The Effect of FDI on Employment and Technology in China♣

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1. INTRODUCTION

The economic success of China since the start of the economic liberalization thee decades ago is well known. Equally well known is China's success in integrating in the global economy through trade and investments. China is a major receiver of foreign direct investments (FDI) and foreign multinational companies (MNCs) have been instrumental in China's high growth of production and exports.

China's attitude towards inflows of FDI is, however, mixed. Economic nationalism seems to be on the rise and the attitude towards foreign firms is becoming more restrictive. For instance, all new foreign investments are since 2006 investigated by the authorities to make sure that they are not "threatening national economic security". China has also identified seven sectors as being of strategic importance and where foreign operations are severely restricted if allowed at all. Another example is the recent

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tax increase for foreign owned firms in China. This increase ended a tax regime that actually favored foreign firms. No matter how appropriate the establishment of a uniform tax regime is, it is still signaling that the attitude towards foreign firms is different today than a decade ago.

There are many explanations to the changing attitude towards FDI. The large dominance by foreign firms of China's economy is likely to be one since it stirs up deep rooted fair of foreign dominance. Another seems to be that the attitude towards FDI is more based on emotions and anecdotal evidence than on solid research.

This chapter tries to contribute to a better understanding of how inflows of FDI affect two aspects of the Chinese economy: employment and technology. This is admittedly two very different aspects but there are several reasons for our choice of topics. The first one is that technology and job creation represents two opposing issues on the development spectra. Job creation in the modern sector has been identified as the *via regia* to the first steps of economic development since the work by Lewis (1954). Technology, on the other hand, becomes crucial for development at a later stage when the possibilities of economic growth through reallocation of resources or through factor accumulation are declining.

Secondly, the two issues are in my view also representing what on one hand can be seen as the most important development challenge in China, job creation, and on the other hand what is being emphasized by the government, technology development. Job creation is crucial for sustained economic and social progress in China. It seems that China is not creating enough jobs to absorb the large surplus of workers which is likely to partly explain increasing inequalities and could very well lead to the much feared political turmoil. Considering the large importance of job creation, the Chinese government has bee surprisingly quiet about this issue. This is not true when it comes to technology development, which has received massive attention by Chinese policy makers in recent years. It is hoped that China will become a technology sophisticated nation and the term indigenous technology is particularly important.

Finally, there is a clear relationship between technology and employment. New technology might on one hand make Chinese firms competitive which enable them to grow and employ more workers. New technology might on the other hand also decrease demand for labor by substituting large number of low skilled employees with fewer high skilled employees or by substituting capital for labor. Hence, technology policies will affect the degree of job creation.

In examining the importance of FDI for employment and technology we will also touch upon the effect of FDI on the market structure. The reason is that it is likely that the effect of FDI on technology development might run through its effect on the market structure.

2. FDI IN CHINA

The increase of FDI to China has been remarkable. From being non-existent as late as in the early1980s, inward FDI increased to about 3.5 billion US dollars in 1990, 41 billions in 2000 and 69 billions in 2006 (UNCTAD, 2008). China is today among the four largest receivers of FDI and the largest among developing countries. There are reasons to expect that the large inflows of FDI to China will continue. One reason is that they are still relatively modest in relative terms. For instance, China's FDI inflow as a share of GDP was about 11 percent in 2006 (UNCTAD, 2008). This is considerably lower than the average for the world (25 percent) and East Asia (29 percent). Looking at the share of FDI in total capital formation (about 8 percent in China) gives a similar picture of relatively modest inflows to China when it is related to the size of the economy.

--Table 1 about here--

If FDI is not particularly high at an aggregate level, the same can not be said about the role of FDI in Chinese manufacturing. Table 1 shows some descriptive statistics of the Chinese manufacturing sector by ownership. The data used in this study has been compiled by the National Bureau of Statistics of China (NBS). The dataset is based on a census of large- and medium-sized enterprises and a representative sample of small enterprises with more than 10 employees and an annual turnover above 5 million RMB for the period 1998-2004.

The number of private firms is, by far, the largest: about 10,000 private firms in 1998 increased more than tenfold to over 112,000 in 2004. This is partly a reflection of the dynamic private sector growth in China and partly caused by privatization of state owned enterprises.[1]

Foreign firms include wholly foreign-owned firms and joint ventures between foreign and domestic firms. Foreign firms and firms with other ownership categories have increased by about 30 and 300 percent, respectively. The number of foreign firms is more than 55,000 in 2004, only second to private-domestic firms. In contrast to the

[1] According to officials at the National Bureau of Statistics, some of the increase is also caused by an improved coverage of the sample survey on small firms.

dynamic development in the private and foreign sectors, the number of non-private domestic firms has declined by more than 50 percent and amounts to 36,000 firms in 2004. This is largely caused by widespread foreclosures and privatization.

Comparing characteristics of firms by different ownership, we see that foreign firms are relatively capital intensive with high levels of productivity and wages. This suggests that the Chinese economy and Chinese workers have benefited from inflows of FDI. Foreign firms are about the same size as non-private domestic firms and other firms and substantially larger than private domestic firms. The main difference between foreign and domestic firms is the export orientation: about half of the production in foreign firms is exported. This is a reflection of multinational firms' production networks where China's role often is as a location where imported inputs are assembled to finished goods that are exported.

--Table 2 about here--

The large increase in foreign firms shown in Table 1 has led to an increased share of foreign firms in Chinese manufacturing as seen in Table 2. The foreign share increased from about 22 percent to 36 percent. The other variables show a similar pattern of rapid increases, and foreign-owned firms account for about one third of employment, and 40 percent of value added. The most noticeable figure is that a staggering 76 percent of total exports is conducted by foreign firms. Hence, the rapid increase in Chinese exports is to a large extent caused by export oriented FDI.

Table 3 shows the share of FD at an industry level and also some other variables that we will return to later in the paper. The number of foreign firms is highest in electronic products, and textiles, clothes and shoes (not shown). In relative terms, FDI is of large importance in many industries but of particularly high importance in footwear, furniture, sport goods, computers and office machines, where more than two thirds of the value added come from foreign-owned firms. The petroleum industry and the two metal industries have a very small presence of foreign firms, the former mainly because of large restrictions on FDI.

--Table 3 about here--

3. THE EFFECT OF FDI ON MARKET STRUCTURE

It is from the discussion above clear that inflows of foreign firms to China have been large and that foreign firms account for a substantial share of the economy. It follows that foreign firms have had a large impact on the structure of Chinese industry. It is perhaps less clear how the foreign firms have affected market concentration and the overall level of competition. Different theoretical models and previous empirical evidence show the relationship between FDI and market structure to be highly complex.[2] In other words, FDI can both increase and decrease the degree of competition depending on the specific context.

On the one hand, FDI may increase the number of firms in an industry and thereby decrease the concentration and increase the competition in the market, in

[2] See e.g. UNCTAD (1997) and OECD (2002) for more detailed reviews.

particular in industries with high start-up costs and high barriers to entry (e.g. Barba Navaretti and Venables, 2004, p. 174). This is true for greenfield investments but not for mergers and acquisitions and the former type therefore has a more competitive effect on the local economy (Haller, 2004). Moreover, the entrance of foreign MNEs might have a positive effect on production in existing domestic firms through spillovers and even increase the number of firms if employees in MNEs leave to set up their own businesses (Caves, 1996). This would also tend to increase competition.

However, it is equally possible that FDI may raise the level of concentration in the host-country market (Aitken and Harrison, 1999). Foreign MNEs possess competitive firm-specific assets and might therefore be able to capture a leading market position. The number of firms in an industry might then fall after the entry of foreign MNEs, if only the most efficient firms can survive and the less efficient (domestic) firms are forced to exit. As a consequence, the industry will become more concentrated. It is important to note that in this case, high concentration is associated with initial high intensity of competition. Once firms are forced out of the market, competition will tend to decline.

Looking at empirical studies on FDI and market structure, it seems fair to say that the issue is unsettled. For instance, is Co (2001) finds both positive and negative effects of FDI on competition in the U.S., depending on market conditions and the extent of spillovers. Chung (2001) also finds mixed effects of FDI on competition and suggests the degree of competitive pressure imposed by FDI to depend on both the entry mode and various investment traits.

Studies on China are rare and most focus on the geographical distribution of FDI. Wen (2004) examines spatial concentration in China between 1980 and 1995 and finds an increased concentration. FDI has presumably contributed to this increased concentration. Broadman and Sun (1997) find that FDI in China is highly spatially concentrated and that the geographical distribution is determined mostly by GNP, infrastructure development, level of general education, and coastal location.

We use the price cost margin rather than measures on concentration to examine the effect of FDI on the level of competition. We follow a standard approach and use the price cost margin (PCM) as a measure for competition, which is defined as:

$$PCM = \frac{Value\ added\ - payroll}{Value\ added}$$

A high value on PCM means a large mark-up and presumably a low level of competition.

The price cost margin is higher in foreign firms than in domestic firms in about two thirds of the industries as seen in Table 3. There seem to be important sector-specific effects in price cost margins, since foreign and domestic firms show a similar pattern across sectors. For instance, price cost margins are particularly high in food, beverage, petroleum, metals and machinery and low in cloths, footwear, wood products and some chemical industries. For domestic firms, the price cost margin is also relatively high in publishing and plastics and low in various machinery sectors. More importantly, there is no obvious relation between the share of foreign firms in a sector and the price cost margins in domestic firms: price cost margins are relatively high in some sectors with low foreign presence, such as ferrous metals and petroleum products, but also high in some sectors with high foreign presence, such as plastics and computers.

The above figures suggest that there is no strong relationship between FDI and price cost margins. Econometric estimations have the advantage of controlling for factors that might also affect price cost margins. Lundin et al. (2007a) estimate the price-cost margin at a firm level in a sample of large and medium sized Chinese firms over the period 1998-2004. They control for different firm characteristics such as total factor productivity and exports, and find that presence of FDI at a four digit industry level has a statistically significant negative effect. Hence, FDI seems to increase competition and decrease price-cost margins but the estimated coefficients are small and the economic effects, hence, of relatively marginal importance. It is also seen that foreign firms and private firms tend to have lower price cost margins than state owned firms. This indicates that measurements on prices costs margins might be biased in an economy where prices on goods and production factors are not totally liberalized. For instance, state owned enterprises often obtain subsidies in terms of, for instance, access to capital below market interest rates, which might explain the relatively high price cost margins. Restrictions on foreign, and private domestic, activities in some sectors might be another explanation.

Finally, it is interesting to note that the effect of FDI on competition is found for domestic firms as well as for foreign firms present in China. Moreover, it seems that foreign firms in China that serve the domestic market have higher price-cost margins than foreign firms that are mainly producing for exports, which suggest that competition is lower in China than in the world market.

4. FDI AND EMPLOYMENT IN CHINA

China will face a number of obstacles towards its road to higher incomes and living standards. One of the main challenges is arguably to create job in the modern sector for its large population. The Chinese labor force is predicted to grow at an annual rate of 1.3 percent over the next years (Chow et al., 1999, p.483). A few decades from now, an aging population will make this growth come to a halt and perhaps even reverse it. A more serious problem is that 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, the growth of the labor force and the large number of workers outside 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. For instance, Cai (2004) estimates a large drop in the labor participation rate from 73 percent in 1995 to 62 percent in 2000. Moreover, registered urban unemployment increased from around 2.9 to 4.2 percent of the labor force between 1995-2005 (National Bureau of Statistics, 2006). How the rural situation looks like is more uncertain. Unemployment is of course of limited importance in a developing country where few people can afford to be unemployed and where the problem rather is one of underemployment. The increased unemployment at least suggests that the problem of job creation remains. There are also anecdotal stories about current widespread closures of Chinese firms. This is said to be caused by the introduction of social security charges in 2008, which has increased labor costs by about 25 percent.

Manufacturing seems to be the best possibility for modern sector employment expansions. The Chinese manufacturing sector is large, although the exact size is unknown and presumably underestimated in official statistics. For instance, Banister

(2005) claims that the official figures underestimate the number of workers in township and village enterprises and the number of unregistered workers and estimate manufacturing employment to about 100 million workers, or about twice the size of total G7 manufacturing employment. Corresponding to what was said above about increased unemployment, there are signs of stagnating and even declining Chinese manufacturing employment. Official labor statistics put manufacturing employment at about 98 million in 1996 and about 83 million in 2002 (National Bureau of Statistics, 2007, Table 5-4). Banister's estimates show a similar declining trend. The lack of employment in manufacturing is problematic in view of the above discussed labor force growth and the large informal sector. One consequence is that China is experiencing rapidly increasing inequality, which to some extent is caused by stagnating incomes in the informal sector and increasing incomes in the formal modern sector (Lindbeck, 2008).

Hence, an important question is where we can expect the necessary new jobs to be created? There is unfortunately 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 such 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 (Lundin et al., 2007b).

Firm ownership seems also to be 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. Hence, private domestic and foreign owned firms are relatively more likely to generate jobs than are SOEs.

The total amount of people employed outside agriculture and the informal sector can presumably be affected by inflows of FDI. FDI might, for instance, increase the country's competitiveness by combining firm- and country-specific assets (e.g. Blonigen, 1997). This typically involves combining access to foreign markets and modern technology with a large supply of cheap labor. Such a combination of firm- and country-specific assets has frequently improved and expanded existing host-country industries, introduced production in new industries, and changed the comparative advantage of the host country (Lipsey, 2004; 2006).

In addition to introducing new industries and establishing new firms in the host country, inflows of FDI can increase employment through establishing linkages with domestic firms through purchases of locally produced goods and services. Moreover, firm specific knowledge might diffuse from foreign to local firms through so called spillovers. One channel of such spillovers is through turnover of employees (Fosfuri et al., 2001; Glass and Saggi, 2002; Görg and Strobl, 2005) and managers (Gershenberg, 1987; Pack, 2001). This channel might be particularly important also because foreign firms tend to provide more training than domestic firms (ILO, 1981; Djankov and Hoekman, 1999; Lindsey, 1986). It is also possible that FDI introduces new and better quality inputs to be used in the production of upstream domestic firms, thus making them more competitive and enabling them to expand production and employment.

There is another effect, however, which suggests that inflows of FDI might decrease employment in domestic firms. This will happen if foreign firms increase the competition for domestic firms and force them to exit the market or downsize their workforce. Laid off workers might eventually be absorbed in other firms and industries but the adjustment costs can be substantial (Davidson and Matusz, 2001). It could be imagined that such a crowding-out effect is important when foreign MNEs do not only focus on export markets, but also target the domestic market. There are at least two different channels through which such crowding out can take place. First, MNEs have firm-specific advantages, which give them a competitive edge against their domestic competitors despite a comparatively poor knowledge of local conditions. Second, MNEs might also raise the wage levels and press up the wages of their domestic competitors (Lipsey and Sjöholm, 2004a, 2004b). Such wage increases will deter job growth in domestic firms when their cost advantages are diminishing. Finally, the replacement of domestic firms with foreign firms will have negative employment effects if the latter are more capital intensive, which is typically the case in developing countries.

The previous discussion and tables suggest that foreign firms are important as employers. However, we cannot from Tables 1 and 2 draw the conclusion that they are important creators of new jobs. The reason is that the above figures might be caused by foreign firms acquiring domestic firms with little changes in total employment. One possibility would be to examine the effect of takeovers on employment (Lipsey and Sjöholm, 2008). Such an analysis has not been done on China, partly because the identification code of a firm changes in the Chinese data after a takeover. As an alternative approach Karlsson et al. (2009) look at employment growth in firms of different ownership over the periods 1998-2001 and 2001-2004. Only firms present in both years are included and their figures are shown in Table 4.

--Table 4 about here--

The figures show that employment growth in non-private domestic firms has been negative in both periods: firms present in both 1998 and 2001 saw their labor force decline by 14 percent and the corresponding figure for firms present in both 2001 and 2004 is 17 percent. The category "other firms" also shows negative employment growth in the first period and a positive but small growth in the second period. Private firms, domestic as well as foreign ones, show positive growth in both periods. In the first period, private-domestic firms increased their labor force by 19 percent, almost twice as much as the increase in foreign firms. The situation changed in the second period when foreign firms increased their labor force by more than 24 percent, i.e. slightly more than private-domestic firms. To sum up, both private-domestic and foreign firms have increased their number of employees by two-digit figures in both periods.

Some of the observed differences in employment growth between ownership groups could be caused by differences in the sector distribution of firms. Therefore, we show the development in the five largest sectors. The previous results seem to hold at a more disaggregated level: employment has declined in non-private domestic firms and increased, with some exceptions, in private-domestic and foreign owned firms.

The above results seem to hold in econometric studies. Karlsson et al. (2009) controls for a host of firm and industry characteristics in an econometric study on

Chinese firm level data for the period 1998-2004. FDI is found to have a positive effect on employment growth. The relatively high employment growth in foreign firms is associated with their firm characteristics and their high survival rate. Employment growth is also higher in private-domestic Chinese firms than in Chinese state-owned enterprises. There also seems to be a positive indirect effect of FDI on employment in private-domestically owned firms, presumably caused by spillovers.

5. FDI AND TECHNOLOGY

As previously mentioned, there is a concern in China that inflows of FDI do not contribute to technology development to the same extent as they contribute to production and exports. For instance, it is noted by policy makers and academics alike that while foreign firms account for a large share of export and production, their share of R&D is small. The recent emphasis on “indigenous innovation” and “indigenous capacity building” in the Chinese science and technology policy partly reflects an uncertain and even sceptical attitude towards FDI.

However, the discussion on FDI and R&D in China neglects how indigenous technology development is affected by FDI. Such an effect could arise if, for instance, domestic firms learn from foreign-owned firms. FDI might also affect the competitive pressure in the market which, in turn, could affect the amount of technology development in domestically-owned firms. Once more, there has been a large focus on the (direct) effect of FDI on technology development in the ongoing debate, whereas the indirect effect of FDI on technology development in domestically-owned firms has not been discussed or examined to the same extent.

It is important to note that the expected impact of FDI on the R&D of domestically-owned firms is not clear. First, and as previously mentioned, there could be a demonstration effect or technology externalities from FDI that might increase R&D in domestic firms. This effect is typically attributed to a spillover effect from foreign to domestic firms. However, there could also be an effect of FDI on R&D in domestic firms through the impact of FDI on the market structure. The direction of this effect is more uncertain since it depends both on how FDI affects market structure and how market structure affects R&D. Increased competition could both increase R&D, by firms struggling to compete, or decrease R&D because of diminishing monopoly rents.

Innovations are in the classic Schumpeterian view of creative destruction made by firms which earn no rents if they fail to innovate and which obtain monopolistic power if they succeed. The market will be characterised by Arrow's "replacement effect", i.e. new firms replacing monopolists that fail to innovate (Arrow, 1962). However, when competition intensifies and, in turn, trims down monopoly rents, the incentive to innovate will decrease. This theory therefore predicts a negative relationship between market competition and innovation.

In contrast to the "replacement effect", the "selection effect" of market competition predicts a positive relation between competition and innovation. Competition may stimulate innovation, when firms with innovation advantages further strengthen their innovation capabilities in order to escape competition with "neck-to-neck" rivals (see e.g. Vickers, 1997; Boone, 2000; and Aghion and Schankerman, 1999).

In more recent theoretical work, the relationship between competition and innovation is described as non-monotone, which can happen when there are different types of innovators in terms of leaders and followers. Both the level of the technology gap and the degree of rivalry are important aspects that are taken into account in so-called step-by-step innovation models (see e.g. Aghion et al. (2001) and Boone (2001)). The step-by-step innovation models are of particular relevance for analysing "unlevelled" industries, i.e. industries where different firms have different levels of innovation capacity. In such industries, there are technically laggard firms which have to catch up with the leading-edge technology before they can compete with their more technology advanced rivals. The ability to catch up partly depends on the level of competition. When competition is low, the leading firms will invest relatively little in R&D, which means that laggard firms have a higher potential of catching up and thereby a higher incentive to innovate. In the case of high market competition, the leading firms have a higher incentive to innovate to remain in their strong position. This makes it more difficult for followers to catch up and will, in turn, tend to decrease their incentives to innovate and they will instead try to find industrial niches with less competition from the leading firms.

General trend

The strong expansion of S&T in China is seen in Table 2. All S&T indicators have increased, often more than doubled, between 2000 and 2004. For instance, S&T expenditures have increased by 138 percent and R&D expenditures by 170 percent (current prices).

The S&T expenditures discussed above include wages for personnel, and purchases of fixed assets and raw materials. There are obviously other measures for Chinese firms to improve upon technology, some of them are presented in the table. For instance, expenditures on technological renovation are even larger than total S&T expenditures. Moreover, expenditures on other types of S&T activities, such as import of technology or purchase from other domestic actors, have also increased. Interestingly, import of technology has increased only modestly, in comparison to the high growth in other indicators. It is also worth to point out that expenditures on import of technologies is substantially less than expenditures on own technological development, suggesting that the often voiced concern of a dependence on imported technologies might be exaggerated. However, it should also be pointed out that this concern is often based on a correct observation that Chinese import is more technology intensive than Chinese export.

The number of S&T personnel has also increased, although at a lower rate than S&T expenditures. S&T personnel are divided in three categories: with or without formal qualifications (primarily education), and R&D personnel. The latter is the most qualified subgroup.[3] It is primarily R&D personnel or employees with little formal qualifications that have increased in numbers.

--Table 5 about here--

All of the above figures measure inputs in S&T. Output of S&T is typically more difficult to measure but one indicator is the number of patents. As seen in the table, patent applications are relatively few but increase rapidly, confirming previous results that the growth in patents in China between 2003 and 2005 is the highest in the world (WIPO,

[3] Note that the three subgroups do not sum up to total S&T personnel since S&T personnel are based on exact head count, while R&D personnel are based on so called "full time equivalence" in accordance with OECD standards.

2006). Another measure on S&T output that is often used in R&D/innovation surveys is the introduction of new products. The assumption is that S&T will materialize in new products.[4] The drawbacks with this measure are, firstly, that new products might materialize without any formal S&T and secondly, that S&T might aim at improving already existing products or processes, rather than developing new ones. Bearing these caveats in mind, we see in Table 2 that sales and exports of new products increased substantially over the period. It is also worth mentioning that most products are sold only on the domestic market.

To sum up the discussion above, it is seen that China is rapidly increasing its S&T activities. There are two different explanations, with very different implications to this development. The first one is that the growth in S&T is only a reflection of the general rapid development of the Chinese economy. In other words, in a country growing with almost 10 percent annually, and where S&T are growing from low levels, the previously seen development might be natural and only what one could expect for a country like China. If this description is correct, the structure of the Chinese economy should remain largely unchanged. The second possible explanation is that these figures reflect a structural change of Chinese industry with an increased S&T intensity. One way to further examine the issue is therefore to examine S&T intensities within Chinese firms.

Table 6 shows technology intensities. The figures do not support the hypothesis of a strong expansion of S&T within Chinese firms: S&T intensities have increased modestly or even been stable. For instance, the share of firms with any S&T increased from 12 to 15 percent but the overall S&T intensity, measured as S&T expenditures as a share of sales, was stable at around 1.2 percent. The implications are, firstly, that an

[4] In the Chinese statistics, new products refer to products new to the firm, rather than new to the market.

overwhelming share of Chinese firms do not engage in any S&T, and secondly, that although S&T expenditures have been growing rapidly in China (Table 1) they have only matched the growth in sales, leaving the overall S&T intensity almost constant.

Other technological efforts, such as import, renovation, efforts on absorption, or domestic purchases, have also shown relatively small changes. The largest change is the decline in import of technology, suggesting again, a slight decline in the dependence on foreign technologies. The last input measure shows a decline in the share of S&T personnel. The development differs, however, between different types of S&T personnel.

The number of patents is, as previously mentioned, still relatively low in China but growing, and Table 3 shows that there is a strong growth in patent intensities in Chinese firms. For instance, the number of patent applications per 100 employees increased from 0.04 to 0.10 and similar growth is seen in the other measures on patenting.

--Table 6 about here--

Finally, the introduction of new products has increased over the period. The growth of new products for export is particularly high, but most products are still sold only on the domestic market.

The conclusion from Table 6 is that the S&T intensity in Chinese industrial firms does not seem to have increased between 2000 and 2004. However, structural changes of the Chinese economy could explain the observed pattern. For instance, if the relative importance of low-tech industries has increased during the studied period, the result would be an overall stable S&T intensity even if the intensity would increase in individual firms. One way to control for this possibility is to examine the issue at a sector level, which is done for a selection of industries in Table 7.

R&D intensities in most but not all of the high-tech industries were higher than the average R&D intensity in manufacturing. R&D was roughly 2 percent of value added on average in Chinese manufacturing in 2003 and 4.4 percent in high-tech industries. In an international comparison to the U.S. and Japan, the difference is remarkable. For instance, the R&D intensity in 2001 in high-tech industries was more than five times higher in the US and Japan than in China. The results suggest that "high-tech" industries are not very technology intensive in China and that the success of these industries are rather a result of low costs and high integration with world markets (Adams et al., 2006).

Moreover, R&D as a share of value added has either declined or been relatively stable between 2001 and 2004, not only in manufacturing in general but also in high-tech industries.

--Table 7 about here--

Foreign Direct Investment and R&D

Returning to how FDI might affect R&D, some descriptive statistics on FDI, competition and R&D is shown in table 1. It is interesting to note that the foreign share of R&D is relatively small. More precisely, the foreign share of R&D expenditures was 21 percent in 1998 which, for instance, was larger than the foreign share of employment and about the same as the foreign share of LMEs. However, the foreign share of R&D has only increased to about 29 percent in 2004, which is lower than the foreign share of any other economic indicator in Table 1. One conclusion that can be drawn from the figures is that even if China is becoming increasingly attractive as a location of foreign firms' R&D, as suggested by for instance UNCTAD (2005), this trend is growing more slowly than the increase in foreign firms' production, employment and exports.

R&D intensities are generally relatively high in pharmaceuticals, machinery, transport equipment, electronics, computers, and office machinery but there is a large difference between foreign and domestic firms. R&D intensity is higher in foreign than in domestic firms in three sectors alone: non-metallic mineral products, ferrous metals, and non-ferrous metals. It is difficult to detect a direct relationship between price cost margin and R&D intensity. Domestic firms conduct relatively large shares of R&D in some sectors with high price cost margins, such as computers, and in some sectors with low price cost margins, such as machinery. Accordingly, there is no obvious relation in Table 2 between the share of FDI and the R&D intensity in domestic firms. This result is also confirmed in an econometric study by Lundin et al. (2007) which finds no effect of FDI on R&D in Chinese firms. As previously said, FDI seem to marginally increase the level of competition in China. One interesting question is if this increased competition increase R&D expenditures in Chinese firms but the study by Lundin et al. (2007) do not find any evidence of such an effect of competition.

6. TECHNOLOGY AND EMPLOYMENT

The above discussions have focused on how FDI impact employment and technology. There is one final link that will be examined in this section: the link between technology and employment.

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.[5] 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 increases in market shares by plants with a relatively high productivity growth and Levinshohn and Petrin (1999) find a similar mechanism in Chile.[6] Survival is also closely related to productivity: firms exiting the market tend to have relatively low levels of

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

productivity.[7] 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, only if the loss of unskilled workers is larger than the increase in skilled workers.

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.[8]

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

[8] 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.

Table 8 shows the numbers of firms and employees between 1998 and 2004. The figures differ from employment figures previously shown in Table 3 since it is based on a different sample of firms. 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).[9]

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 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

[9] 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.

increase in firms without S&T.[10] This might suggest that most activities in high-tech industries are of relatively low skill-intensity.

-- Table 8 about here --

Lundin et al. (2007b) also examined technology and employment at a sector level (2-digit and 4-digit of the equivalent to ISIC). 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.

As previously said, the degree of firm survival affects employment. Lundin et al. (2007b) examined survival rates of different types of firms. They found that that roughly 59 percent of all firms that existed in 1998 survived until 2001. The survival rate decreases substantially in the period 2001 to 2004, where it amounts to about 40 percent. The exit rate in the first period is broadly in line with the results for other countries.[11] The second period, however, shows an exit rate that is considerably higher than what is typically the case in other studies. 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, S&T does not seem to have an effect on job-creation but seems to affect firm survival. Hence, although the figures suggest that S&T do not create jobs, they seem to maintain jobs by affecting the survival rate.

[10] 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.

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

Controlling for various factors that affect employment requires an econometric approach. Lundin et al. (2007b) used a Heckman two stage estimation approach to examine the effect of S&T on employment growth. In the first step, the effect of S&T was estimated and the obtained Mills ratio was used in the second step where the effect of S&T on growth in employment was examined. The estimations showed a clear positive effect on survival from S&T: firms with S&T programs had higher survival rate than firms without S&T programs and the higher the S&T intensities the higher the survival rates. It was also found that foreign firms had relatively high survival rates and the same was found for firms that were integrated in the global economy through exports or imports.

The effect of S&T on growth in employment were less clear cut with a negative effect in some specifications and a positive but small effect in some estimations. Their conclusion was that there are no strong evidence of a positive effect on employment growth even after controlling for the higher survival rate in firms with S&T.

7. CONCLUDING REMARKS

To be included.

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Table 1. Firm characteristics by ownership

Firm characteristics	Domestic Non-private		Foreign		Domestic Private		Other	
	1998	2004	1998	2004	1998	2004	1998	2004
Number of firms	85543	36268	23817	55248	9974	112856	10341	43379
Average employment per firm, headcount	352	281	304	309	150	127	497	320
Export as a share of sales (%)	7.9	7.0	45.9	48.3	13.1	13.4	9.6	9.4
Average annual wage per employee, 1000 Yuan	6.5	11.3	12.0	16.6	6.8	10.6	7.5	12.1
Value added per employee, 1000 Yuan	114.5	249.5	259.6	369.1	209.1	283.8	168.6	306.5
Fixed assets (capital) per employee, 1000 Yuan	42.3	67.2	106.5	104.6	41.3	51.3	55.2	78.8

Note: The nominal values of fixed assets and value-added are deflated by producer price index (PPI) at the three-digit industry level and wage is deflated by an annual consumer price index (CPI).

Table 2. The number of foreign firms and the foreign share of Chinese manufacturing 1998-2004

(Share of total manufacturing)

Year	Firms	Value-added	R&D expenditure	Export	Employment
1998	0.22	0.26	0.21	0.58	0.14
1999	0.23	0.28	0.23	0.61	0.16
2000	0.25	0.30	0.20	0.63	0.18
2001	0.27	0.31	0.23	0.66	0.20
2002	0.29	0.33	0.23	0.68	0.23
2003	0.31	0.36	0.25	0.71	0.27
2004	0.36	0.40	0.29	0.76	0.34

Table 3. Foreign firms, price cost margins, and R&D intensities, across 2-digit level industries in 2004

		Share of foreign firms (%)		Price Cost Margin (%)		R&D intensity (%)	
		VA	R&D	FDI	Domestic	FDI	Domestic
13	Processing food from agriculture	38	8	11.3	15.4	0.09	0.22
14	Production, processing of food	43	29	15.6	13.2	0.15	0.40
15	Beverage	39	43	19.9	17.0	0.25	0.37
17	Textiles	28	32	10.6	8.1	0.32	0.36
18	Wearing apparels	45	15	9.6	11.0	0.09	0.17
19	Leather, footwear	67	50	9.4	11.4	0.11	0.23
20	Wood, timber, bamboo products	33	11	9.0	14.5	0.21	0.37
21	Manufacture of furniture	82	82	11.1	10.5	0.15	0.28
22	Pulp and paper	43	38	12.3	11.5	0.23	0.26
23	Publishing, print	46	37	17.7	16.2	0.21	0.21
24	Musical instruments, sport goods	69	54	9.0	8.0	0.19	0.66
25	Refined petroleum products	9	7	16.4	15.9	0.08	0.16
26	Basic chemicals	21	15	12.0	12.3	0.67	0.77
27	Pharmaceuticals, medicinal chemistry	23	22	14.8	10.9	1.44	1.34
28	Manufacture of chemical fiber	31	18	8.1	8.5	0.21	0.63
29	Rubber products	46	23	10.0	11.9	0.20	0.69
30	Plastics products	55	28	11.6	14.5	0.27	0.59
31	Non-metallic mineral products	23	26	14.3	13.1	0.50	0.35
32	Ferrous metals	11	4	15.7	12.4	0.41	0.24
33	Non-ferrous metals	16	25	11.4	11.3	0.82	0.56
34	Metal product	50	21	15.4	12.1	0.15	0.54
35	Machinery, general	34	24	14.1	8.2	0.67	1.29
36	Machinery, special purpose	24	13	15.6	7.3	0.60	1.43
37	Transport equipment	46	32	13.1	8.0	0.70	1.30
39	Electrical machinery & apparatus	43	23	11.0	10.8	0.47	1.17
40	Computer, communication	86	49	11.9	13.5	0.60	2.93
41	Office machinery, measuring instrument	82	42	12.1	10.3	0.84	2.85
42	Manufacture n. e. c	45	07	11.6	4.6	0.09	1.47

Table 4. Employment and employment growth by ownership and sector

		Firms existing both 1998 and 2001				Firms existing both 2001 and 2004			
	Ownership	Number of firms	Employment 1998	Employment 2001	Growth 1998-2001	Number of firms	Employment 2001	Employment 2004	Growth 2001-2004
Total	Domestic non-private	31919	14762545	12658873	-14.3%	15987	7319868	6062059	-17.2%
	Foreign	13939	4739187	5237500	10.5%	18903	6529004	8118380	24.3%
	Domestic private	3963	631799	751690	19.0%	15064	2384847	2870745	20.4%
	Other	4130	2606045	2428156	-6.8%	8094	4392152	4463280	1.6%
Textile	Domestic non-private	1737	1277583	1119767	-12.4%	737	480768	424221	-11.8%
	Foreign	1028	313019	336074	7.4%	1298	413289	463078	12.0%
	Domestic private	380	74581	85246	14.3%	1574	304234	356902	17.3%
	Other	300	342707	310397	-9.4%	543	550788	522171	-5.2%
Non-metallic metal	Domestic non-private	3737	1346829	1161815	-13.7%	1819	543249	459812	-15.4%
	Foreign	616	163115	179139	9.8%	762	204599	228771	11.8%
	Domestic private	328	70821	69975	-1.2%	1298	251423	270135	7.4%
	Other	457	269502	242837	-9.9%	806	391785	373013	-4.8%
Ferrous metal	Domestic non-private	754	1490880	1306723	-12.4%	350	991916	825911	-16.7%
	Foreign	100	44066	45582	3.4%	98	38455	45807	19.1%
	Domestic private	103	19371	23179	19.7%	297	46884	71722	53.0%
	Other	94	125866	115351	-8.4%	146	276716	305914	10.6%
Transport equipment	Domestic non-private	1817	1641486	1411438	-14.0%	969	853789	633780	-25.8%
	Foreign	393	214113	209314	-2.2%	509	223419	276305	23.7%
	Domestic private	136	25348	32937	29.9%	523	100284	136222	35.8%
	Other	197	146664	119849	-18.3%	372	206784	232341	12.4%
Computer, tele-com equipment	Domestic non-private	404	321963	259482	-19.4%	195	151497	130371	-13.9%
	Foreign	900	493094	599365	21.6%	1171	786394	1145731	45.7%
	Domestic private	57	14461	16091	11.3%	188	33237	43366	30.5%
	Other	107	80712	78275	-3.0%	229	187571	200413	6.8%

Table 5. S&T in Chinese Manufacturing

	2000	2004	Growth 2000-2004 (%)
S&T expenditure	101	240	138
R&D expenditure	41	111	170
Technological renovation	122	295	142
Import of technology	28.2	39.7	41
Technology absorption	2.0	6.1	205
Domestic technology	3.0	8.2	173
S&T personnel (1000 Head counts)	1669	1839	10
With formal qualifications	631	635	1
Without formal qualifications	309	430	39
R&D personnel (1000 FTE)	630	814	29
Patent Application (Piece)	19850	64577	225
Invention patent application	5564	20458	268
Invention patent granted	10949	30343	177
New product sales	884	2280	158
New product exports	163	531	225

Source: National Bureau of Statistics of China.

Note: Nominal terms are in billion Yuan. R&D personnel are measured as Full–Time Equivalent (FTE), whereas the other types of S&T personnel are measured by headcount.

Table 6. S&T Characteristics in Chinese Manufacturing (%)

	2000	2004
Share of firms with S&T	11.9	14.8
S&T expenditures/Sales	1.20	1.21
R&D expenditures/Sales	0.49	0.56
Technological renovation/Sales	1.45	1.48
Import of technology/Sales	0.34	0.20
Technology absorption/Sales	0.02	0.03
Domestic technology/Sales	0.04	0.04
S&T personnel/total employment	3.00	2.78
With formal qualifications/Total employment	1.14	0.96
Without formal qualifications/Total employment	0.56	0.65
R&D personnel/Total employment	1.13	1.23
Patent application/ 100 Employee	0.04	0.10
Invention Patent Application/ 100 Employee	0.01	0.03
Invention patent granted/ 100 employee	0.02	0.05
New product sales /Sales	10.5	11.47
New product exports/Sales	1.94	2.67

Source: National Bureau of Statistics of China .

Table 7. R&D intensity in high-tech industries (%)

	R&D/value-added 2001	R&D/ value-added 2003	R&D/value-added U.S. (2001)	R&D/value-added Japan (2001)
Manufacturing average	3.4	2.0	8.7	9.9
High-tech average	5.0	4.4	27.2	26.3
Areospace	15.0	15.8	14.4	22.3
Pharmaceutical products	2.6	2.7	14.8	22.9
Computers and office machines	4.1	2.5	36.7	30.7
Electronic, telecommunications	5.8	5.4	37.2	18.6
Medical equipments and Meters	2.5	3.0	36.8	30.2

Source: National Bureau of Statistics of China and China Statistics Yearbook on high technology industries, 2004 & 2005.

Table 8. 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.