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China's Innovation System Reform and Growing Industry and Science Linkages

MOTOHASHI Kazuyuki
RIETI

XIAO Yun
National Bureau of Statistics, Government of People's Republic of China

The Research Institute of Economy, Trade and Industry
http://www.rieti.go.jp/en/

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China's Innovation System Reform and Growing Industry and Science Linkages[1]

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By Kazuyuki Motohashi[2] and Xiao Yun[3]

Summary

In this paper, linkages of S&T activities between industry and science are investigated in the context of innovation system reforms. A firm level dataset from S&T survey at National Bureau of Statistics (NBS) of PRC for about 22,000 manufacturing firms is used for econometrics analysis of firm's S&T outsourcing activities. In transition period of China's innovation system from 1996 to 2002, firm's S&T outsourcing activities have been increased significantly. In addition, positive association between basic research oriented firms and collaboration with science sector can be found. China's innovation system was suffered from Russian model, where S&T activities at public research institutes and production activities at state owned enterprises are completely separated. However, in transition period of innovation system reform toward network type one, we can find that some firms have gained their technological capability to collaborate with universities and PRIs.

Keywords:

China, innovation system, science industry linkage

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[2] Associate Professor, Research Center for Advanced Science and Technology, University of Tokyo and Faculty Fellow at Research Institute of Economy, Trade and Industry (RIETI). E-mail: motohashi@rcast.u-tokyo.ac.jp.

[3] National Bureau of Statistics, Government of Peoples Republic of China

1. Introduction

In China's Tenth Five-Year Plan from 2001 and 2005, economic development driven by technological progress is treated as a central theme, and further stimulating innovation activities and institutional reforms to abolish imperfections associated with socialist system constitutes one of major pillars to achieve sustainable and balanced growth of Chinese economy (World Bank Institute, 2001). This statement is based on series of innovation system reforms started in 1980's, which has been conducted in a consistent way with China's economic reforms from centrally planning system to market based economy.

In 1985, the Resolution of the Central Committee of the Communist Party of China on the structural reform of the science and technology system was enacted, and served as a cornerstone of departing from the Russian model of innovation system, where S&T activities at public research institutes (PRIs) and production at state owned enterprises (SOEs) were completely separated (Xue, 1997). Under this system, S&T outputs at PRIs are freely transferred to SOEs and there was no incentive for research and development at enterprise level.

Therefore, several policy actions concerning innovation system reforms have targeted at introduction of proper incentive systems for both science and industry sectors for innovation, i.e., R&D for new product developments, improvement of production processes etc. In science sector, PRIs and universities are given greater autonomy on selling their research outputs, while institutional funding from the government is reduced. In industry sector, SOE reforms have been implemented in the 1990's, and market based competition becomes to put greater pressures for their R&D for efficient production process and competitive products (Liu and White, 2001).

In this paper, linkages of S&T activities between industry and science are investigated in the context of innovation system reforms. A firm level dataset from S&T survey at National Bureau of Statistics (NBS) of Peoples Republic of China is used for quantitative analysis. This survey is conducted for large and medium sized enterprises annually, and covers survey items on S&T outsourcing to various kinds of counterparts, such as other domestic firms, universities, PRIs and international organizations. Econometric analysis, based on the panel data from 1996 to 2002 of about 22,000 manufacturing firms, illustrates dynamic nature of interplays of firm's S&T activities with other innovation players such as public research institutes and universities in

transition period of China's innovation system.

The organization of this paper is as follows. In next section, description of the dataset, as well as a recent trend of S&T activities of Chinese manufacturing firms is provided. Then, S&T outsourcing activities are investigated by type of firm' ownership, industry and size. This descriptive statistics section is followed by quantitative analysis on the determinants of S&T outsourcing activities. Finally, this paper is concluded with discussion on the results, as well as some policy implications.

2. Data and Recent Trend of S&T Activities

The dataset used in this paper is based on NBS's Survey on Science and Technology Activities. An annual survey is conducted for all large and medium sized enterprises (LMEs). The results of this survey are used as official S&T statistics in China, and the aggregated statistics is published as *Chinese S&T Statistical Yearbook* every year. There are two types of questionnaires, one is for manufacturing firms and the other is for non manufacturing ones. In this study, annual data for manufacturing firms, which have more detailed survey items as compared to non manufacturing one, are used.

LMEs are defined as a firm with no less than certain amount of physical capacity of production. The threshold point varies by industry, and its unit corresponds to technical characteristics of each sector, such as 'ton' for some chemicals and 'sheets' for some textiles.[4] There are about 22,000 samples in each year. In 2000, census survey of S&T activities, including also small firms (non LMEs), was conducted, and the share of S&T spending of LMEs in 2000 to total is about 67.3%. Therefore, it is possible to say that annual data for LMEs can represent an overall trend of S&T activities in Chinese manufacturing sector.

A survey scope is quite wide, and in addition to common variables found in regular R&D survey, such as R&D expenses and staffs, it covers innovation output variables, such as sales of new products and the number of patent applications, as well. Additional survey items for science and technology activities are also available. It should be noted that the definition of S&T activities is wider than that of R&D, which is harmonized by OECD for international comparison (OECD, 2002). For example, S&T activities include implementation of R&D results in actual production facilities, which is not covered by the definition of R&D. The data on firm's outsourcing activities, which are extensively used in this paper, are based on the concept of S&T, instead of R&D.

[4] Detail definitions for LMEs can be found in Jefferson et. al (2003).

There are also two supplemental surveys, one at science and technology project level and the other at science and technology institute level. These two types of surveys provide detail information on the contents of S&T projects conducted at research unit level of each enterprise. Furthermore, the firm level dataset from S&T Survey can be linked with the Annual Enterprise Survey, also conducted by NBS, which provides information on firm's production and financial performance.

Figure 1 shows a trend of S&T and R&D activities. We can see decreasing share of S&T firms, while share of R&D firms increases. The ratio of R&D to sales in R&D firms is also increasing. As is mentioned above, activities covered by S&T but not by R&D are mainly post R&D activities, such as implementation into actual production facilities. Therefore, Figure 1 suggests that firm with conducting only after R&D activities are decreasing.

(Figure 1)

Changes in innovation system reform in China should be evaluated under broader context of whole economic system reforms. Particularly, SOE reform is the most important, because proper incentives for innovation stem in market based competition. The share of value added of SOEs went down from 73.1% in 1995 to 34.2% in 2002. In contrast, stock holding and foreign owned enterprises have gained their shares, i.e., from 6.8% to 33.1% and from 7.0% to 15.9% respectively (Motohashi and Yue, 2004). Tremendous structural change associated with SOE reforms from the middle 1990's has caused significant impact on firm's incentive structure for innovation activities.

In order to investigate the impact of this structural change on aggregated trend of S&T activities, Figure 2 describes the same indicators as Figure 1, but by firm ownership in 2002. Jefferson et. al (2003) also describes S&T activity by firm ownership in detail. This figure uses the same classification of firm ownership, but shows the data in more recent year. In all of three indicators, the values in stockholding enterprises are greater than those in SOEs, but the difference is small. These values in foreign owned enterprises are even smaller than those in SOEs. Therefore, a shift from SOEs to these two types of enterprises cannot explain an aggregated trend in Figure 1.

In a process of such firm's ownership changes, firm's owners and managers have more incentive for higher performance of their firm, and innovation strategy for higher productivity can be served as a central component in order to survive in competitive environment. In past literature, positive association between SOE reforms and economic performance is supported in general, and market pressure applies not only for

privately owned companies, but also for remaining SOEs. (Jefferson et. al. 2000; Zhang et. al, 2001; Zheng et. al.,2001). In this sense, it is natural to see that innovation intensity indicators do not change very much across firm ownership types.

(Figure 2)

Decreasing share of S&T firms may be explained by specialization of firm's business strategy, in a sense that some enterprises may specialize their activity in manufacturing and stop S&T activities due to intensifying market competition. On the other hand, there are some others increasing a level of not only S&T but also R&D activities to survive in innovation competition.

Figure 3 focuses on 7,362 enterprises staying in the sample from 1996 to 2002, and compares the ratio of R&D to sales by groups of 'started S&T activities during the period from 1996 to 2002', 'kept S&T activities during the same period' and 'stopped S&T activities during the same period'. Our attention should be paid to the third category, and it is found that the firms in this category were low in the S&T to sales ratio, already in 1996. These firms further lowered its S&T activities from 2000, which supports our hypothesis that they have specialized in activities other than S&T, while the other category firms have intensified their S&T activities.

(Figure 3)

3. Characterizing S&T Outsourcing Activities

In S&T Survey, the data for intramural S&T activities and outsourcing expenses are separately collected. While only total amount of outsourced S&T are available in 1996 and 1997, the survey for outsourced S&T to universities and public research institutes are conducted in 1998 and after. From 2000 survey, the type of outsourcing activities is further broken down, by type of counterpart, i.e., outsourcing to universities, public research institutes, international counterparts and domestic firms.

Table 1a and 1b present the share of S&T outsourcing firms by type of counterpart in S&T firms and the average of S&T outsourcing intensity (to the total S&T amount), respectively. The share of S&T outsourcing firms is gradually increasing, and the share reached 30% in 2002. Universities and public research institutes are popular counter parts of outsourcing. One of factors behind this trend is on-going science system reforms to encourage industry science linkages. As compared to domestic interactions, international technology collaboration is still in low level.

(Table 1a and 1b)

While S&T outsourcing activities are becoming popular, the outsourcing intensity increased until 1999 and flattened afterwards. There are no clear signs of upward trends in data by type of counterparts either. An average ratio of outsourcing to total S%T is a little less than 7% in 2002, and about a half of this amount goes to universities and public research institutes (PRIs).

Figure 4 shows a trend of S&T outsourcing firms by type of firm ownership. This share increases in all types from 1996 to 2002. Stockholding firms and SOEs are two major categories which relatively high ratio. In contrast, the ratio is low in foreign owned enterprises. Some foreign owned enterprises were established as a production base. In such enterprises, S&T activities are not relevant, because technological contents are provided from parent companies.

(Figure 4)

Table 2 shows S&T outsourcing indicators in 2002 by industry, firm size and type of ownership. First, a great variance in S&T outsourcing activities can be found across industries. More than 30% of firms are collaborating with universities and PRIs in petrochemicals and drugs. Major motivation for working with these institutions is a need for scientific knowledge in innovation process. It is found that innovations in chemical industry including drugs and petrochemicals are driven by scientific knowledge in developed countries (Arora et. al, 2001; Motohashi, 2004), and this is the case for Chinese enterprises.

(Table 2)

In terms of size distribution of S&T outsourcing activities, the size effect can be seen in share indicators, but it is not so clear for intensity indicators. Relatively small firms with no more than 500 employees spend out to universities and public research institutions at almost the same intensity rate as large firms with more than 2000 employees. Interesting patterns are shown also in comparison across ownership types. Shareholding companies and SOEs are very active in S&T outsourcing activities, while foreign owned firms are not so active except for international outsourcing.

In general, innovation policies toward network based system with active interaction of innovation players are working. S&T outsourcing activities at Chinese firms is becoming popular across firm's ownership types. In Chinese innovation system, PRIs including Chinese Academy of Science play relatively important role, as compared to

OECD countries. In a process of pubic research institute reforms, a substantial number of spin out companies have been emerged. This is the case for university as well. These firms are included in a survey sample of S&T Survey, and they should make a significant contribution of increasing trend of S&T outsourcing activities.

4. Determinants of S&T outsourcing

In order to further investigate factors behind upward trend of S&T outsourcing activities, regression analysis is conducted in this section. Both qualitative variable of whether a firm conducts S&T outsourcing and the share of S&T outsourced in total S&T are regressed with the following explanatory variables.

- LEMP: log of number of employment
- LRD: log of intramural R&D expenditure
- LAGE: log of firm age in year
- ST_NEW: share of S&T expenses to new product development in total S&T
- HI_EMP: share of number of university graduated high level S&T staffs to total number of S&T staffs
- RD_B&A: share of basic and applied R&D to total R&D (1 minus the share of development R&D to total R&D)
- GOV_FUND: share of S&T funding from the government to total S&T fund raised
- Dummy variables for ownership type (7 types), location of firm (31 provinces) and industry (41 two digit level categories)

Summary statistics of these variables in 1996 and 2002 are presented in Table 3.

(Table 3)

LEMP and LRD are included to control for firm size. In addition, a sign of coefficient to LRD shows whether S&T outsourcing and intramural R&D are complement or substitute. In developed countries, positive relationship between them is observed. (Cohen et al.,2002; Motohashi, 2004), suggesting the necessity of absorptive capacity of firms to make most of external technology sources (Cohen and Levinthal, 1990). In China, an innovative capacity of firm is supposed to be weak. Therefore, firms with external collaboration may not spend enough R&D. In this case, R&D outsourcing substitutes in-house R&D, instead of complementing it. In conjunction with these size variables, LAGE is introduced to investigate the role of new technology based firms such as spin out enterprises from universities and PRIs.

ST_NEW, HI_EMP and RD_B&A will capture a firm's S&T activity scope, i.e.,

orientation toward basic technology or product development focus. The higher ST_NEW is, the more a firm focuses on product innovation. In contrast, the higher HI_EMP and RD_B&A are, the more a firm invests in basic technology. It is expected that a firm outsourced S&T to science sector, i.e. universities and PRIs, invests more in basic technology, as compared to the other types of outsourcing.

Finally, GOV_FUND shows an importance of government funding to S&T outsourcing activities. In order to transform Chinese innovation system toward network type one, the Chinese government has introduced several initiatives to facilitate interactions among innovation players. This variable reflects the impacts of such policies.

Table 4 shows changes of results from regression models over time. Dependent variables are a qualitative variable whether a firm outsourced S&T and the share of S&T outsourced in total S&T expenses.[5] First, positive size effects are found in coefficients with LEMP, while mixed results are shown with LRD. Positive relationship with a dummy variable shows outsourcing and in-house complementarity, while results of intensity regressions suggest the size of outsourcing is substitutional to that of in-house R&D. However, negative coefficient with LRD for the S&T intensity regression is not statistically significant. Due to technological upgrading of Chinese firms, complemental relationship is becoming dominant recently.

(Table 4)

As for firm's scope of S&T activity variables, negative and statistically significant coefficients are found with STNEW for all years. It is more interesting to see that the number of positive and statistically significant coefficients with HI_EMP and RD_B&A increases over time. This finding suggests that S&T outsourcing activities become concentrated into firms with basic technology orientation recently. GOV_FUND has a positive and statistically significant coefficient for all years due to the effect of government policy to facilitate networking. However, another way to interpret this finding is that government supports to networking may be crowding out private initiatives. Finally, coefficients to dummy variables on firm ownership (using SOEs as a base category) are also provided. Intensive S&T outsourcing activities in share holding companies are confirmed even after controlling for industry and province.

[5] It should be noted that no data for breakdown of intramural R&D into basic, applied and development are available in 1998.

In Table 5, regression results by the same specification, but by type of counterparts in 2002 are presented. Positive coefficients to LEMP are found in all models, while some negative coefficients to LRD are found again. The necessity to having absorptive capacity is higher in international S&T outsourcing, while it is lower in S&T outsourcing to public research institutes. HI_EMP and RD_B&A are positively correlated with S&T outsourcing, particularly to university and public research institutes. This is quite reasonable because one of motivations underlining such linkages is capturing basic technology seeds in science sector. Positive and statistically significant coefficients to GOV_FUND are found in all models again. In terms of differences across firm's ownership types, the share of S&T outsourcing to universities and PRIs are higher in share holding companies, and strong positive correlation are found between international outsourcing and foreign owned enterprises.

(Table 5)

5. Conclusion

In this paper, growing linkages between science and industry sectors are investigated by using a firm level dataset from NBS's S&T Survey. In a process of innovation system reforms, the share of R&D firms as well as the ratio to the sales has increased. On the other hand, a decline of the share of S&T firms is found. It may be due to that Chinese firms put more focus on their business strategy. Low S&T intensity firms in 1996 are more likely to stop its S&T activities during the period from 1996 to 2002. These firms are supposed to focus on non S&T activities, such as production and marketing, in order to survive in market competition. On the other hand, high S&T intensity firms in 1996 have further intensified their S&T and R&D activities.

In transition period of China's innovation system, active S&T outsourcing activities are found. The ratio of outsourced S&T to total S&T had increased until 1999, then it was flatted out. However, as the absolute amount of S&T activities increases, Chinese firms' S&T linkage activities have never stop growing. S&T outsourcing activities are active, particularly for SOEs and stock holding companies. In contrast, foreign owned companies are not actively engaged in networking activities. It should be noted that substantial number of foreign owned companies are overseas production sites using technology from parent companies abroad. These companies do not need S&T outsourcing.

Under Russian model of innovation system, S&T activities used to conduct in PRIs and universities, and are separated from SOEs. Therefore, even though various policy

actions have been taken in order to change innovation system toward network type one, Chinese manufacturing firms are still low in their level of technological capability. In this sense, collaboration with PRIs and universities which has relatively higher level of technology is effective way to achieve competitive innovation capabilities. Economic analysis of the previous sections shows that firms working with PRIs or universities have focused more on basic and applied research, instead of development. Although overall level of basic R&D investment is very low in China, some firms with long term orientation on their R&D are supposed to seek for long term competitive position by working with PRIs and universities.

Starting from the system of separation between science and industry, interactions between these sectors used to be facilitated by public organizations for technology market (Xue, 1997). As industry sector gains its technological capability to absorb R&D results by PRIs and universities, Chinese firms have increased its S&T outsourcing activities to science sector, directly, since 1990's. In the late 1990's, the Chinese government took substantial policy actions toward science and industry linkages, such as PRC Technology Transfer Promotion Act in 1996 and Regulations on Technology Transfer for PRIs in 1998 (NRCSTD,2003). These government pushes also contribute to further development of collaborations in S&T activities between science and industry sectors.

However, a level of such collaborations is still lower than that of developed countries. For example, more than half of Japanese R&D firms with are conducting joint research project with universities (RIETI, 2004). Relative technological capability of firms as compared to PRIs and universities is still significantly lower in China than that in Japan, and except for top tier companies, most of Chinese firms have not enough absorptive capacity to collaborate with science sectors. As well as promotion for science and industry linkage policy, it is important to consider improving technology level of domestic companies in order to bridge the gap in innovation system, created in centrally planning era

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Figure 1: Trends of S&T firms, R&D firms and RD/sales for S&T firms

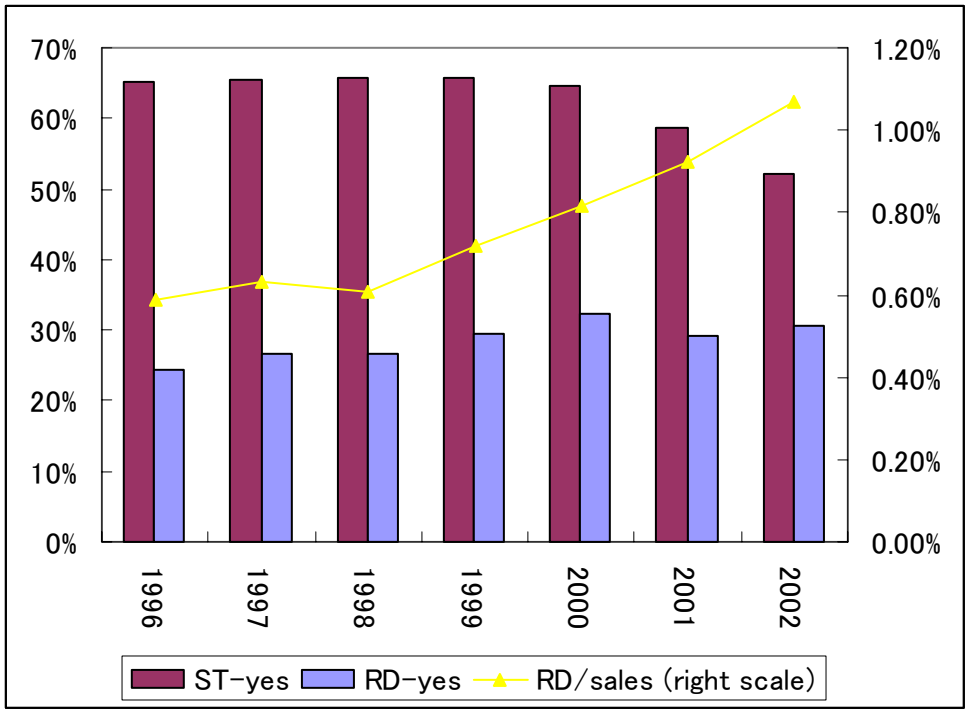

Figure 2: Share of S&T firms, R&D firms and R&D/sales by ownership

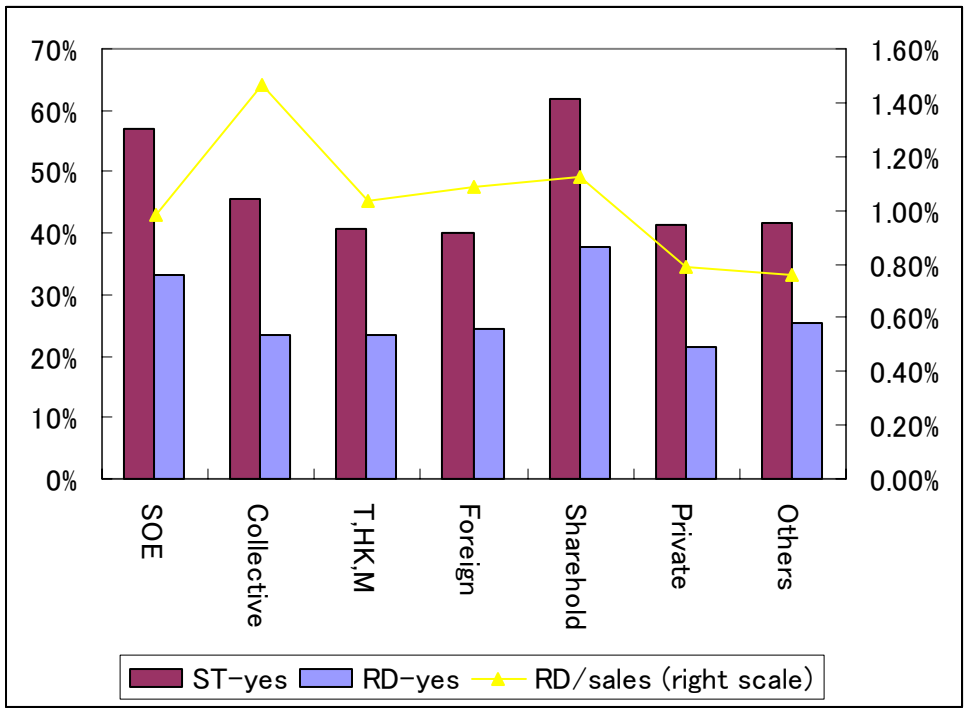

Figure 3: “Start”, “Keep” and “Stop” S&T from 1996 to 2002

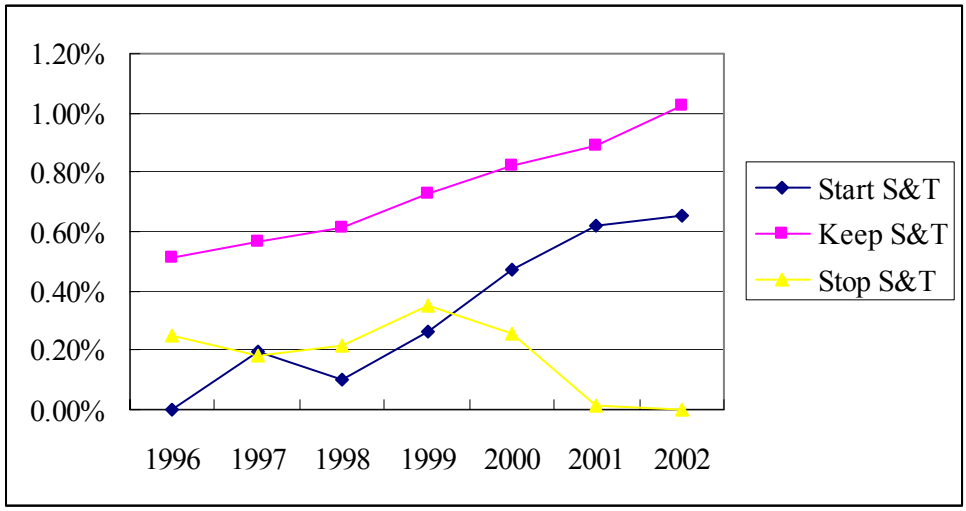

Table 1a and 1b: S&T outsourcing by type of counterparts

	Share of S&T outsourcing to S&T firms					
year	ST-out	Univ or PRIs	University	PRIs	In'l Org	Domestic Firms
1996	18.7%	-	-	-	-	-
1997	18.3%	-	-	-	-	-
1998	24.4%	18.0%	-	-	-	-
1999	28.0%	20.1%	-	-	-	-
2000	28.1%	22.1%	14.8%	14.5%	2.4%	10.4%
2001	28.0%	21.6%	14.4%	14.8%	2.9%	11.2%
2002	30.6%	23.3%	16.2%	15.7%	3.8%	13.2%

	S&T outsourced/total S&T for S&T firms					
year	ST-out	Univ and PRIs	University	PRIs	In'l Org	Domestic Firms
1996	4.5%	-	-	-	-	-
1997	4.8%	-	-	-	-	-
1998	6.3%	3.6%	-	-	-	-
1999	7.0%	3.8%	-	-	-	-
2000	6.8%	3.9%	1.7%	2.2%	0.6%	2.0%
2001	6.8%	3.7%	1.5%	2.1%	0.7%	2.1%
2002	6.8%	3.6%	1.5%	2.1%	0.7%	2.1%

Figure 4: Trend of S&T outsourcing by firm ownership

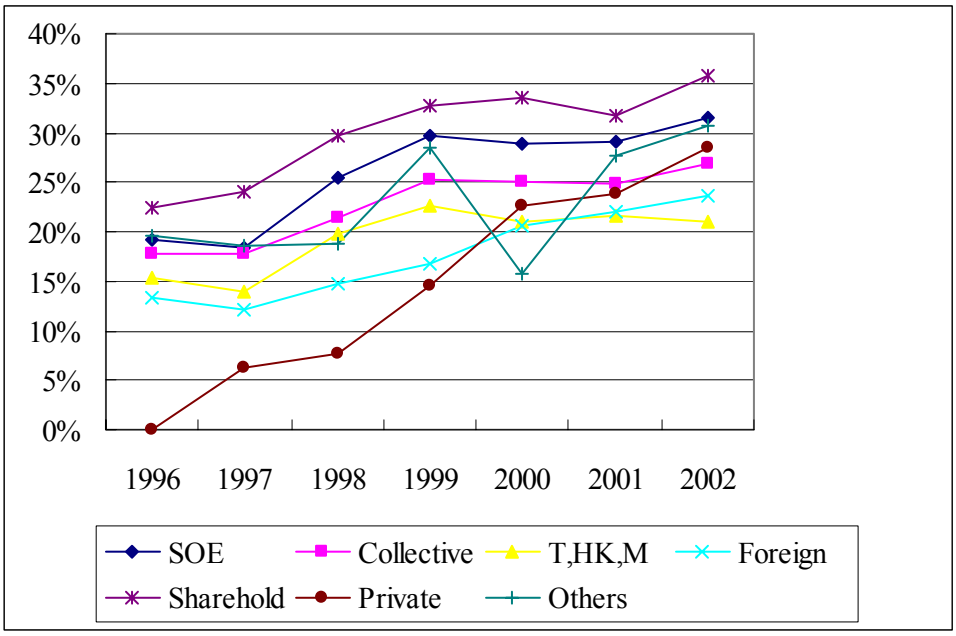

Table 2: S&T outsourcing indicators in 2002

	# of firms	Share of S&T outsourcing in 2002				S&T Outsouced/total S&T in 2002			
		University	PRIs	In'l Org	Domestic Firms	University	PRIs	Int'l Org	Domestic Firms
Mining	150	28.5%	29.0%	1.6%	16.6%	2.6%	3.6%	0.1%	2.2%
Food and tabacco	228	13.3%	13.3%	1.2%	8.0%	1.5%	1.5%	0.1%	1.5%
Texitile	139	8.5%	6.3%	1.8%	5.3%	0.6%	0.7%	0.1%	0.5%
Leather, paper, wood	114	8.7%	8.2%	3.1%	7.3%	0.9%	1.3%	0.7%	1.0%
Petrochemical	44	38.8%	47.5%	7.5%	31.3%	1.8%	6.0%	0.5%	4.1%
Chemical (exc. Drugs)	510	17.3%	16.1%	4.4%	10.9%	1.5%	2.0%	0.9%	1.5%
Drug	347	30.5%	39.3%	4.0%	19.6%	4.4%	9.3%	0.4%	3.5%
Primary metals	330	16.0%	18.1%	2.8%	13.8%	1.2%	1.9%	0.4%	1.8%
Fabricated metals	70	10.6%	9.3%	2.6%	12.2%	0.8%	0.6%	0.5%	1.8%
Machinery	548	16.4%	14.2%	3.6%	11.7%	1.0%	1.4%	0.6%	1.3%
Transportation	289	13.7%	12.2%	6.7%	17.4%	0.7%	1.1%	1.3%	1.9%
Electrical and electronics	590	15.7%	13.7%	6.7%	13.4%	1.1%	1.2%	1.7%	1.4%
Other manufacturing	11	3.0%	3.0%	1.5%	9.0%	0.0%	0.3%	0.0%	0.6%
Utilities	310	19.6%	17.2%	0.8%	27.4%	3.5%	4.1%	0.1%	10.1%
-200	1,297	6.4%	6.2%	1.9%	6.4%	0.9%	1.0%	0.8%	1.3%
201-500	3,226	10.0%	10.7%	2.2%	9.3%	1.4%	2.0%	0.5%	1.7%
501-1000	3,130	13.4%	14.1%	3.1%	11.2%	1.5%	2.4%	0.8%	2.0%
1001-2000	2,308	19.3%	17.5%	3.7%	15.6%	1.6%	2.4%	0.6%	2.6%
2001-	2,053	33.2%	29.9%	8.7%	24.1%	1.8%	2.2%	1.1%	2.6%
SOE	4,485	17.3%	16.4%	2.4%	15.3%	1.6%	2.2%	0.3%	2.8%
Collective	1,005	13.6%	13.9%	2.4%	11.0%	1.9%	2.3%	0.2%	1.5%
T,HK,M	1,012	8.6%	8.7%	4.8%	8.1%	0.7%	1.3%	0.9%	0.9%
Foreign	1,204	9.1%	7.5%	9.3%	8.8%	0.6%	1.0%	3.4%	1.7%
Sharehold	3,729	20.3%	20.2%	4.0%	14.4%	1.8%	2.5%	0.5%	2.0%
Private	523	15.3%	13.4%	2.1%	11.1%	1.8%	1.9%	0.4%	1.2%
Others	62	11.3%	14.5%	1.6%	8.1%	1.3%	3.7%	0.2%	0.6%

Table 3: Summary Statistics of Explanatory Variables

		1996	1998	2000	2002
lemp	mean	6.72	6.58	6.41	6.24
	S.D.	1.01	1.07	1.14	1.20
lrd	mean	6.28	5.89	6.77	7.13
	S.D.	1.81	2.10	1.83	1.88
lage	mean	3.08	2.98	2.92	2.72
	S.D.	0.94	0.96	0.94	0.97
stnew	mean	0.60	0.52	0.47	0.44
	S.D.	0.41	0.42	0.40	0.40
sthighemp	mean	0.25	0.14	0.19	0.21
	S.D.	0.24	0.18	0.21	0.22
rdbasic	mean	0.12	-	0.04	0.09
	S.D.	0.30	-	0.16	0.24
govfund	mean	0.05	0.07	0.06	0.04
	S.D.	0.17	0.20	0.17	0.15

Table 4: Regression results (1)

	S&T Outsourcing (Probit)				S&T Outsouced/total S&T (Tobit)			
	1996	1998	2000	2002	1996	1998	2000	2002
lemp	0.129	0.194	0.153	0.193	0.005	0.008	0.008	0.008
	(5.52)**	(9.51)**	(7.53)**	(9.68)**	(2.52)*	(3.80)**	(3.94)**	(4.33)**
lrd	0.079	0.033	0.127	0.146	-0.006	-0.010	-0.004	-0.002
	(6.50)**	(3.44)**	(11.21)**	(12.83)**	(5.55)**	(9.34)**	(3.55)**	(1.40)
lage	-0.054	-0.073	0.011	0.020	-0.002	-0.008	-0.002	-0.001
	(2.04)*	(3.38)**	(0.51)	(0.97)	(0.88)	(3.12)**	(0.72)	(0.42)
stnew	-0.673	-0.474	-0.756	-0.693	-0.071	-0.080	-0.080	-0.068
	(12.86)**	(9.64)**	(14.91)**	(13.82)**	(16.07)**	(14.96)**	(15.60)**	(14.21)**
sthighemp	0.016	0.297	0.163	0.169	0.000	0.037	0.034	0.027
	(0.20)	(2.97)**	(1.94)	(2.07)*	(0.04)	(3.37)**	(3.90)**	(3.39)**
rdbasic	0.064		0.174	0.163	0.003		0.005	0.011
	(1.01)		(1.61)	(2.20)*	(0.61)		(0.41)	(1.53)
govfund	0.381	0.404	0.397	0.465	0.030	0.062	0.024	0.037
	(3.55)**	(4.66)**	(4.28)**	(4.30)**	(3.18)**	(6.38)**	(2.46)*	(3.40)**
Colletive Owned	0.061	0.022	0.043	0.011	0.004	0.008	0.006	0.010
	(0.97)	(0.37)	(0.71)	(0.16)	(0.67)	(1.25)	(1.02)	(1.39)
Taiwan, HK, Macau	-0.100	0.056	-0.131	-0.134	0.008	0.008	0.001	-0.008
	(0.91)	(0.63)	(1.52)	(1.75)	(0.83)	(0.85)	(0.11)	(1.06)
Foreign Owned	-0.231	-0.291	-0.104	-0.171	0.002	0.033	0.014	0.017
	(2.08)*	(3.09)**	(1.31)	(2.38)*	(0.18)	(3.25)**	(1.66)	(2.39)*
Share holding	-0.073	0.049	0.077	0.123	0.008	0.015	0.009	0.008
	(0.96)	(0.94)	(1.72)	(2.73)**	(1.29)	(2.50)*	(1.97)*	(1.70)
Private Owned		-1.018	0.210	0.193	-0.030	-0.047	0.010	0.011
		(3.02)**	(1.49)	(2.04)*	(0.43)	(1.72)	(0.69)	(1.18)
Others	0.096	-0.354	-0.248	-0.054	0.001	-0.011	-0.005	0.006
	(0.53)	(1.85)	(1.11)	(0.23)	(0.06)	(0.55)	(0.24)	(0.25)
Constant	-0.762	-0.982	-3.240	-7.369	0.113	0.145	0.008	-0.015
	(1.11)	(1.90)	(4.21)**	(8.33)**	(1.82)	(2.60)**	(0.13)	(0.10)
Province Dummies	yes	yes	yes	yes	yes	yes	yes	yes
Industry Dummies	yes	yes	yes	yes	yes	yes	yes	yes
Observations	5575	5998	6506	6646	5589	5998	6506	6640

Absolute value of z statistics in parentheses

* significant at 5%; ** significant at 1%

Table 5: Regression results (2)

	S&T Outsourcing in 2002 (Probit)				S&T Outsouced/total S&T in 2002 (Tobit)			
	University	PRIs	Domestic Firms	Int'l Org.	University	PRIs	Domestic Firms	Int'l Org.
lemp	0.256	0.189	0.137	0.170	0.003	0.002	0.002	0.002
	(11.45)**	(8.35)**	(6.15)**	(4.89)**	(3.32)**	(1.76)	(1.93)	(3.26)**
lrd	0.146	0.127	0.107	0.213	-0.001	-0.001	-0.001	0.001
	(11.31)**	(9.76)**	(8.21)**	(9.80)**	(1.59)	(1.98)*	(1.58)	(3.20)**
lage	0.012	0.025	0.016	-0.045	0.000	0.002	-0.001	-0.001
	(0.55)	(1.13)	(0.70)	(1.26)	(0.01)	(1.65)	(0.79)	(1.51)
stnew	-0.435	-0.558	-0.503	-0.679	-0.010	-0.017	-0.021	-0.014
	(7.49)**	(9.44)**	(8.48)**	(7.13)**	(4.93)**	(6.51)**	(7.69)**	(7.49)**
sthighemp	0.240	0.219	-0.006	0.029	0.012	0.011	0.001	0.003
	(2.58)**	(2.34)*	(0.06)	(0.20)	(3.53)**	(2.43)*	(0.26)	(0.97)
rdbasic	0.232	0.179	0.061	0.171	0.004	0.007	-0.001	0.000
	(2.85)**	(2.21)*	(0.72)	(1.27)	(1.18)	(1.65)	(0.26)	(0.01)
govfund	0.518	0.352	0.374	-0.023	0.019	0.007	0.016	-0.004
	(4.41)**	(2.90)**	(3.12)**	(0.10)	(4.58)**	(1.18)	(2.56)*	(0.88)
Colletive Owned	0.024	-0.009	0.057	-0.036	0.007	0.005	0.000	-0.002
	(0.30)	(0.11)	(0.69)	(0.25)	(2.37)*	(1.28)	(0.03)	(0.83)
Taiwan, HK, Macau	-0.151	-0.143	-0.306	0.357	-0.001	-0.001	-0.010	0.004
	(1.66)	(1.54)	(3.32)**	(2.75)**	(0.31)	(0.16)	(2.36)*	(1.44)
Foreign Owned	-0.262	-0.321	-0.214	0.606	-0.003	-0.002	0.002	0.022
	(3.09)**	(3.62)**	(2.55)*	(5.28)**	(1.05)	(0.43)	(0.45)	(8.16)**
Share holding	0.131	0.167	0.010	0.137	0.002	0.005	0.000	0.001
	(2.67)**	(3.37)**	(0.20)	(1.63)	(1.33)	(1.87)	(0.05)	(0.61)
Private Owned	0.177	0.153	0.139	0.061	0.008	0.006	-0.002	0.001
	(1.68)	(1.44)	(1.29)	(0.33)	(2.04)*	(1.14)	(0.46)	(0.35)
Others	-0.434	0.058	-0.314	-0.033	-0.007	0.027	-0.011	-0.002
	(1.47)	(0.23)	(1.08)	(0.07)	(0.77)	(2.18)*	(0.85)	(0.28)
Constant	-7.266	-8.190	-6.767	-3.691	-0.011	-0.002	-0.010	-0.017
	(7.59)**	(9.77)**	(8.56)**	(4.36)**	(0.19)	(0.03)	(0.13)	(0.30)
Province Dummies	yes	yes	yes	yes	yes	yes	yes	yes
Industry Dummies	yes	yes	yes	yes	yes	yes	yes	yes
Observations	6646	6615	6612	6280	6639	6636	6646	6646

Absolute value of z statistics in parentheses

* significant at 5%; ** significant at 1%