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The Industry-university-research Cooperation of Chinese Medium and Small Technological Enterprises

Taking Scientific Papers Supported by the TIF between 2000-2010 for Sample

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Abstract. Taking 2062 scientific papers supported by the TIF between 2000-2010 for sample, we define variables and coding for those papers' external characteristics, and analyze the industry-university-research cooperation of MSTEs. The results show that: through the use of external resources, MSTEs completed the innovation projects, IURC are active; the papers jointly completed mainly belong to engineering technology and basic research level; the universities are the most important external intellectual resources of MSTEs; most MSTEs cooperates with universities and research institutions in the field of engineering technology; MSTEs in Jiangsu, Beijing, Sichuan, Shanghai, Guangdong are more likely to cooperate with universities or research institutions in other provinces. At last, we propose some suggestions.

Introduction

Confronting the challenge from competition and pressure of international markets, medium and small firms only can achieve sustainable development by incessant innovation. However, medium and small firms have some shortages, such as limited output scale, lacking of talent, financial problem, insufficient source of information and limited R & D capabilities [1]. These factors are likely to become an obstacle for medium and small technological enterprises' (MSTEs) innovation and make innovation only by firms become unrealistic. However, the open collaborative innovation breakthroughs for MSTEs provided an opportunity for over the innovation bottleneck was described above. A large number of external resources can input a new blood of innovation and provide space of innovation. On the other hand, it also can provide more scientific idea of innovation and board management method of innovation. Therefore, MSTEs should take advantage of other companies, universities and government departments to integrate the experience and knowledge of their own resources for achieving sustained innovation. It can be said that strengthening IURC (industry-university-research cooperation) and presuming open collaborative innovation have great strategic significance for MSTEs.

MSTEs' Technological Innovation Fund (TIF) is to support MSTEs' technology innovation of the government special fund, supporting and guiding the activities of MSTEs' technology innovation mainly through financial subsidies and promoting the transformation of scientific and technological achievements. From 1999 to the end of 2009, the number of total support projects was 19335 and the amount of subsidy was 11.14 billion yuan, 12,000 MSTEs benefited; From 2000 to 2008, during the implementation of the TIF, MSTEs received 4202 patents, invention patents 1334[2]. Facing more serious insufficient resources, MSTEs' technology innovation is heavily depend on external innovation resource, and they have a relatively strong demand for cooperation innovation. Meanwhile MSTEs received assistant from the TFI have a strong representation. Therefore, it is very valuable and meaningful for the study of their innovative of IURC.

This study focuses on IURC performance of Chinese MSTEs, and the sample is the scientific papers funded by the TIF. On the one hand, TIF mainly targeted at high-tech products in the research, development, production or service operations of small and medium enterprises and scientific papers funded by the TIF must involve MSTEs; on the other hand, the results generally include innovative products, patents, technology, consulting reports, scientific papers which documented a large number of scientific papers of knowledge and technology information and is the essential foundation for further research activities. Scientific paper's effectiveness is reflected in the practical solution to the current and future issues of social contribution. Through research on the output of scientific papers, IURC can analyze the process of knowledge innovation and knowledge transfer capabilities [3].

Literature review

1950s, the establishment of the Silicon Valley model and its huge success attracted scholars interesting toward IURC. Understanding of researchers is always from the perspective of technological innovation and defines technological innovation as "a unique, integrated inter-organizational relations." They think that "because of this inter-organizational relationships are often set target with diverse nature to avoid the shortcomings of the traditional organizational structure and to improve the effectiveness of technological innovation" [4]. Some researchers believe that IURC between universities and companies is actually heterogeneous organizations cooperation [5]. Knowledge is media links of science and industry. Links to science and industry is determined by the production style of knowledge to achieve their complementary resources advantages [6].

Some researchers believe that compared to applied research, basic research are more significant on the aspect of external economy and private benefits of basic research are often lower than the social benefits. So firm lack sufficient motion and the investment to the basic research is less than the most optimal investment amount. The time companies involved is earlier, the obligation to provide resources for stronger, more serious. The risk of input on the aspect of technology area will be increased for additional input like manpower and financial fund [7]. But there are also some researchers think that although the companies participate technology innovation earlier, greater the risk they have, it can decrease frequency and intensity of conflict for firm during the process of cooperation that achieving high consistency on the aspect of research target by finding universities to cooperate soon. The sooner company finds, the easier consistency firm and university can have [8]. Which (or what) stage should be the important point of knowledge and technology transferred and which is not depends on the technological strategy of firm and firm's purpose of participating cooperation of industry-university for innovation.

Researchers' study about performance of IUR alliance focused on two areas. Some researchers claim through the "input-output" model, we can evaluate the performance of IURC. Some researchers have designed a multi-dimensional asses medium and small enterprises of the effectiveness of IUR alliance, that are resources input of firms to university research, corporation and university research institutes in the league in the process of participation, Union results (explicit knowledge and tacit knowledge transfer) [9]; Some researchers have made some standard to measure IUR alliance failure [10]. Another school advocates the use of qualitative research methods to evaluate the performance of alliances. Some researchers have further analyzed the key factors affecting the performance of alliance and they found alliance partnerships have a major impact on alliance performance. Partnership can be summarized the contents of the partnership trust, commitment, dependency and termination costs [11]; the researchers also proposed a model of IURC, saying that "cooperation on research performance evaluation is based on business expectations of the IURC, based on technological innovation as IURC are consistent with the expectations that have the efficiency and effectiveness; researchers also found that the interaction between the partners has an important impact on research performance; Some researchers believe that the evaluation of technology transformation not only depends on whether the transferee learn the technology from transferor and applied to business development process, but also the technology dependence of transferee to the transferor is reduced.

Research design

Sample. This study uses the TIF database of CNKI as data source. The database includes 2650 scientific papers supported by the TIF. Choosing sample depends on the following rules: first, scientific papers was from 2000 to 2010, total 11 years, excluding 1999 (TIF was established in 1999, and any study has certain time lag) and 2011 (incomplete data); second, types of papers supported by TIF include the journal papers, conference papers and dissertation; considering the most of postgraduate dissertation completed independently, it does not have the cooperation of characteristics, also is not really a result of the MSTEs' IURC. Based on the above criteria, we select a total of 2062 scientific papers constituted sample for analysis in this study.

Coding. We encode external characteristics of each scientific paper, including the level of research, published year, number of authors, number of units, the region of the unit, the state of cooperation, cross-regional cooperation. Among them, only different statistical units are accounted, when count number of units and units belong to same type is only considered one unit. State of cooperation is mainly based on the author units determining and coding. The unit of authors can be divided into industry (I), university (U), research (R) and government (G). This study assessed the MSTEs in the state of IURC, and thus only industry-university cooperation (IU, cooperation both has business units and university units, the same as following), industry-research cooperation (IR), industry-government cooperation (IG) and industry-university-research cooperation (IUR) will be encoded by the style of 0-1. Identity of trans-regional cooperation depends on whether the units that author belong to is in the same province / autonomous regions.

The methods of analyses. This study mainly takes frequency analysis, cross-table analysis, and correlation analysis technology as method. All data are analyzed by SPSS16.0 software.

Analysis and discussion

Descriptive statistics analysis. From the year of papers published, the number of papers formed and published from 2000 to 2010 was increasing. There are 423 papers in 2010 supported by the TIF, accounting for sample size (2062) of 20.5%. On the aspect of different number of units that author belong to, the papers completed by only one unit are 1199 accounting for 58.1%, the papers completed by two different units are 662 papers accounting for 32.1%, papers completed by three different units together are 166 papers accounting for 8.1%, the paper completed by inter-unit cooperation account for 41.9% of total. It somewhat indicates the innovation performance of MSTEs which are supported by TIF relies on the help of external resources and IURC has been reflected. In addition, on the aspect of the author groups, the paper completed by one person are only 117 papers accounting for 5.7% and the papers complete by the two or more together account for 94.3%. It indicates that cooperation have become the mainstream of research, which proves once again that IURC exist widely. On the aspect of research level samples belong to, 2062 papers, including the standard and quality control, higher education, engineering technology, basic research, technical guidance, policy research, and practical technology can be divided into seven research levels. Engineering technology, technical guidance, basic research are on the level of the top three, which accounted for 70.5%, 26.6% and 2.1%. It indicates that TIF mainly support projects belong to engineering technology and basic research to help MSTEs achieving translation of technological achievement.

TABLE 1 The results of frequency (n=2062)

year	Frequency	%			Frequency	%			Frequency	%
2000	10	0.5	units	1	1199	58.1	The level of research	Engineering technology	1454	70.5
2001	26	1.3		2	662	32.1		basic research	549	26.6
2002	76	3.7		3	166	8.1		technical guidance	44	2.1
2003	128	6.2	The region	Guangdong	102	4.9	The number of authors	1	117	5.7
2004	196	9.5		Zhejiang & Shandong	107	5.2		2	335	16.2
2005	187	9.1		Liaonin & Shanxi	109	5.3		3	595	28.9
2006	240	11.6		Beijing	122	5.9		4	551	26.7
2007	229	11.1		Chongqing	134	6.5		5	260	12.6
2008	255	12.4		Sichuan	142	6.9		6	113	5.5
2009	292	14.2		Hubei	192	9.3		7	54	2.6
2010	423	20.5		Jiangsu	206	10		8	24	1.2

The cooperation of MSTEs with universities, research institutions. Overall, the papers jointly completed by MSTEs with universities, research institutions and government agencies are total 486, accounting for the total sample 2062 to 23.6%, which I & U jointly completed 391 scientific papers, I & R jointly completed 49 scientific papers, I & G jointly completed 6 scientific papers, IUR jointly completed 40 scientific papers (see Figure 1). This shows that the university is the most important external intellectual resources of MSTEs and cooperation with universities is the main method to achieve translation of technological achievement for MSTEs. In addition, the cooperation of universities and research institutions are less, the reason is maybe that under the Chinese scientific research system, universities and research institutions on the aspect of knowledge reserve is homogeneity, and scientific research are one of main functions for both, and thus research institutions and universities are alternative.

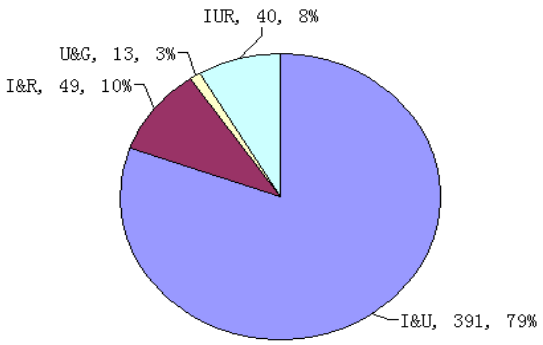

Figure 1 The IURC of MSTEs (n=486)

Analyzing the cooperation of MSTEs with universities, research institutions and government, we can find that from 2000 to 2011, the number of scientific papers jointly completed was increasing, such as paper completed by MSTEs with universities, or research institutions, or government are 149 in 2010 (see Figure 2). This somewhat indicates MSTEs under the support of TIF adhere to the path of IURC, co-work closely with external intelligence bodies, especially with universities to complete research projects, and produce a series of innovative results.

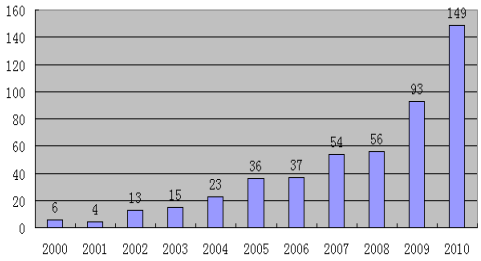

Figure 2 The IURC per year of MSTEs (n=486)

From the level of research, in the total 486 scientific papers jointly completed by MSTEs with universities, or research institutions, or government, 331(68.1%) are engineering and technology level; 142(29.2%) belong to basic research level. It shows that the current MSTEs are likely to choose the field of engineering and technology to cooperate with universities or research institutions and emphasize on practice-based technical cooperation rather than basic research.

The regional IURC of MSTEs. Among the 486 scientific papers jointly completed by MSTEs with universities and research institutions, there are 248 scientific papers' units located two or more provinces. Overall, MSTEs just cooperate with universities, research institutions within the province and inter-provincial flow of knowledge and IURC activities are rare. However, on the aspect of time trend, cross-regional cooperation of MSTEs with universities, and research institutions stably increase until 2007. After falling at 2008, the current state shows overall upward trend (see Figure 3). It can be said that inter-district IURC of MSTEs become more and more vivid. On the aspect of sub-regional, MSTEs from Jiangsu, Beijing, Sichuan, Shanghai, Guangdong, Hunan, Shandong, Tianjin, Henan, Zhejiang, Liaoning was very active on cross-regional IURC, especially in Jiangsu, Beijing, Sichuan, Shanghai, Guangdong.

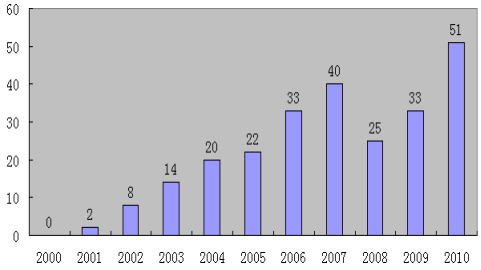

Figure 3 The cross-regional IURC of MSTEs (2000-2010, n=248)

The related analysis of IURC. In this study, we analyze the relatives of number of authors, cooperation papers, number of units, cross-regional cooperation and the correlation matrix is shown in Table 1. The results show that the number of authors and IURC, the number of units, cross-regional IURC are significant positive correlation, which the correlation between the number of author and the number of units are highest and indicates the more the number of authors completing papers are, the more the different units are, and vice versa; IURC and the number of units, cross-regional IURC also show a positive correlation. Correlation coefficient between IURC and number of units is the high 0.644, indicating that the more different units involved, the more scientific papers are more formed by MSTEs with universities, scientific research institutions; the coefficient of different units and cross-regional IURC is 0.478, indicating that this two are significant positive correlation and the more different units participated in the more cross-regional IURC will have.

TABLE 2 Correlation matrix (n=2062)

	Number of authors	**IURC**	**Number of units**	**cross-regional of IURC**
Number of authors	1	.233**	.305**	.144**
IURC	.233**	1	.644**	.234**
Number of units	.305**	.644**	1	.478**
cross-regional of IURC	.144**	.234**	.478**	1

**. Correlation is significant at the 0.01 level (2-tailed).

Conclusions and recommendations

Taking the scientific papers funded by the TIF for sample, this paper discusses the cooperation of MSTEs with universities and research institutions. The results show that: firstly, scientific papers are important outcome of TIF and the amount of papers funded by TIF was increasing; secondly, through the use of external resources, MSTEs completed the innovation projects, IURC were active; thirdly, the papers jointly completed mainly belong to engineering technology and basic research level; fourthly, the universities are the most important external intellectual resources of MSTEs and cooperation with university is main method to achieve transformation of scientific achievement; fifthly, most MSTEs cooperates with universities and research institutions in the field of engineering technology and emphasis on practice-oriented technical cooperation; sixthly, MSTEs in Jiangsu, Beijing, Sichuan, Shanghai, Guangdong are more likely to cooperate with universities or research bodies in other provinces; seventhly, IURC of MSTEs and the number of units, cross-regional IURC show a positive correlation and the more different units participate, the more IURC of cross-regional cooperation appear. In this study, political implications is obviously: firstly, it is important to promote IURC through TIF and we should strengthen this measure; secondly, TIF should support the cooperation projects to promote MSTEs' IURC and focus on engineering technology projects; moreover MSTEs not only need to strengthen the cooperation within the province, but also should use the intelligent resources from other province; at last, innovation of IURC should be encouraged.

There are some limitations in this study: on the one hand, the sample is only the scientific papers supported by the TIF, so it is difficult to reflect the IURC performance of MSTEs over the country; on the other hand, the domestic scientific papers are only part of the results of TIF, and it is may even be very small, patents and international papers or other results is an important part. Future research could be improved in these two areas.

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