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Technology Development and Job Creation in China

Nannan Lundin, Fredrik Sjöholm, He Ping and Jinchang Qian

Research Institute of Industrial Economics
P.O. Box 55665
SE-102 15 Stockholm, Sweden
info@ifn.se
www.ifn.se

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Nannan Lundin

Örebro University and Research Institute of Industrial Economics

Fredrik Sjöholm*

Research Institute of Industrial Economics

He Ping

National Bureau of Statistics of China

Jinchang Qian

National Bureau of Statistics of China

Abstract

This paper examines how Science and Technology (S&T) contribute to job creation in the Chinese manufacturing sector. The ambition of transforming China into an innovation-oriented nation and the emphasis on indigenous innovation capacity building have placed Science and Technology (S&T) high on the Chinese policy agenda. At the same time, the need for job creation is pressing, both to absorb the huge supply of underemployed people, and to enable the annual 20 million new labor market entrants to find employment. We examine the relationship between S&T and job growth in the Chinese industrial sector. S&T can be expected to have both positive and negative effects on employment. For instance, new technology might increase competitiveness and enable Chinese firms to expand their labor force. On the other hand, new technology might be labor-saving, thereby enabling Chinese firms to produce more output with fewer employees. Based on a large sample of manufacturing firms in China between 1998 and 2004, we analyze how S&T affect employment growth. Our results suggest that S&T activities have no effect on job creation.

Keywords: China; Science and Technology; Job-Creation

JEL codes: J21; O14; O33

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1. Introduction

New technology is important for economic development: it raises national income by increasing output for a given amount of production factors. It is safe to say that no country has ever industrialized and developed without substantial technology change. This might be one reason why policy makers around the world tend to pay considerable attention to technology development. China is one such country. Science and Technology (S&T) have become one of the most promoted areas in Chinese economic policy over the last few years (Lundin et al, 2006). The recently released National Guidelines for Medium- and Long-term Plans for Science and Technology Development of China (2006-2020) stress the importance of technology change in general and indigenous technology change in particular (Chinese Ministry of Science & Technology, 2006). The official rhetoric is paralleled by a strong increase in S&T by Chinese firms, and China is one of the world's largest performers of S&T today (OECD, 2005).

It is widely expected among Chinese policy makers that increased S&T efforts will improve the competitiveness and growth of the Chinese economy. Less debated is the role of S&T on job creation, which is unfortunate considering the serious lack of jobs in the formal sector. There is a large number of unemployed people in China and an even larger amount seeking an existence in the informal sector. Moreover, the rapidly declining state owned enterprises have not been matched by a sufficient expansion of the private sector, putting additional stress on the need to create new jobs.

S&T might affect the degree of job-creation. However, it is not obvious whether the effect is positive or negative. On the one hand, it might enhance competitiveness and thereby increase the demand for labor. On the other hand, S&T might lead to relatively skill intensive or capital intensive production and thereby a reduced demand for labor. Which is the dominating mechanism is an open question.

We contribute to the literature on job-creation in developing countries by examining the relationship between S&T and employment. Our analysis is based on a large data set on all large and medium sized enterprises in the Chinese industry between 1998 and 2004. One methodological problem is that we can only observe employment in surviving firms and survival might be affected by S&T. The results on how S&T affect employment could therefore be biased. We try to control for this potential bias by applying a Heckman two-step estimation procedure. Our analysis shows that S&T have a positive effect on firm survival. However, there is no positive effect on job-creation even after controlling for the higher survival rate of firms engaged in S&T. The result is robust to alternative samples and estimations. We conclude the paper by arguing that S&T development may have many advantages, but it does not seem to solve one of the major policy issues in China, namely insufficient job-creation.

2. S&T and job creation – a conceptual framework and previous studies

There are reasons to believe that S&T can have both positive and negative impacts on employment. The positive impact is mainly caused by the effect of S&T on firms' survival and growth. More specifically, firms conduct S&T to improve existing production processes and products, or develop new ones. New products and processes will materialize in productivity gains through improved efficiency in production (lower costs) or through higher prices on output (new products). Improved productivity benefits the firm in terms of higher competitiveness and thereby an increased possibility of staying in the market and expanding its activities.

There are also theories suggesting that some technological change might be negative for employment. More precisely, the literature on skilled biased technological change suggests that technology and labor (or some types of labor) might be substitutes rather than complements. This means that improved technology might, for instance, make the firm use more capital but less labor, or more skilled labor but less unskilled labor (e.g. Ekholm and Midelfart, 2005; Thoenig and Verdier, 2003).

Turning to the empirical literature, the positive relationship between S&T and productivity is well documented and need not be elaborated on further.[1] There is also ample evidence of a positive effect of productivity on firms' growth and survival. For instance, Okamoto and Sjöholm (2005) examine productivity growth in Indonesia and find a strong effect on aggregate productivity from increases in market shares by plants with a relatively high productivity growth. Accordingly, Levinshohn and Petrin (1999) find a similar mechanism in Chile with growth of market shares for firms with high productivity.[2] Survival is also closely related to productivity: firms exiting the market tend to have relatively low levels of productivity.[3] It should be noted that firm growth is not automatically associated with growth in employment. Moreover, high productivity can, of course, be caused by factors other than S&T.

Most empirical studies on technology and employment examine changes in the demand for skilled and unskilled labor, typically in developed countries. There seems to be substantial evidence of skilled-biased technological change, irrespective of differences in methodologies and countries (Ochsen and Welsch, 2005; Xiang, 2005; Bauer and Bender, 2004; Hollanders and ter Weel, 2002; Kang and Hong, 2002; Berman et al., 1998). Whether skill-biased technological change will reduce total employment depends on two factors. First, the change in relative prices (wages for skilled and unskilled labor) will have an impact on the changes in the number of employees. If, for instance, the relative prices on unskilled labor fall, this will mitigate the negative effect on employment of unskilled labor. Second, changes in the relative demand for different types of workers decrease the total number of employees,

[1] See e.g. Wieser (2005) for a recent survey of the literature on R&D and firm productivity.
[2] See also Olley and Pakes (1996), and Foster et al. (1998) for similar findings in developed economies.

only if the loss of unskilled workers is larger than the increase in skilled workers.

The above studies are concerned with issues that are only related to the focus of our paper. We intend to examine the effect of S&T, rather than that of productivity, on total employment, rather than on the composition of employment. Whereas, to the best of our knowledge, no such studies have previously been conducted on developing countries, there are a few studies on developed countries. For instance, Van Reenen (1997) examines the effect of innovations on employment in a panel of 598 British firms. The results show a positive effect of innovations on employment which is robust to changes in specifications and controls. Moreover, Smolny (1998) examines the effect of process and product innovations on a panel of 2,405 German firms. Once more, there is evidence of a strong positive effect of innovation on employment.[4]

3. The Chinese context

The Chinese labor force is predicted to grow at an annual rate of 1.3 percent over the next decades (Chow et al., 1999, p.483). Moreover, there is a large pool of Chinese underemployed workers or workers in the informal sector. For instance, around 65 percent of China's 131 million internal migrants are without *hukou* (household registration) and are therefore excluded from the formal job markets (Cai et al., 2005). Taken together, this growth of the labor force and the large number of workers outside the formal labor market underline the need for substantial job creation in China. Unfortunately, some reports suggest that job growth has come to a halt. For instance, registered urban unemployment increased from around 2.9 to 4.2 percent of the labor force between 1995-2005 (National Bureau of Statistics, 2006). Moreover, Cai (2004) estimates a large drop in the labor participation rate from 73

[3] See, for instance, various chapters in the book by Roberts and Tybout (1996).
[4] There are also other studies on technology change and employment in industrialised countries conducted at a more aggregated level. Most studies find a positive effect of technology change on employment. See Pianta (2006) for a survey of the literature.

percent in 1995 to 62 percent in 2000.

Which Chinese firms will then be likely to provide the new jobs? There is strong evidence that firm ownership is important for job creation. For instance, the main reason for the insufficient job creation in China is that the private sector, including foreign owned multinationals and joint-ventures, has difficulties in absorbing the same number of workers that are laid off from SOEs. This is shown in manufacturing employment, which has declined from about 98 million in 1996 to about 83 million in 2002, largely because increased private sector employment has been out-weighted by declining employment in manufacturing SOEs from 32 million in 1996 to less than 10 million in 2002 (National Bureau of Statistics, 2005, Tables 1-6 and 1-16).[5] Hence, private domestic and foreign owned firms are relatively more likely to generate jobs than are SOEs.

Besides ownership, there is relatively little knowledge on what Chinese firms tend to generate job growth but size might be an important factor. In a study of the manufacturing sector in Shanghai, Chow et al. (1999) find small firms to be relatively able to generate jobs over the period 1989 to 1992. This situation is likely to be present also today and in other parts of China, considering that the share of manufacturing employees in small firms has increased from 38.6% in 2000 to 49.5% in 2004. [6]

Referring to our issue of the impact of technology on job creation, there is hardly any previous studies that can be consulted. It has been shown that large firms (many employees) conduct more S&T than small firms (few employees) (Lundin et al., 2006) but we cannot draw any conclusions from this stylized fact regarding the causality between S&T and employment growth. In other words, it might be that large firms tend to be more willing to invest in S&T and thus, it is not a causal effect from S&T to employment growth.

[5] Banister (2005) argues that these figures do not adequately cover unregistered workers and workers in township and village enterprises (TVA). However, her estimates show that although the level of employment is higher than the official figures, the trend of declining employment remains.

4. Data and descriptive statistics

Data

Our data is on large- and medium-sized enterprises in the Chinese manufacturing sector over the period 1998-2004 and has been complied by the National Bureau of Statistics of China. The classification of large- and medium sized firms is based on a combined firm-size indicator, where employment, turnover and fixed asset are taken into account.[7]

The included variables are from two different sources. The first source is balance sheets of firms from the Chinese industrial statistics, the other is S&T statistics. Merging these two datasets and using unique firm identification codes, we obtain a dataset with two categories of variables: 1) Firm-level economic variables, such as employment, wages, sales, value-added, profit, exports, fixed assets, time of establishment and ownership, and 2) Technology related variables including S&T and R&D expenditures, human resource inputs such as S&T personnel and R&D personnel, and purchase of foreign technology.

Industry and ownership classifications

The industry classification is similar to the classification ISIC, Rev. 3 and the included sectors are shown in Appendix A3. When output data, such as value-added and sales, is deflated into real values, the deflators are based on either the three-digit or the four-digit producer price deflators, depending on availability.

Furthermore, following the OECD classification, we divide the dataset into high-tech and non-high-tech industries (OECD, 2005 and Hatzichronoglou, 1997). The high-tech industries include the following five industrial sectors: Aircraft and spacecraft; Pharmaceuticals; Office, accounting and computing machinery; Radio, TV and communications equipment; and

[6] The authors' own calculation, based on aggregated information complied by National Bureau of Statistics of China.

Medical, precision and optical instruments. It should be stressed that products and processes in firms in a high-tech industry do not necessarily have a high technology content. This is particularly true for non-OECD countries such as China, because of differences in the industrial structure as compared to OECD countries (e.g. the dominance of labor-intensive processing manufacturing).[8]

Finally, for a comparison across various ownership groups, we follow the classification applied by Jefferson et al. (2003), and Hu et al. (2005) in their previous analyses of S&T activities in Chinese LMEs.[9]

Other data issues

S&T and R&D expenditures are two key measures on technology development used in our study. According to the commonly used international classification from the OECD, these two concepts are defined as follows.

> **S&T:** systematic activities, which are closely concerned with the generation, advancement, dissemination and application of science and technology. These include such activities as Research and Experimental Development (R&D), Science and Technical Education and Training (STET) and Scientific and Technological Services (STS). (Frascati Manual, 2002, OECD).
>
> **R&D**: comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to devise new applications. The term R&D covers three activities: basic research, applied research and experimental development. (Frascati Manual, 2002, OECD).

In the current indicator system in China, the definition of R&D is in line with the Frascati Manual. International classifications of S&T indicators are less straightforward and the Chinese classification is no exception. The definition of S&T followed the UNESCO manual when the Chinese S&T statistics system was first introduced in the mid 1980s. In the last two

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[7] See Appendix A for the detailed classification.
[8] See Lundin et al. (2006) for a discussion.
[9] See Appendix A2 for the detailed classification.

decades, the definition of S&T has changed more towards the Frascati manual recommendation. S&T in the Chinese indicator system include R&D, technology acquisition (licenses) and renovation, and miscellaneous expenditures on preparation for the production of new products and applications of R&D results. Hence, S&T include several activities not included in R&D. Therefore, we will primarily use S&T in our analysis since we want to analyze how technology development affects job creation in a broad sense. R&D expenditures will be used as a robustness check in parts of the analysis.

Another important definition issue is firm survival. Using the firm identification code, we define firm survival as when the firm's identification code remains in the dataset and likewise, the "death" of the firm is defined as when the firm code disappears from the dataset. However, it is difficult to distinguish between natural market exit (bankruptcy) and other reasons for firms to disappear from the dataset. More specifically, the identification code of a firm can disappear for the following reasons:

- Natural exit.
- Ownership change (e.g. due to privatisation or merger and acquisition) or industry switch.
- Decrease of firm size to below the threshold when firms become re-classified as small firms and are excluded from the LME survey.

Obviously, the different causes for a firm to disappear from the data might blur any analysis of firm survival. However, our main reason for analyzing survival is to correct for a possible bias in the job-creation analysis. The different causes for firms to disappear from the data are presumably of minor importance for this issue.

Finally, the coverage of LMEs was enlarged in the 2004 Economic Census of

China, as compared to surveys in previous years. Furthermore, in the 2004 census, S&T statistics was reported at the firm level. Previous surveys reported S&T at the level of enterprise groups and all firms belonging to a group were added together and recorded as one observation. As a result, the total number of firms and the number of firms with S&T both increased in 2004.

Descriptive Statistics

Table 1 shows the numbers of firms and employees between 1998 and 2004. The number of firms has increased over the period, from 23,105 in 1998 to 27,712 in 2004, and the whole increase is in the second period when the number of firms increased by almost 24 percent.[10] It is interesting to note that growth has been comparably high for firms without S&T. For instance, the number of firms without S&T increased by about 4 percent during the first period, as compared to a decline of about 10 percent for firms with S&T. The development in the second period is even more striking with a large increase in firms without S&T (40.3 percent) and a small increase in the number of firms with S&T (4.2 percent).[11]

Growth in employment shows a pattern similar to growth in firms. More precisely, employment declined by almost 20 percent between 1998 and 2001 with a relatively large decline for firms with S&T. Furthermore, employment increased by about 29 percent between 2001 and 2004, once more with a substantial growth in employment in firms without S&T (84 percent) and a small growth in employment in firms with S&T (4 percent).

The relatively large increase in employment in firms without S&T should not come as a surprise at an aggregate level. China has a comparative advantage in labor intensive sectors but not in technology intensive sectors. What we want to examine is if in a given

[10] Once more, some of the increase between 2001 and 2004 is, according to officials at the National Bureau of Statistic, caused by an improved coverage of the census and not only by an increase in the real number of firms.

sector, firms with S&T have grown more or less than firms without S&T. Looking at different sectors, it is particularly interesting to note that even in high-tech industries, firms and employment have increased substantially but with most of the increase in firms without S&T.[12] This might suggest that most activities in high-tech industries are of relatively low skill-intensity.

Table 1 also includes the five largest industries (in terms of value added) at the two-digit level in 1998. The figures at an industry level reveal the same story as above where employment and the number of firms without S&T tend to increase more (decrease less) than the corresponding changes in firms with S&T. The sectors in Table 1 are rather broad and it is, of course, possible that firms with and without S&T are located in different sub-sectors and that this explains the different growth in employment. To control for this possibility, we calculated employment growth at a four-digit level, which is the most disaggregated level available. Employment growth tends, once more, to be highest in firms without S&T but the difference is less significant than the figures above, especially in the second period. More specifically, employment growth was higher in firms without S&T than in firms with S&T in 100 of the 141 available sectors in the first period, and in 75 sectors in the second period (not shown).

Table 1 suggests that employment has increased more in firms without S&T than in firms with S&T, but the causality between S&T and growth in employment is unclear. An alternative approach to the issue of S&T and job creation is to compare employment growth within firms with and without S&T. This is done in Table 2 where, for instance, we compare growth in employment between 1998 and 2001 in firms that conducted S&T and

[11] Here, once more, some of the changes might be due to the construction of the data rather than being real changes. All firms that belonged to large enterprise groups with S&T were reporting positive S&T before 2004. In the 2004 census, S&T were reported at the level of the firm and not at the level of the enterprise group.

[12] High-tech industries are based on the classification in the OECD and include medical and pharmaceutical products, aircraft and spacecraft, electronic and telecommunication equipment, computer and office equipment and medical equipments and meters.

firms that did not conduct S&T in 1998. Hence, unlike previous tables, the sample only includes those firms that are present over the period 1998-2001 and/or 2001-2004.

Table 2 shows that employment has declined in the included firms; the number of employees decreased by about 17.3 percent between 1998 and 2001 and by about 3.2 percent between 2001 and 2004. The performance was similar in firms with and without S&T in the first period, but growth in employment has been positive in firms without S&T and negative in firms with S&T in the second period.

It is worth noting that firms in high-tech industries have seen a lower than average decline in employment in the first period and a positive employment growth in the second period. This could be an indication of an increased importance of high-technology in the Chinese economy. However, it should also be emphasized that, even within high-tech industries, employment growth has been substantially higher in firms without S&T.

The pattern of a comparably strong employment growth in firms without S&T is also seen in other sectors: employment growth is higher in firms with S&T than in firms without S&T in only one industry in 1998-2001 (Ferrous Metals) and one industry in 2001-2004 (Petroleum products). Hence, there does not seem to be any positive effect of S&T on job creation, as far as one can tell from the descriptive figures in Table 2.

As previously discussed, employment has declined rapidly in Chinese SOEs. This is likely to be one cause for the negative growth in employment seen in Table 3. It is also possible that the development in SOEs shades the role of S&T in job creation. Therefore, we divide our sample of firms by ownership in Table 3.

Table 3 shows that, not surprisingly, the number of employees has declined rapidly in SOEs: with around 20 percent between 1998 and 2001, and with 12 percent between 2001 and 2004. Employment has also declined in both periods in Collective, Shareholding, and Other domestic firms. The result for private domestic firms is mixed with a small decline in the first period (-3.7 percent) and with an increase in the second period (22 percent).

Firms with foreign ownership are divided into three groups: joint ventures with firms from Hong-Kong, Macau, and Taiwan; joint-ventures with firms from other countries; and wholly foreign-owned firms. Joint ventures with greater China have had a positive growth in employment in both periods, whereas the other type of joint ventures had a stagnant job growth in the first period and a positive job growth in the second period. Wholly foreign owned firms have shown the highest growth in employment with about 22 percent in the first period and about 38 percent in the second period.

Returning to the relationship between S&T and job growth, it is seen that our previously expressed suspicion that a negative relation is due to the development in SOEs is only partly correct. Job growth has been poorer in SOEs with S&T than in SOEs without S&T. However, the same development is also found in all three groups with foreign ownership where employment has grown faster in firms without S&T. In fact, all types of foreign firms with S&T had a negative employment growth in the first period.

Firms with S&T have a higher employment growth than firms without S&T in two ownership groups, Collectives and Shareholdings, whereas the results for private firms are inconclusive with a seemingly positive effect of S&T on employment in the first period, but a negative effect in the second period.

The above results suggest that S&T do not have a positive impact on job creation. If anything, the results suggest that firms without S&T have increased their employment faster.

There is another mechanism through which S&T might affect employment: survival. In other words, there might be a positive relation between S&T and the survival of firms, something that is overlooked in Tables 3 and 4 where, obviously, only surviving firms are included. Table 4 includes figures on how large a proportion of all firms that were present in, for instance, 1998, survived until 2001. The survival rate is divided among firms with and without S&T. The figures show that roughly 59 percent of all firms that existed in 1998 survived until 2001. The survival rate decreases substantially in the second period, where it amounts to about 40 percent. The exit rate in the first period is broadly in line with the results for other countries.[13] The second period, however, shows an exit rate that is considerably higher than what is typically the case in other studies. Once more, our exit rate can be caused by other factors than the "death" of a firm and is therefore not directly comparable with figures from other studies.

The survival rate differs between industries and seems to be particularly high in Petroleum and low in Textiles. More importantly, there seems to be a positive relation between S&T and survival: firms with S&T are comparably likely to survive in all industries and in both time periods.

To sum up the results, the simple tabulations in the tables above seem to suggest that, first, S&T have no positive effect on job-creation and second, that S&T have a positive effect on firm survival. Hence, although the figures suggest that S&T do not create jobs, they seem to maintain jobs by affecting the survival rate.

The main constraint of the above analysis is obvious: job growth and firm survival are affected by a host of factors other than those included in the tables. If such characteristics differ between firms with and without S&T, there is a risk that our comparison is biased. Indeed, Table 5 shows there to be large differences between firms with and without S&T in all sectors and in all time periods. More specifically, firms with S&T tend to be relatively large, capital intensive firms with high profits, productivity, and wages, and with a large amount of imports of technologies. Firms with no S&T tend to have a substantially

[13] See e.g. Roberts and Tybout (1996), and Bernard and Sjöholm (2003).

higher amount of exports.

Controlling for various factors that affect employment and allowing all Chinese firms to be included in the data requires an econometric approach to which we now turn.

5. Econometric model and results

Model

To assess the impact of S&T on job-creation, we use a Heckman two-step estimator to control for the sample selection problem caused by attrition (firms dropping out from the data set) (Puhani, 2000). This aims at controlling for the effect of firm survival before we estimate the impact of S&T on job creation. In the first step, we estimate a probit model for firm exit as specified in Equation (1). We experiment with using different sets of controls, ranging from an S&T status dummy only, to the most comprehensive model, which includes S&T intensity, ownership, skill- and capital intensities and a set of dummy variables to control for export- and import status, as well as for year- and industry-specific effects. We use the most comprehensive model to calculate the inverse Mills ratio.

$$\begin{aligned}
&\hat{P}(Exit_{it}) = \Phi(Z_{i,t-1}) \\
&\mathrm{Z}_{i,t-1} = \alpha + \beta_{st}\mathrm{S\,\&\,T_share}_{i,t-1} + \lambda_1\mathrm{Firmsize}_{i,t-1} + \lambda_2\mathrm{Skill_Share}_{i,t-1} + \lambda_3\mathrm{Capital_intensity}i,_{t-1} + \\
&\sum\beta_w\mathrm{Ownership}_i + \beta_{\mathrm{ex}}\mathrm{Export_dummy}_{i,t-1} + \beta_{\mathrm{im}}\mathrm{Import_dummy}_{i,t-1} + \sum\beta_t\mathrm{Year_dummy} + \sum\beta_{ind}\mathrm{Ind_dummy}_j
\end{aligned} \quad (1)$$

In the second step, the inverse Mills ratio is added to the model of employment growth as an explanatory variable. The employment growth model is specified as follows[14]:

$$\begin{aligned}
\mathit{\Delta X}_{i,t} &= \mathit{InX}_{it} - \mathit{InX}_{it-1} = \alpha + \sum\beta_n\mathrm{S\,\&\,T_share}_{i,t-n} + \lambda\mathrm{Firm}_{i,t-1} + \sum\beta_w\mathrm{Ownership}_i \\
&+ \sum\beta_t\mathrm{Year_dummy} + \sum\beta_{ind}\mathrm{Ind_dummy}_j + \sum\beta_R\mathrm{Reg_dummy} + \gamma\mathrm{Mills}_{it} + \varepsilon_{it}
\end{aligned}, \quad (2)$$

where i is the index for firms, j is the index for industries and t is the index for year. The model is estimated by applying OLS and fixed effect estimators on the full dataset as well as on sub-samples by ownership and by industry sector. The variables included in the specification are defined as:

X_{it}: Employment

$S\&T\_share_{i,t-n}$: The ratio of S& T expenditures to sales, where *n* is the number of lags.

$Firm_{i,t-1}$: A vector of lagged firm characteristics such as size, labor productivity, skill intensity, export- and import intensity.

$Ownership_i$: Ownership dummy variable indicating SOE, collective, joint venture with firms from Taiwan, Hong Kong and Macau, joint venture with firms from other foreign countries, wholly foreign-owned, private and other domestic firms.

$Year_t$: Year dummy variable.

$Industry_j$: Industry dummy variables at the four-digit level.

Reg_dummy: Regional dummy variables at the province level.

$Mills_{it}$: The inverse of Mills ratio from the probit model estimation in Step 1, calculated as

$\frac{\phi(Z_{it})}{1-\Phi(Z_{it})}$, where ϕ is the standard normal probability density function and Φ is the standard normal cumulative density function .

We hope to avoid an endogeneity problem by using lagged values on S&T and other independent variables in our estimations. However, we will also use a matching approach, both as a robustness check and as an alternative attempt to control for the possibility that S&T is a function of, for instance, job growth.

The idea behind the propensity score matching estimator is that for every firm that performs S&T, we identify an "identical" firm that does not perform any S&T. We then

[14] See Appendix A4 for detailed definitions of the control variables at the firm- and industry level.

compare job growth in the treated group (performs S&T) and the control group (does not perform S&T).[15] The treatment is defined by the S&T dummy variable ($S\,\&\,T\_dummy_{i,t-1}$), i.e. whether firm *i* performs S&T activities or not at time *t-1*, and employment growth (ΔX_i) is defined as the outcome variable. We use a set of lagged firm characteristics ($Firm_{i,t-1}$), such as firm size, labor productivity, export intensity, import intensity, capital intensity, and industry affiliation at the two-digit level ($Industry_j$) to identify similar firms and perform the matching of treated and control firms. The propensity score is estimated by the following specification[16]:

$$p(Firm_{i,t-1}, Industry_j) = \Pr\left\{S\,\&\,T\_dummy_{i,t-1} = 1 \middle| Firm_{i,t-1}, Indsutry_j\right\}$$

(3)

The average treatment effect on the treated (ATT) is estimated as follows:

$$ATT = E\left\{E\left\{\Delta X_{1i} - \Delta X_{0i} \middle| S\,\&\,T\_dummy_{i,t-1} = 1,\ p(Firm_{i,t-1}, Industry_j)\ \right\}\right\}. \qquad (4)$$

The matching method implies some methodological drawbacks, such as the loss of information when using an S&T dummy variable (instead of S&T intensity) and the reduced sample size, as well as the sensibility of results on the choice of control variables. The main advantage of the approach is its ability to control for endogeneity problems and we use it as a complement to the Heckman two-step analysis discussed above.

Results

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[15] We apply the nearest neighbor matching with replacement; see Becker and Ichino (2002) for more details.

[16] The use of a lagged S&T dummy variable (instead of the contemporaneous S&T dummy) is motivate by the assumption that S&T does not have an immediate effect on employment growth, which is consistent with the specification of Equation (2).

Table 6 shows probit estimations on firms' likelihood to exit from the market and how this likelihood is affected by a host of firm characteristics. A negative coefficient means that the likelihood of exit decreases. In addition to controlling for sample selection bias, we can also make use of this estimation to identify the factors that affect firm exit. As previously discussed, the data is constructed in such a way that we cannot distinguish death of firms from two other forms of exit: a change in ownership or a decline in size to below the threshold. Bearing this caveat in mind, we notice in the first column that S&T have a positive and statistically significant impact on survival: firms with any S&T are significantly less likely to exit compared to firms with no S&T.

In the previous sections, we have seen that firms with and without S&T differ in a number of aspects which could also affect the exit rate. We try to control for such characteristics in the following estimations. Column 2 shows that large firms are substantially less likely to exit. Moreover, all the included ownership variables are statistically significant with negative signs showing that firms with any of these ownerships are less likely to exit than the group of comparison: other domestic firms. We can also see that the coefficients differ between ownership groups with a large negative coefficient for foreign ownership and a smaller negative coefficient for collective ownership. The inclusion of additional variables decreases the effect of S&T on survival in column 1, thereby suggesting that some of the previously estimated effect is caused by differences in other characteristics than S&T.

We include a number of new variables in column 3. The results show that firms integrated with the global economy in terms of export or import of technology are, as expected, relatively less likely to exit. Moreover, a high skill-share or high capital intensity has no effect, or a very limited impact on survival and the inclusion of these two additional controls does not change the other coefficients.

The previous estimations show that firms with any S&T are less likely to exit than firms without S&T. In columns 4-6, we continue to examine if the amount of S&T affects exit by examining the effect of S&T intensities on firm survival . The results suggest that the higher the S&T intensity, the less likely is the firm to exit. The other coefficients are similar to previous estimations.[17]

Next, we turn to the issue of main interest in this paper: how S&T affects job growth. We approach the issue by estimating regressions in Table 7 with growth in employment as the dependent variable and with various independent variables, including the S&T intensity, that are considered to potentially affect job-growth. As previously expressed, it is important to control for the possible bias caused by a sample where it is only possible to observe growth in employment in surviving firms. The need to control for this aspect seems particularly high in view of the positive effect of S&T on job survival found in Table 6. We control for this potential bias by calculating the Mills ratio from column 6 in Table 6 and then include it in the job-growth regressions.

The time it takes for S&T to affect job-growth is uncertain. We therefore start in column 1 by including five lags of S&T. The results show that only lag one is statistically significant with a positive sign. One disadvantage with the inclusion of many lags is that it substantially reduces the sample. This is seen in column 2 where the sample increases from 16,834 observations (column 1) to 130,150 observations when only one lag is included. The change of sample size presumably explains the change in the result for S&T, which is not found to affect job growth in estimation 2. Looking at the other variables in the OLS estimations in columns (1) and (2), it is seen that large firms have a relatively low job-growth. Moreover, there is a positive impact on job growth of productivity, skill, export, and import of technology. Job growth also differs between different ownership types.

We continue with a fixed effect estimation in column 3. This implies that we

[17] We did also try with a more narrow measure on technology development, R&D. The results did not change in any major respect.

only examine variations within firms. The fixed effect estimation shows that the increase in S&T intensity has a positive and statistically significant effect on job-creation. However, the coefficient is very small, suggesting that the economic significance is negligible. The effect of size, productivity, skill, and technology import is similar to previous estimations but there is less evidence of an effect of export on job-growth.

As previously said, we try to control for a possible selection bias by including the Mils ratio from estimation 6 in Table 6. The results for such estimations are shown in columns (4)-(6) in Table 7. The Mills ratio is statistically significant, which shows that its inclusion is warranted. However, the other results remain stable with a positive effect on job-growth mainly of productivity, skills and technology import and a negative effect of size. Hence, small firms with a skilled labor force and high labor productivity tend to grow relatively fast. There is no clear-cut evidence of an effect of S&T on job-growth.

As in the previous estimation on survival, we tried different measures on technology, such as dummy variables for S&T and R&D, and R&D intensity, but the results were not affected by these different definitions to any larger extent. We have also examined the relation between S&T and job-growth in groups of firms with different ownerships and in high-tech and other industries. The results are shown in Table 8. Firms have been divided into four different ownership groups: SOEs and collective firms; private firms; joint ventures with firms from Hong-Kong, Macau, and Taiwan (HKTM); wholly foreign-owned firms and joint ventures with firms from outside of greater China. The estimations divided by ownership show some interesting results. S&T have a positive and statistically significant effect on job-growth among SOEs. One reason could be that SOEs tend to be guided by other objectives than profit-maximization and that employment in these firms might be determined differently than in firms with other types of ownership. Still, the coefficient is very small, indicating that the positive effect is of little economic significance.

There is no effect on job-growth due to S&T among private Chinese firms or among joint-ventures with firms from HKTM. More interestingly, S&T have a negative impact on job-growth among other types of foreign owned firms. The negative economic effect is quite high with a one percent increase in the S&T intensity leading to a 0.24 percent decline in employment.

Furthermore, we divide the sample into high-tech industries and other industries. It does not seem to be the degree of technology sophistication of the sector that is of importance for the effect of S&T on job-growth. The effect of S&T is positive and statistically significant in non-high-tech industries, but with small economic significance.

Finally, we experiment with different specifications of propensity score estimations in Table 9, ranging from firm characteristics only, to expanding the model with ownership dummy variables and industry affiliation dummy variables. Even though the magnitudes of ATTs vary with different specifications, the signs of ATTs are consistently negative, but not always significant, i.e. employment decreases at a higher rate in firms with S&T activity (treatment) on average than in firms without S&T activity, as shown in estimation (3) or, at best, there is no difference in employment growth, as compared to firms without S&T, as shown in estimations (2) and (4).

6. Concluding remarks

China is striving hard to upgrade its technological capability. Public guidelines on transforming China into an innovation driven economy are paralleled by sharp increases in expenditures on S&T. The idea of technological leapfrogging is a commonly expressed hope among policy makers, not the least in developing countries, but is a policy with its own costs. It is without doubt necessary for countries that want to maintain a high and sustainable economic growth to constantly improve technology but such upgrading can take place through several channels, such as the purchase of existing technologies or the development of new technologies. Chinese public policies seem to aim for the latter. However, indigenous technology development is costly and, as witnessed in many other developing countries, often inefficient. The question to ask for Chinese policy makers is whether resources could be spent better if spent differently.

Naturally, this is a very difficult question to answer and depends on what is being identified as the main economic challenge for China. In this paper, we argue that job creation is at least one of the most pressing economic issues in China: the pool of underemployed people is huge and Chinese industry does not seem to absorb a sufficiently large number of workers. We continue and ask the question whether S&T might affect job-growth in the Chinese industry. One can think of both positive and negative effects of S&T on employment: positive if they enable the firm to survive and expand, and negative if labor is substituted for capital.

Our analysis of the Chinese industry between 1998 and 2004 shows that the number of large and medium sized firms has increased by about 24 percent while employment has only increased by about 4 percent. More importantly, most of the expansion has taken place in firms without any S&T: the number of firms without S&T has increased more rapidly than the number with S&T, and employment in firms without S&T has grown more rapidly than employment in firms with S&T. Our econometric analysis aims at answering whether S&T causes the comparably low job-growth, or if performance is caused by some other observed or unobserved firm characteristics. One econometric problem is that we only observe job-growth in firms that remain in the sample (survivals) and this survival might be a function of S&T. We try to control for this potential bias using a Heckman two-step procedure where we include the inverse Mills ratio from a probit analysis on exit into the regression analysis. This approach seems important in the light of a strong positive impact of

S&T on the firm's likelihood to stay in the sample. We are inclined to interpret this result as a positive effect of S&T on firm survival but realize that the effect could also be caused by a lower probability of firms with S&T to be acquired, or a lower probability that these firms fall under the size threshold for being included in the large and medium sized category. Controlling for survival has little impact on the result for job-growth: S&T have no or even a negative effect on job-growth. The result is stable to the inclusion of a host of various variables that might affect job-growth and to estimations in different industries and different ownership groups. The results are also robust when we apply the propensity score matching estimator: the treatment effects are negative in various matching specifications, but not always significant.

Our conclusion is that S&T might be important in China for a number of reasons. However, they are not likely to solve the large problem of job-creation in large and medium sized enterprises. Addressing this concern requires different policies than those focusing on technology development.

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Table 1. Number of firms and employment by S&T status in the Chinese industry

		1998		2001		1998-2001		2004		2001-2004	
		No of firms	Employment	No of firms	Employment	Growth in firms (%)	Growth in employment (%)	No of firms	Employment	Growth in firms (%)	Growth in employment (%)
All firms	All	23105	33799488	22375	27221616	-3.2%	-19.5%	27712	35121937	23.9%	29.0%
	ST=0	11720	9800935	12174	8530922	3.9%	-13.0%	17084	15674462	40.3%	83.7%
	ST>0	11385	23998553	10201	18690694	-10.4%	-22.1%	10628	19447475	4.2%	4.0%
High technology industries	All	2052	2386270	2385	2360284	16.2%	-1.1%	3119	3887558	30.8%	64.7%
	ST=0	570	343688	849	504529	48.9%	46.8%	1417	1552194	66.9%	207.7%
	ST>0	1482	2042582	1536	1855755	3.6%	-9.1%	1702	2335364	10.8%	25.8%
Ferrous Metals	All	430	2311463	388	1897992	-9.8%	-17.9%	928	2139947	139.2%	12.7%
	ST=0	223	294960	209	201154	-6.3%	-31.8%	672	612572	221.5%	204.5%
	ST>0	207	2016503	179	1696838	-13.5%	-15.9%	256	1527375	43.0%	-10.0%
Transport Equipment	All	1268	2354424	1354	2026648	6.8%	-13.9%	1668	2216519	23.2%	9.4%
	ST=0	438	396496	535	390528	22.1%	-1.5%	699	592130	30.7%	51.6%
	ST>0	830	1957928	819	1636120	-1.3%	-16.4%	969	1624389	18.3%	-0.7%
Basic Chemicals	All	1845	2365526	1757	1829700	-4.8%	-22.7%	1664	1742936	-5.3%	-4.7%
	ST=0	850	649129	874	556388	2.8%	-14.3%	819	600111	-6.3%	7.9%
	ST>0	995	1716397	883	1273312	-11.3%	-25.8%	845	1142825	-4.3%	-10.2%
Textiles	All	2294	3336139	1751	2338522	-23.7%	-29.9%	2450	2807521	39.9%	20.1%
	ST=0	1448	1647319	1094	1052759	-24.4%	-36.1%	1799	1737940	64.4%	65.1%
	ST>0	846	1688820	657	1285763	-22.3%	-23.9%	651	1069581	-0.9%	-16.8%
Petroleum Prod.	All	155	619659	164	428594	5.8%	-30.8%	367	525990	123.8%	22.7%
	ST=0	54	67134	61	99385	13.0%	48.0%	254	197753	316.4%	99.0%
	ST>0	101	552525	103	329209	2.0%	-40.4%	113	328237	9.7%	-0.3%

Note: Sectors have been chosen based on their size (value added) in 1998.

Table 2. Employment by S&T, sector, and year

		FIRMS EXISTING BOTH 1998 AND 2001				FIRMS EXISTING BOTH 2001 AND 2004			
		No of firms In both 1998, 2001	Employment In 1998	Employment In 2001	Growth in employment 1998-2001 (%)	No of firms In both 2001-2004	Employment In 2001	Employment In 2004	Growth in employment 2001-2004 (%)
ALL	All	13678	23133225	19125606	-17.3%	8887	16849019	16307942	-3.2%
	ST=0	6129	5674079	4778958	-15.8%	3712	4173138	4620203	10.7%
	ST>0	7549	17459146	14346648	-17.8%	5175	12675881	11687739	-7.8%
HIGH TECH	All	1398	1830782	1610291	-12.0%	1137	1621924	1735332	7.0%
	ST=0	334	232507	240614	3.5%	313	322211	445845	38.4%
	ST>0	1064	1598275	1369677	-14.3%	824	1299713	1289487	-0.8%
Ferrous Metals	All	233	1644892	1403571	-14.7%	181	1407765	1256062	-10.8%
	ST=0	96	144796	109495	-24.4%	65	81695	96638	18.3%
	ST>0	137	1500096	1294076	-13.7%	116	1326070	1159424	-12.6%
Transport Equipment	All	878	1933898	1607284	-16.9%	673	1404925	1217057	-13.4%
	ST=0	256	265445	209951	-20.9%	188	193034	209976	8.8%
	ST>0	622	1668453	1397333	-16.2%	485	1211891	1007081	-16.9%
Basic Chemicals	All	1118	1604819	1264529	-21.2%	671	1105020	923387	-16.4%
	ST=0	458	382151	308689	-19.2%	225	240614	212657	-11.6%
	ST>0	660	1222668	955840	-21.8%	446	864406	710730	-17.8%
Textiles	All	1069	1743761	1448006	-17.0%	634	1234471	1215872	-1.5%
	ST=0	612	749077	623982	-16.7%	311	450797	494086	9.6%
	ST>0	457	994684	824024	-17.2%	323	783674	721786	-7.9%
Petroleum Products	All	100	447400	258035	-42.3%	101	360873	276645	-23.3%
	ST=0	28	34596	33254	-3.9%	25	64413	44319	-31.2%
	ST>0	72	412804	224781	-45.5%	76	296460	232326	-21.6%

Table 3. Average employment by S&T, ownership, and year

		FIRMS EXISTING BOTH 1998 AND 2001				FIRMS EXISTING BOTH 2001 AND 2004			
		No of firms In both 1998, 2001	Employment In 1998	Employment In 2001	Growth in employment 1998-2001 (%)	No of firms In both 2001-2004	Employment In 2001	Employment in 2004	Growth in employment 2001-2004 (%)
SOE	All	7648	17273347	13802597	-20.1%	3208	9155995	8059018	-12.0%
	ST=0	3052	3489127	2748998	-21.2%	1119	1544624	1627300	5.4%
	ST>0	4596	13784220	11053599	-19.8%	2089	7611371	6431718	-15.5%
Collective	All	1939	1634270	1447056	-11.5%	642	800984	781872	-2.4%
	ST=0	983	690123	585250	-15.2%	305	331413	315907	-4.7%
	ST>0	956	944147	861806	-8.7%	337	469571	465965	-0.8%
jv-hk	All	930	768106	726242	-5.5%	937	1033738	1292986	25.1%
	ST=0	563	349164	365839	4.8%	525	548024	710238	29.6%
	ST>0	367	418942	360403	-14.0%	412	485714	582748	20.0%
jv-foreign	All	1029	722546	718375	-0.6%	834	809247	951667	17.6%
	ST=0	593	299951	336539	12.2%	413	339773	431246	26.9%
	ST>0	436	422595	381836	-9.6%	421	469474	520421	10.9%
Foreign	All	235	152326	186421	22.4%	420	481289	665780	38.3%
	ST=0	227	147403	181917	23.4%	325	353860	498028	40.7%
	ST>0	8	4923	4504	-8.5%	95	127429	167752	31.6%
Shareholding	All	1711	2430047	2118891	-12.8%	2471	4272350	4206673	-1.5%
	ST=0	619	636972	508839	-20.1%	830	922346	871169	-5.5%
	ST>0	1092	1793075	1610052	-10.2%	1641	3350004	3335504	-0.4%
Private	All	78	51159	49241	-3.7%	338	267536	326439	22.0%
	ST=0	49	29323	28128	-4.1%	183	127614	159723	25.2%
	ST>0	29	21836	21113	-3.3%	155	139922	166716	19.1%
Other	All	108	101424	76783	-24.3%	37	27880	23507	-15.7%
	ST=0	43	32016	23448	-26.8%	12	5484	6592	20.2%
	ST>0	65	69408	53335	-23.2%	25	22396	16915	-24.5%

Table 4. Survival by S&T, sector and year (%)

		No of firms in 1998	Remained in 2001	%	No of firms in 2001	Remained in 2004	%
ALL FIRMS	All	23105	13678	59.2%	22375	8887	39.7%
	ST=0	11720	6129	52.3%	12174	3712	30.5%
	ST>0	11385	7549	66.3%	10201	5175	50.7%
HIGH TECH	All	2052	1398	68.1%	2385	1137	47.7%
	ST=0	570	334	58.6%	849	313	36.9%
	ST>0	1482	1064	71.8%	1536	824	53.6%
Ferrous Metals	All	430	233	54.2%	388	181	46.6%
	ST=0	223	96	43.0%	209	65	31.1%
	ST>0	207	137	66.2%	179	116	64.8%
Transport Equipment	All	1268	878	69.2%	1354	673	49.7%
	ST=0	438	256	58.4%	535	188	35.1%
	ST>0	830	622	74.9%	819	485	59.2%
Basic Chemicals	All	1845	1118	60.6%	1757	671	38.2%
	ST=0	850	458	53.9%	874	225	25.7%
	ST>0	995	660	66.3%	883	446	50.5%
Textiles	All	2294	1069	46.6%	1751	634	36.2%
	ST=0	1448	612	42.3%	1094	311	28.4%
	ST>0	846	457	54.0%	657	323	49.2%
Petroleum Products	All	155	100	64.5%	164	101	61.6%
	ST=0	54	28	51.9%	61	25	41.0%
	ST>0	101	72	71.3%	103	76	73.8%

Table 5. Firm characteristics by S&T and year (firm average 1000 Yuan)

		1998	2001	2004
Average employment per firm	ST=O	836	701	917
	ST>0	2108	1832	1830
Export as a share of sales (%)	ST=O	20.3%	22.0%	31.1%
	ST>0	9.7%	12.3%	17.0%
Import of technology as a share of sales (%)	ST=O	0.2%	0.1%	0.1%
	ST>0	0.7%	0.6%	0.4%
Profits as a share of sales (%)	ST=O	0.0%	3.9%	5.4%
	ST>0	3.2%	6.8%	7.9%
Average wage per employee	ST=O	6.9	10.2	14.3
	ST>0	8.9	12.8	20.3
Value added per employee	ST=O	93.9	176.2	288.8
	ST>0	112.7	211.6	438.8
Fixed assets (capital) per employee	ST=O	92.1	140.5	125.4
	ST>0	93.0	148.6	201.0

Table 6. Firm exit (Probit estimations. Dependent variable: exit =1, survival=0)

	(1)	(2)	(3)	(4)	(5)	(6)
S&T dummy	-0.338** (0.008)	-0.228** (0.009)	-0.211** (0.009)			
S&T intensity				-0.001 (0.002)	-0.018** (0.005)	-0.014** (0.007)
Size		-0.254** (0.003)	-0.247** (0.003)		-0.273** (0.003)	-0.259** (0.003)
Ownership SOE		-0.224** (0.040)	-0.220** (0.040)		-0.266** (0.040)	-0.255** (0.040)
Ownership Collective		-0.083* (0.040)	-0.079* (0.040)		-0.078* (0.040)	-0.074* (0.040)
Ownership JV_KTM		-0.318** (0.041)	-0.291** (0.041)		-0.295** (0.041)	-0.269** (0.041)
Ownership JV_Foreign		-0.330** (0.042)	-0.304** (0.042)		-0.319** (0.042)	-0.290** (0.042)
Ownership Foreign		-0.529** (0.044)	-0.489** (0.045)		-0.478** (0.045)	-0.442** (0.045)
Ownership Shareholding		-0.248** (0.040)	-0.240** (0.040)		-0.275** (0.040)	-0.261** (0.040)
Ownership Private		-0.221** (0.042)	-0.219** (0.042)		-0.207** (0.042)	-0.208** (0.042)
Skill share			-0.011 (0.009)			-0.028* (0.015)
Capital intensity			-0.0001** (0.00004)			-0.0001** (0.0004)
Export dummy			-0.103** (0.010)			-0.119** (0.009)
Import Dummy			-0.045** (0.017)			-0.155** (0.016)
Year Dummy	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Industry Dummy (4-digit)	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Nr. of Obs.	170489	165964	165796	165964	165964	165796

Notes: (1) Firm age and profit share are also included as firm controls, but do not yield any significant results. (2) Robust standard errors are within parentheses.* Significant at 5%; ** significant at 1%.

Table 7. Employment growth regression (dependent variable: employment growth)

	Without Mills ratio			With Mills ratio		
	(1) OLS	(2) OLS	(3) FE	(4) OLS	(5) OLS	(6) FE
S&T share (lagged -1)	0.022 (0.002)**	0.002 (0.002)	0.001** (0.000)	0.022 (0.002)**	0.002 (0.002)	0.001** (0.000)
S&T share (lagged -2)	0.020 (0.058)			0.017 (0.058)		
S&T share (lagged -3)	-0.042 (0.048)			-0.041 (0.048)		
S&T share (lagged -4)	0.036 (0.038)			0.035 (0.037)		
S&T share (lagged -5)	-0.044 (0.029)			-0.044 (0.029)		
Year dum.	Yes	Yes	Yes	Yes	Yes	Yes
Industry dum	Yes	Yes	-	Yes	Yes	-
Regional dum	Yes	Yes	-	Yes	Yes	-
Lagged firm size	-0.055** (0.004)	-0.041** (0.002)	-0.397** (0.004)	-0.062** (0.007)	-0.049** (0.004)	-0.405** (0.004)
Lagged labor Productivity	0.118** (0.006)	0.127** (0.003)	0.530** (0.003)	0.119** (0.006)	0.127** (0.003)	0.530** (0.003)
Ownership SOE	0.011 (0.026)	0.026* (0.012)		0.005 (0.026)	0.019 (0.012)	
Ownership Collective	0.002 (0.027)	0.020 (0.012)		0.002 (0.027)	0.019 (0.012)	
Ownership JV_KTM	0.044 (0.026)	0.041** (0.012)		0.038 (0.027)	0.034* (0.013)	
Ownership JV_Foreign	0.035 (0.026)	0.009 (0.012)		0.029 (0.027)	0.002 (0.012)	
Ownership Foreign	0.076** (0.027)	0.058** (0.013)		0.068** (0.028)	0.048** (0.014)	
Ownership Shareholding	0.015 (0.026)	0.033** (0.012)		0.010 (0.026)	0.027* (0.012)	
Ownership Private	0.021 (0.027)	0.058** (0.013)		0.017 (0.027)	0.053** (0.013)	
Lagged skill share	0.090* (0.040)	0.026** (0.005)	0.032** (0.001)	0.087* (0.040)	0.026** (0.005)	0.032** (0.001)
Lagged export Share	0.033** (0.011)	0.060** (0.004)	-0.006 (0.010)	0.031** (0.011)	0.057** (0.004)	-0.009 (0.010)
Lagged imp. share	0.206** (0.073)	0.020** (0.008)	0.052* (0.025)	0.189** (0.074)	0.020** (0.008)	0.047* (0.025)
Mills ratio				-0.054 (0.045)	-0.082* (0.030)	-0.078** (0.024)
Nr of Obs.	16834	130150	130150	16818	130085	130085
R^2	0.15	0.10	-	0.15	0.10	-

Note: (1) S&T share is defined as S&T expenditure to sales ratio. S&T expenditure to value-added ratio is also calculated as a robustness check.
(2) Firm size is measure by log of real sales and log real value-added.
(3) All industrial control variables are calculated at both the two- and four-digit level. The results from the estimation using four-digit industry level controls are presented in the Table.
(4) Firm age and capital intensity are also included in the model as robustness checks, but do not yield any significant results.
(5) Robust standard errors are within parentheses.* Significant at 5%; ** significant at 1%.

Table 8. Employment growth regression by ownership (fixed effect estimations)

	(1) SOE+ collective	(2) Private	(3) JV-HKTM	(4) Foreign + JV-Foreign	(5) High-tech	(6) Other industries
S&T share (lagged -1)	0.001** (0.000)	-0.104 (0.133)	-0.076 (0.075)	-0.239** (0.072)	0.000 (0.000)	0.024** (0.001)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
Lagged firm size	-0.417** (0.006)	-0.501** (0.017)	-0.444** (0.010)	-0.401 (0.008)	-0.380** (0.010)	-0.394** (0.004)
Lagged labor productivity	0.544** (0.005)	0.633** (0.017)	0.583** (0.010)	0.493** (0.009)	0.478** (0.010)	0.536** (0.004)
Lagged skill share	0.028** (0.001)	0.014 (0.096)	0.193** (0.058)	0.228** (0.041)	0.159** (0.030)	0.031** (0.001)
Lagged export Share	0.036 (0.025)	0.025 (0.043)	-0.020 (0.018)	-0.035** (0.016)	-0.053* (0.025)	0.002 (0.011)
Lagged import share	0.010* (0.052)	0.210 (0.243)	0.023 (0.122)	0.013 (0.032)	0.031 (0.080)	0.050* (0.026)
Year dummy	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
No of obs.	60166	8078	15438	16149	13334	116816

Note:(1) See notes for Table 7 above.
(2) The Mills ratio is included in the model as a robustness check and yields similar results.

Table 9. Difference in annual average employment growth
between S&T performing and non-S&T performing firms by matching
(outcome variable: annual employment growth)

Specification of Propensity score estimation	**Treated**	**Controls**	**ATT/ Difference**
(1) *Unmatched*	*-0.050*	*-0.018*	*-0.032 (0.002)*
(2) Firm characteristics only	-0.050	-0.047	-0.003 (0.003)
(3) Firm characteristics + Ownership dummy	-0.050	-0.039	-0.010* (0.003)
(4) Firm characteristics + Ownership dummy + Industry affiliation	-0.050	-0.046	-0.004 (0.004)
Number of Observations	51643	78507	

Notes:
Standard errors are within parentheses.

Appendix A1: Classification of large, medium and small enterprises

	Large (1)	Medium (2)	Small (3)
Employment (Person)	2000+	300-2000	300-
Turnover (Million Yuan)	300+	30-300	30-
Fixed assets (Million Yuan)	400+	40-400	40-

Source: National Bureau of Statistics of China.

Notes: Firms with a minimum turnover of 5 million Yuan are included in the sample of the economic census of China. The classification of firm size is made according to the above combined indictors. Firms are classified as large if all three criteria in column (1) are satisfied. The remaining firms are classified as medium if all three lower bounds in column (2) are satisfied. Otherwise they are classified as small.

Appendix A2: Ownership classification of large, medium and small enterprises

Ownership	Code	Definition
SOE	110	State-owned enterprises
	141	Stated-owned, jointly operated enterprises
	151	Wholly stated-owned enterprises
Collective	120	Collective-owned enterprises
	130	Shareholding cooperatives
	142	Collective-owned, jointly operated enterprises
Joint venture (HKTM)	210	Overseas joint venture
	220	Overseas cooperative
	230	Overseas wholly owned enterprises
Joint venture (Foreign)	310	Foreign joint venture
	320	Foreign cooperative
Wholly foreign owned	330	Foreign wholly owned enterprises
Shareholding	159	Other limited liability enterprises
	160	Shareholding limited enterprises
Private	171	Private wholly owned enterprises
	172	Private-cooperative enterprises
	173	Private limited liability enterprises
	174	Private shareholding enterprises
Other domestic	143	State-collective jointly operated enterprises
	149	Other jointly operated enterprises
	190	Other enterprises

Appendix A2: Industry classification at the two-digit level

Code	Industry
13	Processing food from agriculture
14	Production, processing of Food
15	Beverage
16	Tobacco
17	Textiles
18	Wearing apparels
19	Leather, footwear
20	Wood, timber, bamboo products
21	Manufacture of furniture
22	Pulp and paper
23	Publishing, print
24	Musical instruments, sport goods
25	Refined petroleum products
26	Manufacture of basic chemicals
27	Pharmaceuticals, medicinal chem
28	Manufacture of chemical fibres
29	Rubber products
30	Plastics products
31	Non-metallic mineral products
32	Ferrous metals
33	Non-ferrous metals
34	Metal product
35	Machinery, general
36	Machinery, special purpose
37	Transport equipment
39	Electrical machinery & apparatus
40	Computer, communication, other e
41	Office machinery, measuring inst
42	Manufacture n. e. c

Appendix A3: Definition of variables

Variable	Definition
Firm level controls	
S&T intensity	S&T to total sales ratio
Firm size	Logarithm of real sales
Labor productivity	Logarithm of real value-added per employee
Profit share	Profit to total sales ratio
Skill intensity	Number of S&T personnel in the total number of employees
Capital intensity	Capital stock divided by the total number of employees
Export intensity	Export to total sales ratio
Technology import share	Expenditure of technology import to sales ratio
Technology Import ratio	Technology to total sales ratio
Export dummy	Export dummy=1 if export >0
Import dummy	Import dummy =1 of technology import >0