Technology Development and Job Creation in China's Manufacturing Sector

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Abstract

This paper examines how Science and Technology (S&T) contributes to job creation in the Chinese manufacturing sector. The ambition of transforming China to an innovation-oriented nation and the emphasis on indigenous innovation capacity building has 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 analyse the relationship between S&T and job growth in Chinese industry. 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, 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 analyse how S&T affects the probability of firm survival and how it affects the growth of employment in surviving firms. Our results suggest that S&T activities have a positive impact on firms' survival but no effect on job creation.

Keywords: China, Science and Technology, Job-Creation

JEL codes: J21, O14; O33

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 spend considerable attention to technology development. China is one such country. Science and Technology (S&T) has over the last few years become one of the most promoted areas in Chinese economic policy (Lundin et al, 2006). The recently released National Guidelines for Medium- and Long-term Plans for Science and Technology Development of China (2006-2020) stresses the importance of technology change in general, and of 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 today one of the world's largest performer of S&T (OECD, 2005).

It is widely expected among Chinese policy makers that increased S&T efforts will improve upon competitiveness and growth of the Chinese economy. Less debated is the role of S&T on job creation. This 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 if the effect is positive or negative. On one hand, it might increase competitiveness and thereby 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 mechanism that dominates 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 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 affects 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 has 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. We conclude the paper by arguing that there might be many advantages with S&T development but it does not seem to solve one of the major policy issues in China, 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 S&T has on firms' growth and survival. More specifically, firms conduct S&T to improve upon existing production processes and products, or to 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 by and increased possibility to stay in the market and to expand 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 labour (or some types of labour) might be substitutes rather than complements. This means that improved technology might for instance make the firm use more capital but less labour, or more skilled labour but less unskilled labour (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) examines productivity growth in Indonesia and find a strong effect on aggregate productivity from increases in market shares by plants with relatively high productivity growth. Accordingly, Levinshohn and Petrin (1999) find a similar mechanism in Chile with growth of markets shares for firms with high productivity.[2] Survival is also closely related to productivity: firms that exit 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 labour, and 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 un-skilled labor) will have an impact on the changes in the number of employees. If, for instance, the relative prices on unskilled labor falls, this will mitigate the negative effect on employment of unskilled labor. Second, changes in relative demand on different types of labor do not

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[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.
[3] See for instance various chapters in the book by Roberts and Tybout (1996).

necessarily have to affect the total number of employed workers, unless the loss of unskilled workers is larger than the increase in skilled workers.

The studies above are concerned with issues related to, but not the same, as the focus of our paper. We intend to examine the effect of S&T, rather than of productivity, on total employment, rather than on the composition of employment. Whereas no such studies have to the best of our knowledge been previously conducted on developing countries, there are a few studies on developed countries that examine the direct effect of various technology aspects on employment. 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. Again, there are evidence of strong positive effects from innovations on employment.[4]

3. The Chinese Context

The Chinese labour 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 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 of the formal labor market underlines the need for substantial job creation in China. Unfortunately, some reports suggest that job growth has come to a halt. As a consequence, registered unemployment increased from around 4 to 6 percent of the labour force between 1995-2000 and labour force participation decreased over the same period from around 73 percent to 62 percent (Cai, 2004).

Which 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 to an insufficient job creation in China is that the private sector, including foreign owned multinationals and joint-ventures, has difficulties to absorb the same number of workers that are laid of from SOEs. This is shown in manufacturing employment which has declined from about 98 millions in 1996 to about 83 millions in 2002, largely because

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[4] There are also other studies on technology change and employment in developing 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.

increased private sector employment has been out-weighted by declining employment in manufacturing SOEs from 32 millions in 1996 to less than ten millions in 2002 (National Bureau of Statistics, 2005, Tables 1-6 and 1-16)[5]. Hence, SOEs are relatively less likely to generate jobs and private domestic and foreign firms relatively more likely.

Besides ownership, there is relatively little knowledge on what Chinese firms that tend to grow in terms of employment but size might be an important factor. Chow et al. (1999) find, in a study of the manufacturing sector in Shanghai, small firm 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 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 can not 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 not a causal effect from S&T to employment growth.

4. DATA AND DESCRIPTIVE STATISTICS

Data

Our data is on large- and medium-sized enterprises in the Chinese industrial sector over the period 1998-2004 and is 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, in which employment, turnover and fixed asset are taken into account.[7]

The included variables are from two different sources. The first one is balance sheets of firms from the Chinese industrial statistics, which is very similar to the same type of data

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[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.

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

[7] See Appendix A for the detailed classification.

used in previous studies on a range of different countries. The other source is S&T statistics. Merging these two datasets and using unique firm identification codes, we obtain a dataset containing variables, which can be divided into two categories: 1) Firm-level economic variables, such as employment, wages, sales, value-added, profit, exports, fixed assets, time of establishment and ownership 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 Medical, precision and optical instruments. It should be stressed that all firms in a high-tech industry do not necessarily have high technology content of products and processes. It is particularly true for non-OECD countries such as China, because of differences in the technological standard and in the industrial structure, compared to OECD countries (e.g. the dominance of labour-intensive processing manufacturing).[8]

Finally, for the 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.

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[8] See Lundin et al. (2006) for a discussion.

[9] See Appendix B for the detailed classification.

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 Manuual, 2002, OECD).

R&D: comprise creative work undertaken on a systematic basis in order to increases 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 Manuual, 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 decades the definition of S&T has changed more towards the Frascati manual recommendation. S&T in the Chinese indicator system includes R&D, technology acquisition (licenses) and renovation, and miscellaneous expenditures on preparation for production of new products and applications of R&D results. Hence, S&T includes several activities not included in R&D. We will therefore primarily use S&T in our analysis since we want to analyse how technology development in a broad sense affects job creation. R&D expenditures will be used in parts of the analysis as a robustness check.

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 the 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 firm and excluded from the LME survey.

Obviously, the different possibilities for a firm to disappear from the data might blur any analysis of firm survival. However, our main reason for analysing survival is to correct for a 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, 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 group and all firms belonging to the group were added together and recorded as one observation in the data. These two changes mean that the total number of firms and the number of firms with S&T both increased in 2004.

Descriptive Statistics

Table 1 shows firms and employees in Chinese industry between 1998 and 2004. The number of firms has increased over the period, from 23,105 in 1998 to 27,712 in 2004, and all of the increase is seen 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, compared to a decline with about 10 percent for firms with S&T. The development in the second period is even more striking with a large increase of firms without S&T and with 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 but with a larger magnitude. More precisely, employment declined with almost 20 percent between 1998 and 2001 and the decline was relatively large for firms with S&T. Furthermore, employment increased by about 29 percent between 2001 and 2004 with a substantial growth in employment in firms without S&T (84 percent) and with small growth in employment in firms with S&T (4 percent).

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

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[10] Again, some of the increase between 2001 and 2004 is according to official 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.

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

S&T.[12] This might suggest that mot 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 reveals the same story as above where the number of firms without S&T and employment in the same firms tend to increase more (decrease less) than 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 explain 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 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 in 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 between 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 emphasised that employment growth has, even within high-tech industries, been substantially higher in firms with no S&T.

The pattern of a comparable strong employment growth in firms without S&T is seen also in other sectors: only in one industry in 1998-2001 (Ferrous Metals) and one industry in 2001-2004 (Petroleum products) is employment growth higher in firms with S&T than in firms without S&T. 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.

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

As previously discussed, employment has declined rapidly in Chinese SOEs over the last years. This is likely to be one cause to the negative growth in employment seen in Table 3. It is also possible that the particularities with SOEs tend to shade the role of S&T in job creation. We therefore 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 firm 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 in three groups: joint ventures with firms from Hong-Kong, Macau, and Taiwan; joint-ventures with firms from other countries; and wholly owned foreign 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 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 higher employment growth than firms without S&T in two ownership groups, Collectives and Shareholdings, whereas the result for private firms are inconclusive with a seemingly positive effect of S&T on employment in the first period but a negative in the second period.

The results above suggest that S&T does 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 survival of firms, something that is overlooked in Tables 3 and Table 4 where, obviously, only surviving firms are included. Table 4 includes figures on how large 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 decrease substantially in the second period where it amounts to about 40 percent. The exit rate in the first period is broadly in line with results for other countries.[13] The second period, however, shows an exit rate considerably higher than what is typically the case in other studies. Again, our exit rate can be caused by other factors than the "death" of a firm and are 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 tabulation of different sets of firms in the tables above seems to suggest that, firstly, S&T has no positive effect on job-creation and secondly, that S&T has a positive effect on firm survival. Hence, although the figures suggest that S&T does not create jobs, it seems to maintain jobs through affecting the survival rate.

The main constraint with the above analysis is obvious: job growth and firm survival are affected by a host of factors other than the ones included in the tables. If such characteristics differ between firms with and without S&T, it is a risk that our comparison is biased. Indeed, Table 5 shows that there are 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 import of technologies. Firms with no S&T tend to have a substantially 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 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 S&T status dummy only, to the most comprehensive model, which

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

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.

$$
\begin{aligned}
&\hat{P}(Exit_{it}) = \Phi(Z_{i,t-1}) \\
&\Phi(Z_{i,t-1}) = \alpha + \beta_{st} S\&T\_share_{i,t-1} + \lambda_1 Firmsize_{i,t-1} + \lambda_2 Skill\_share_{i,t-1} \\
&+ \lambda_3 Capital\_intensity_{i,t-1} + \sum \beta_w Ownership_i + \beta_{ex} Export\_dummy_{i,t-1} \\
&+ \beta_{im} Import\_dummy_{i,t-1} + \sum \beta_t Year\_dummy + \sum \beta_{ind} Ind\_dummy_j
\end{aligned} \tag{1}
$$

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]:

$$
\begin{aligned}
&\Delta X_i = InX_{it} - InX_{i,t-1} = \alpha + \beta_{st} S\&T\_share_{i,t-n} + \lambda Firm_{it} + \sum \beta_w Ownership_i \\
&+ \sum \beta_t Year\_dummy + \sum \beta_{ind} Ind\_dummy_j + \sum \beta_R Reg\_dummy + \gamma Mills_{it} + \varepsilon_{it}
\end{aligned} \tag{2}
$$

where i is index for firms, j is index for industries and t is 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 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

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[14] See Appendix A3 for detailed definitions of the control variables at the firm- and industry level.

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 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]:

$$p(Firm_{i,t-1}, Industry_j) = \Pr\{S\&T\_dummy_{i,t-1} = 1 | Firm_{i,t-1}, Industry_j\} \quad (3)$$

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

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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).

$$ATT = E\{E\{\Delta X_{1i} - \Delta X_{0i} \Big| S\&T\_dummy_{i,t-1} = 1, p(\Big| Firm_{i,t-1}, Industry_j)\}\} \quad (4)$$

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

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[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 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 jobgrowth 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

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

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 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%

Notes: 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			
		Nr of firms In both 1998, 2001	Employment In 1998	Employment In 2001	Growth in employment 1998-2001 (%)	Nr 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			
		Nr of firms In both 1998, 2001	Employment In 1998	Employment In 2001	Growth in employment 1998-2001 (%)	Nr 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. Probit estimation

(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)	-0.015** (0.005)
Size		-0.254** (0.003)	-0.247** (0.003)		-0.273** (0.003)	-0.259** (0.003)
Ownership SOE		-0.224** (0.040)	-0.221** (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)
Foreign		-0.529** (0.044)	-0.489** (0.042)		-0.478** (0.045)	-0.442** (0.044)
Ownership Shareholding		-0.248** (0.040)	-0.241** (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 (0.010)			-0.028 (0.015)
Capital intensity			-0.000 (0.000)			-0.000 (0.000)
Export dummy			-0.103** (0.010)			-0.119** (0.009)
Import Dummy			-0.045** (0.017)			-0.155** (0.017)
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 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)	0.018 (0.058)			0.014 (0.058)		
S&T share (lagged -3)	-0.041 (0.048)			-0.041 (0.048)		
S&T share (lagged -4)	0.036 (0.037)			0.035 (0.037)		
S&T share (lagged -5)	-0.045 (-0.029)			-0.046 (-0.029)		
Year dummy	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Industry dum.	**Yes**	**Yes**	-	**Yes**	**Yes**	-
Regional dummy	**Yes**	**Yes**	-	**Yes**	**Yes**	-
Lagged firm size**	-0.056** (0.004)	-0.041** (0.002)	-0.396** (0.004)	-0.063** (0.007)	-0.049** (0.004)	-0.404** (0.004)
Lagged labour Productivity	0.120** (0.006)	0.127** (0.003)	0.531** (0.003)	0.120** (0.006)	0.126** (0.003)	0.531** (0.003)
Ownership SOE	0.008 (0.025)	0.026** (0.012)		0.002 (0.025)	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	0.045 (0.026)	0.041** (0.012)		0.038 (0.027)	0.034** (0.013)	
Ownership JV_Foreign	0.036 (0.026)	0.009 (0.012)		0.029 (0.026)	0.001 (0.013)	
Foreign	0.077** (0.028)	0.058** (0.013)		0.068** (0.028)	0.048** (0.013)	
Ownership Shareholding	0.015 (0.026)	0.033** (0.012)		0.009 (0.026)	0.027** (0.012)	
Ownership Private	0.021 (0.027)	0.058** (0.013)		0.017 (0.027)	0.054** (0.013)	
Lagged skill share	0.089 (0.040)	0.026** (0.005)	0.032** (0.001)	0.086 (0.040)	0.026** (0.005)	0.032** (0.001)
Lagged export Share	0.034** (0.011)	0.060** (0.004)	-0.005 (0.010)	0.031** (0.011)	0.057** (0.004)	-0.008 (0.010)
Lagged import share	0.204** (0.073)	0.020** (0.008)	0.053** (0.025)	0.185** (0.073)	0.020** (0.008)	0.048** (0.025)
Mills ratio				-0.062 (-1.38)	-0.082** (0.030)	-0.072 (0.024)
Nr of Obs.	16834	130150	130150	16818	130150	130085
R^2	0.15	0.10	-	0.15	0.10	-

Notes: (1) S&T share is defined as S&T expenditure to sales ratio. S&T expenditure to value-added ratio is also calculated as robustness check.
(2) Firm size is measure by log of real sales and log real value-added.
(3) All the 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 industies
S&T share (lagged -1)	0.001** (0.000)	-0.116 (0.134)	-0.085 (0.088)	-0.243** (0.072)	0.003** (0.000)	0.024** (0.001)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
Lagged firm size	-0.417** (0.006)	-0.498** (0.017)	-0.445** (0.010)	-0.407 (0.009)	-0.397** (0.010)	-0.144** (0.004)
Lagged labour Productivity	0.544** (0.005)	0.636** (0.017)	0.584** (0.010)	0.493** (0.009)	0.478** (0.010)	0.537** (0.004)
Lagged skill share	0.028** (0.001)	0.014 (0.096)	0.198** (0.058)	0.224** (0.041)	0.162** (0.030)	0.031** (0.001)
Lagged capital intensity	0.000 (0.000)	0.005 (0.004)	0.000 (0.000)	-0.005** (0.002)	-0.003** (0.000)	0.000 (0.000)
Lagged export Share	0.038 (0.024)	0.017 (0.043)	-0.020 (0.018)	-0.034** (0.016)	-0.054 (0.025)**	0.003 (0.011)
Lagged import share	0.102* (0.052)	0.195 (0.245)	0.025 (0.122)	0.007 (0.032)	0.033 (0.080)	0.050* (0.026)
Year dummy	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Nr. of obs.	60166	8078	15438	16149	13334	116816

Notes: (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	-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 A3: Definition of variable

Variable	Definition
Firm level controls	
S&T intensity	S&T to total sales ratio
Firm size	Logarithm of real sales
Labour productivity	Logarithm of real value-added per employee
Profit share	Profit to total sales ratio
Skill share	Number of S&T personnel in the total number of employees
Capital intensity	Capital stock divided by the total number of employees
Export share	Export to total 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
Industry level control (at the 4-digit industry level)	
Herfindahl index	$\sum_{i=1}^{N} S_i^2$, where S_i is the market share, in terms of sales of the i^{th} firm in industry *j*.
Export intensity	Export to total sales ratio at the 4-digit industry level.
Import intensity	Technology to total sales ratio at the 4-digit industry level.
FDI intensity	The share of sales by FDI firms in total sales at the 4-digit industry level.