tech firms<sup>[16]</sup>.

Most of previous literature haven't taken into account the complexity of the innovation process and the heterogeneity of firm behavior. In this paper we focus on innovation characteristic at micro firm level, playing an important contributor to performance heterogeneity among firms. The rest of the paper is organized as follows. In Section 2 the evaluation model is presented. Survey data are described in Section 3. In section 4 innovation abilities of investigated firms are estimated. Performance estimation is discussed in Section 5. The final section concludes the discussion.

## II. Evaluation Model

### 2.1 Index system

A complete innovation activity transforms ideas into actual productivity through innovation input, R&D, output, management and other specific links. Therefore, in order to cover comprehensive innovation activities, this paper underlines the following 3 points: (i) construct an conceptual model of innovation on the basis of input-output, as shown in Table 1, reflecting an entire innovation process; (i) take innovation projects made by surveyed firms as one of survey issues, discriminate innovation characteristics among firms; (iii) consult experts of Science and Technology institutions. Finally, we've got an index system as shown in Fig.1, including 6 secondary indexes and 24 tertiary indexes. On this basis, the questionnaire is designed. Compared with *Administrative Measures for the Determination of High and New Technology Enterprises* (revised in 2016) and the *Guidelines for Recognition and Management of High-tech Firms*, our survey defines innovation connotation of high-tech firms more comprehensively (as shown in Fig 1). In addition, the survey on firms scale, the technical field, the enterprise nature, the innovation motives and models, etc. are reflected in the column of "Basic Information of high-tech firms" of the questionnaire.

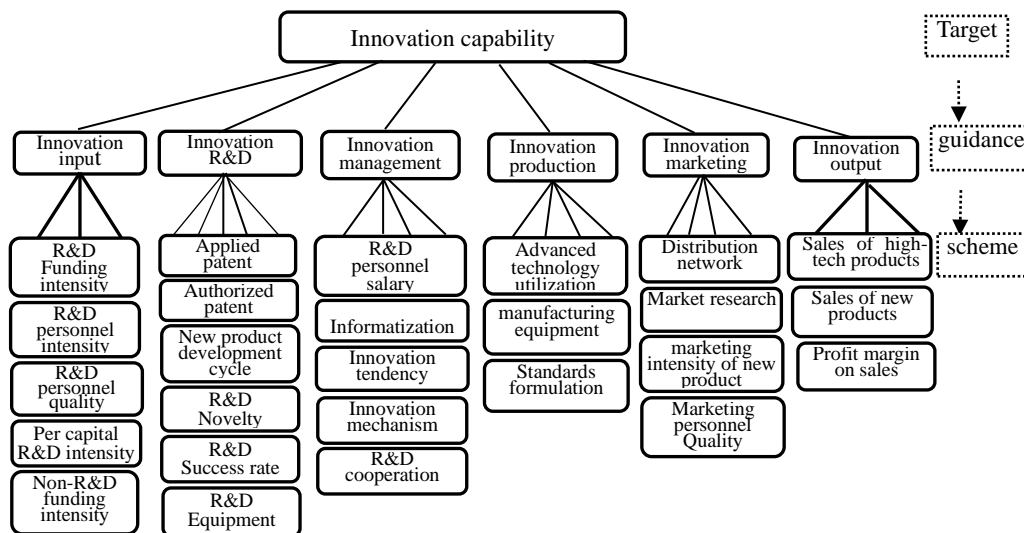


Fig. 1 Evaluation system of innovation capability

### 2.2 Survey and data

Xinjiang Uygur autonomous region is in the west of China. It is abound with resources but faced by vulnerable ecological environment. High-tech firms in Xinjiang has increased from 89 to 599 during the period of 2009-2018, accounting for less than 0.4% of China's. High-tech firms have become the main driving force of technological innovation activities in Xinjiang. About 60% high-tech firms are from biological and new medical, electronic information and new materials fields.

The survey lasted about 10 months from 2016 to 2017, covering 269 high-tech firms approved during the period of 2009-2014. In stage I (preliminary survey), we chose 6 high-tech firms in the two high-tech development zones in Urumqi, and made modification according to their feedback. In stage II (full survey), including two parts, one survey on firms inside the 2 development zones was supported by the science and technology bureau, the other survey outside development zones was assigned to investigation teams, mainly through interviews and emails. In stage III (questionnaires recovery), we checked collected questionnaires and re-issued invalid ones. Finally, 142 valid questionnaires have been recovered, accounting for 52.8% of 269 high-tech firms. The recovery rate of the two development zones exceeds 80%, while the recovery rate outside development zone is only 25.6%. Why? We

find that, those firms refusing to fill questionnaires are mainly SMEs, in relative underdeveloped cities. Their refusal to the survey partly reflects less emphasis on innovation management. Among 114 valid questionnaires from Urumqi, 109 are inside development zones, which shows vital roles of the two development zones in Xinjiang. These survey firms are mainly from the technological fields of electronic information technology, new materials technology, biological and new medical technologies. Major of Xinjiang's high-tech firms are SMEs. The large scale, medium scale and micro scale firms account for 17.6%, 23.2% and 59.2% of the survey firms respectively, of which private firms account for 67.7%.

Compared with annual statistics of the Science and Technology Department of Xinjiang Uygur Autonomous Region, this survey consists of more index reflecting innovation activities, as for innovation management, innovation production and innovation marketing. There are both quantitative and qualitative indexes, which can demonstrate innovation process and characteristics more comprehensively. Moreover, we combine survey data with statistical data of Science and Technology Department of Xinjiang Uygur Autonomous Region. We screen 61 firms out as a specific sample, which have been operating well for at least 5 years. Most of other surveyed firms are at the stage of start-up. Based on comparative analysis of 61-firm sample and 142-firm sample, we hope to find inner driving and prospect of sustainable growing of high-tech industry.

### 2.3 Characteristics of innovation behavior

#### 2.3.1 Emphasis on R&D funds but not R&D personnel

Seeing from 61 firms, R&D funding input keeps increasing and concentrates in new energy and energy-saving technology enterprises. During the period of 2013-2016, R&D funding input of 61 firms have kept increasing. Contribution of new energy, energy-saving technologies and new materials technology firms exceeded 80%. In 2016, R&D investment contribution of firms from new energy and energy-saving technology reached 65.5%, while contribution of high-tech service firms was only 0.6%. There is positive correlation between R&D funding input and firm scale. The larger firm scale is, the more its R&D investment is. There were significant R&D investment differences in different technical fields. R&D funding intensity of 61 firms has increased from 4.7% in 2013 to 5.4% in 2016. Firms of material technology show the greatest advantage of R&D funding, while firms of high-tech service is the lowest (as shown in Fig. 1). On the other hand, R&D funding intensity is negatively correlated with firm scale. The larger firm scale is, the lower the R&D funding intensity is. R&D funding intensity of SMEs is higher (as shown in Fig.2). Compared with the total of 142 survey, 61 firms incline to R&D funding regardless of scale, and the overall level of R&D funding intensity is higher.

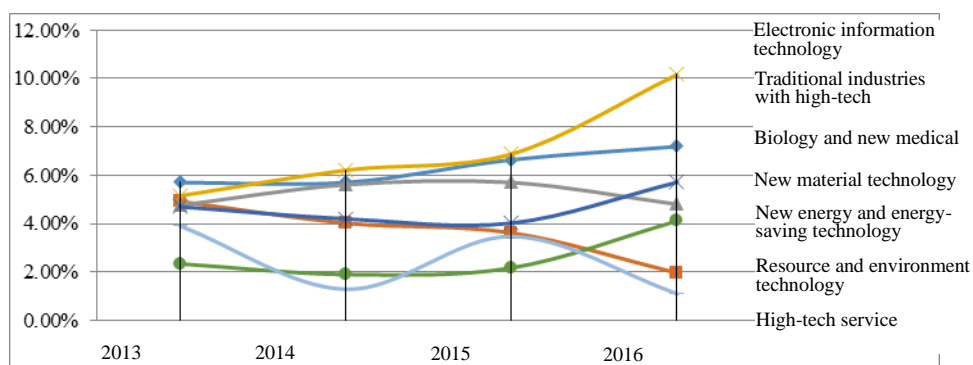


Fig. 2 R&D funding intensity among different fields

During the period of 2013-2016, R&D personnel intensity (R&D personnel/total staff) was 18.1%, 16.0% and 19.3% respectively, indicating that structure of R&D personnel was basically stable. Emerging high-tech firms are more attractive to highly educated talents. In 2016, above 75% of R&D personnel with master degrees or above aggregated in firms of electronic information technology, biological and new medical technology, new materials technology, new energy and energy-saving technology. SMEs pay more attention to enhance their competitiveness

by recruiting high-quality R&D personnel. In 2016, 58.4% of highly educated researchers were from firms with sales less than 100 million yuan. Compared with 142 firms, R&D personnel intensity of 61 firms had no advantages. Both R&D personnel intensity and proportion of R&D personnel with higher education of 61 firms were lower than that of 142 firms. This indicates that growing high-tech firms pay less attention to R&D talents.

### 2.3.2 Independent innovation capability

Firms coming from electronic information technology, new materials technology, new energy and energy-saving technology are the major source of patents among 61 firms. Firms of high-tech service have great disadvantages of independent innovation. Firms coming from biological and new medical technology, high-tech service, with advantages of R&D personnel, had less patents. Such mismatch between advantage of R&D personnel and shortage of Patents indicates immature development in the two fields. R&D capability is proportional to firm scale. Large and medium- sized high-tech firms have obvious advantages in patent output. In particular, patent contribution of SMEs continue to increase, meanwhile that of large and medium-sized firms shows declining.

More than 90% of 142 firms plan to enhance inner power of innovation through motivation mechanism. Raising wages/bonus, promotion and providing training opportunities are common mechanisms, all of which can play effective roles in motivation. Stock, car or housing awards are less used. Wage and salary of senior staffs and R&D personnel are relatively high. Although firms of average salary over 5,000 yuan were less 10%, ones with R&D personnel's salary beyond 5,000 yuan were more than 44%. Comparatively, average salaries of R&D personnel in biological and new medical technology, new energy and energy-saving technology were low, more than 70% of firms were below 5000 yuan. In terms of innovation collaboration with external institutions, about 62% of the surveyed firms actively participate external innovation activities.

Compared with 142 firms, innovation management of 61 firms shows few advantages, either on average salary or R&D personnel's salary. In terms of informatization, 61 firms have greater advantage than 142 firms.

### 2.3.3 Innovation maturity

61 firms have implemented 557 of 617 patents and technologies, accounting for 90% of the total. In terms of advanced production equipment, 24.6% of firms had NC equipment, lower than 30.3% of 142 surveyed firms. In terms of existing major equipment and the production line, 85.2% of equipment and production lines were at the post-1990s standard, which is higher than 81.7% of 142 enterprises. Among 61 firms, 17 firms have participated in formulating national technology standards, only 2 firms in international technology standards, accounting for 100% and 66.7% of 142 firms respectively. We could conclude that high-tech firms with persistent growing have more mature innovation.

### 2.3.4 Innovation marketing

Results of the survey show that 61 firms have formed mature mechanisms of innovation marketing. 54.1% of 61 firms performed new product packaging, higher than 49.3% of 142 firms. Among 61 firms, about 80% had marketing staff over 3 years, about 50% were believed to own good distribution networks, less 15% were faced marketing difficulties, 2 firms admitted weak marketing. These indexes are significantly better those of 142 firms. All of 61 firms have performed E-commerce, about 70% of which have their own corporate websites. 31 firms have implemented ERP too. We could find the common characteristic of 61 firms, owning perfect marketing mechanisms. By contrast, the other surveyed firms have deficiency of marketing network.

### 2.3.5 Innovation profitability

High-tech product sales of 61 firms have kept growing rapidly, accounting for over 80% of the total, with average annual growth of 4.4%. Large scale firms show an absolute advantage of profitability in comparison to SMEs, meanwhile discrepancies existing among industries. Rapid declining of high-tech sales in 2016 resulted to profit

falls in the two industries, high-tech reformed traditional industries and new material technology, reflecting disadvantages of their product competitiveness. Firms of high-tech service were faced with worse marketing condition with negative sales profit rates. Compared with 142 firms, 61 firms has a comparative advantage in innovation output, but their profitability is weak, indicating contradiction between profitability and marketing.

### III. Innovation Capability Estimation

#### 3.1 Index weight

From executives' point of view, innovation R&D is the top factor of innovation capability, and R&D novelty is of the top factor of innovation R&D. Such inclination possibly influence innovation management of high-tech firms. To be interesting, the importance of R&D funding and R&D personnel are not emphasized by executives of the surveyed firms. We take advantage of AHP method to acquire weight of innovation indexes, as the following 4 steps. (i) Design the hierarchical framework of research. (ii) Use Delphi method and scale technology to construct the judgment matrix. (iii) Calculate weight vector and have consistency test. (iv) Calculate the synthetic weight from top level to bottom level and have consistency test. Estimation result shows that R&D funding and R&D personnel are the most important to innovation capability.

#### 3.2 Estimation result

This paper adopts such dimensionless method as:

$$a_{ij} = \frac{x_{ij} - x_{j \min}}{x_{j \max} - x_{j \min}}$$

where  $i = 1, 2, \dots, N$ ,  $j = 1, 2, \dots, m$ ,  $x_{ij}$  is the observed value,  $x_{j \min}$  is the minimum and  $x_{j \max}$  is the maximum. Then,  $a_{ij}$  value is between 0~1. The index weight of each layer can be multiplied by corresponding index data to obtain the score of innovation capability of each firm. For the sake of comparison, we multiply the scores by 100 and make boundary from 0~100. Table 1 list part of results only including the top 5 and the last 5:

Table 1 Estimation including the top 5 and the last 5 of 142 firms

firms	Innovation input	Innovation R&D	Innovation management	Innovation production	Innovation marketing	Innovation output	innovation capability
A <sub>1</sub>	37.15	48.37	62.51	58.35	72.75	75.31	56.69
A <sub>2</sub>	46.52	47.27	81.26	17.80	62.91	75.31	56.58
A <sub>3</sub>	37.46	53.04	67.08	41.34	64.00	75.31	55.72
A <sub>4</sub>	44.94	53.15	82.98	42.39	41.19	42.31	53.87
A <sub>5</sub>	18.52	52.62	72.66	55.21	54.89	73.95	53.19
A <sub>138</sub>	23.14	22.13	42.89	48.66	32.98	0.66	28.65
A <sub>139</sub>	11.00	35.63	17.09	51.49	42.31	28.37	28.44
A <sub>140</sub>	13.22	24.46	25.50	39.50	51.55	18.80	26.99
A <sub>141</sub>	12.95	16.40	27.22	42.39	36.12	42.86	26.68
A <sub>142</sub>	18.64	17.55	47.88	37.93	0.00	0.62	22.27

#### 3.3 Results analysis

Innovation capability difference among industries is basically consistent with industrial distribution. Firms of bio-pharmacy are more than those of electronic information, average innovation capability of the former is higher than that of the latter. However, firms of electronic information take the greatest proportion of the top 10 innovative firms, being absolute advantage. Such condition reflects their own problems respectively. Being a traditional mature industry, bio-pharmacy is lack of "leading" firms to enhance industrial competitiveness. Electronic information industry has more "leading" firms which lag behind R&D of emerging fields. Innovation

capability is asymmetric with resource allocation. Large-sized firms occupy absolute scale advantage of innovation resources and have outstanding manufacturing capability, but their innovation capability are the weakest due to disadvantage of innovation R&D. Although small-sized firms have scale disadvantage of innovation resources, they are the most innovative due to advantage in R&D input, innovation R&D and innovation management. Medium-sized firms are mean in all aspects. One development zone has formed a strong innovation aggregation effect, but their firms' are lack of innovation manufacturing and marketing, which weakens spillover effect of innovation. Firms of the other development zone have obvious disadvantage in R&D input, innovation output, innovation management and innovation R&D.

In comparison with 142 firms, although 61 firms score higher in innovation R&D, innovation manufacturing, innovation marketing and innovation output, their average score of innovation ability is 0.1 lower than that of 142 firms, resulted from lower score of innovation input and innovation management. 61 firms have little advantage of innovation capability. Therefore, it is insufficient of innovation input and innovation management, to hinder high-tech firms at the stage of growing improving innovation competitiveness.

#### IV. Innovation Performance Estimation

##### 4.1 Methodology

DEA is one of the most used non-parametric frontier efficiency analysis method. This method uses a linear programming model to evaluate relative effectiveness (ie, DEA validity) between decision making units (DMUs) with multiple inputs and outputs particularly. This paper uses MAXDEA software to analyze innovation efficiency of 61-sample firms and 142 full-sample firms, estimate the overall technical efficiency (TE) value, pure technical efficiency (PE) value, scale efficiency (SE) value and scale return of high-tech firms. The innovation system reflects a process converting innovation input into output. Based on existing literature, this paper builds the index system as follows:

(1) Input indicator: include funds and personnel input. R&D funding, R&D funding intensity, R&D personnel intensity are selected;

(2) Output indicator: include new knowledge and new production. This paper takes patents as knowledge, including patents applied and patents approved. Software copyright is also selected as knowledge. Besides, sales of high-tech products are used as production indicators including sales proportion and sales revenue of high-tech products.

##### 4.2 Results analysis

###### 4.2.1 Overall efficiency Analysis

As shown in Table 1, average overall technical efficiency of 61 firms is 0.811. 29 of 61 firms have achieved "optimum state" of overall technical efficiency (TE), accounting for 47.5%. The other 39 firms are not at "optimum state", due to scale inefficiency or technical inefficiency? Average of pure technical efficiency of 61 firms is higher than that of overall technological efficiency. 38 firms have achieved "optimum" in pure technological efficiency, 9 more than those "optimum" in overall technological efficiency. Average scale efficiency of 61 firms is 0.890, higher than average value of overall technological efficiency, 29 firms reaching optimal return to scale, 25 firms in increasing stage of return to scale, 7 firms in decreasing stage of return to scale. It can be speculated that overall technical inefficiency is mainly due to scale inefficiency.

Table 1 Overall analysis on 61 firms

Efficiency value	1.00	0.8-1	0.6-0.8	0.4-0.6	<0.4	Average value
Overall technical efficiency (TE)	47.5	14.7	16.4	14.8	6.6	0.811

Pure technical efficiency (PE)	62.3	18.0	14.8	0.00	4.9	0.902
Scale efficiency (SE)	47.5	32.8	6.6	8.2	4.9	0.890

Redundant input and insufficient output could further demonstrate the reason for innovation inefficiency, as shown on Table 2. It can be seen, 13 firms are redundant in technical input, indicating less efficiency of R&D personnel. In terms of output, 29 firms' sales revenue of high-tech products are insufficient, 21 firms are lack of authorized patents, 17 firms' sales rate of high-tech products are insufficient. In all, almost half of 61 firms are faced by insufficient sales of high-tech products.

Table 2 Firms with redundant input and insufficient output of 61 firms

Number of	Redundant input				Insufficient output				
	R&D funding input	R&D funding intensity	R&D personnel intensity	Technical input	Applied Patent	Authorized Patent	Software copyright	Sales rate of high-tech products	Sales revenue of high-tech
	5	8	5	13	14	21	7	17	29

#### 4.2.2 Industrial innovation performance

Innovation performance heterogeneity among industries is obvious. Average of overall technical efficiency of high-tech reformed traditional industries, electronic information technology are higher, 0.913 and 0.847 respectively. Average of the rest technical fields is lower than the total average. Average of high-tech service firms and new energy and energy-saving technology firms are the lowest. More than 50% firms of high-tech reformed traditional industries, electronic information technology, new energy and energy-saving technology have achieved "optimal" in overall technical efficiency. According to industrial distribution of TE values, firms of high-tech reformed traditional industries are distributed in larger-value side, presenting a negative skewed distribution. Firms of new energy and energy-saving technology, electronic information technology are polarized. Average PE and SE of high-tech reformed traditional industries, electronic information technology are higher, while average SE of new material technology, energy and energy-saving technology enterprises is lower, indicating that low SE is a main reason for TE. Average PE of high-tech service is close to 1, but lowest SE result in its worst TE.

#### 4.2.3 Regional innovation performance

Development zones play an important role in fostering high-tech firms. This paper focuses on analyzing the two development zones in Urumqi. As shown in Table 3, TE, PE and SE of Urumqi High-tech Industrial Development Zone (high-tech zone briefly) are all higher than those of Urumqi Economic and Technological Development Zone (Economic Development Zone). Although the two development zones have different positioning, it is necessary for high-tech firms to take advantage of resources inside development zones. Economic Development Zone seem to be insufficient in supporting high-tech firms.

Table 3 Analysis on regional efficiency of 61 firms

	Area	1	0.8-1	0.6-0.8	0.4-0.6	<0.4	Average value
TE	High-tech Zone	50.00	15.63	18.75	9.38	6.25	0.836
	Economic Development Zone	44.44	5.56	16.67	22.22	11.11	0.755
PE	High-tech Zone	62.50	25.00	6.25	0.00	6.25	0.914
	Economic Development Zone	55.56	5.56	33.33	0.00	5.56	0.851
SE	High-tech Zone	50.00	34.38	6.25	9.38	0.00	0.907
	Economic Development Zone	44.44	27.78	11.11	16.67	0.00	0.866



#### 4.2.4 Characteristic at different cycles

By comparison results of 61-firm sample and 142-firm sample estimation, we could find out performance heterogeneity at different cycles. Average innovation performance including TE, PE and SE of 61 firms are all higher than that of 142 firms. Different from 61 firms, redundant input of 142 firms is concentrated on redundant R&D funding input, reflecting inefficiency of R&D funding of start-ups. In terms of insufficient output, 142 firms are prominently expressed as insufficient patents output, indicating that start-ups are lack of innovation output and have not formed effective core competitiveness.

### V. Summary and Conclusion

Based on survey data, this paper investigates innovation activities of high-tech firms in western China, evaluates characteristics of innovation behavior, and adopts DEA to compare innovation performance of 61-firm sample and 142-firm sample. High-tech firms keeping persistent growing show obvious innovation characteristics. Emphasis is attached on R&D funding but R&D personnel, and the latter is not used efficient. The survey shows that raising wages/bonus can effectively motivate innovation. The advantages in R&D funding of high-tech reformed traditional industries and electronic information technology have attributed to output advantages. Firms of biological and new medical technology, high-tech service show a trend of “low input, low output and low performance”. Insufficient sales and poor profitability of high-tech products reflect shortcomings of low added value of technology and lack of market competitiveness. The main reason for low overall efficiency is the low scale efficiency, especially waste of R&D personnel. There is a difference in overall efficiency between two development zones, mainly resulted from scale efficiency difference.

High-tech firms keeping persistent growing have problems in management of innovation talents, technology maturity and knowledge industrialization, which reduces innovation performance. Accelerating improvement of core technology competitiveness of growing firms and cultivating more "core firms". Firstly, establish broad development platforms for scientific and technological talents. The government establishes a talent introduction, cultivation and exchange platform, firms improve talent management mechanism, increase salary of innovation personnel, effectively integrate the inner motivation resources and fully stimulate innovation enthusiasm. Second, improve the fundamental guarantee for conversion of technology achievements, reduce risk and cost of converting through establishing and perfecting financial, insurance, third-party service organizations, technical support and other measures, improve effective conversion rate. Third, strengthen incubation and cultivation function of development zones, promote to implement preferential policies for high-tech firms, enhance construction of science and technology service support systems, provide a good ecological development environment for high-tech firms, and cultivate a large number of “core firms” with strong innovation capabilities and industrial radiation force.

### Acknowledgements

This work is supported by Natural science foundation of Zhejiang province [LY20G030004]

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