Trade Liberalization, Firm Exits, and Productivity: Evidence from Chinese Plants*

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Abstract

China has experienced dramatic trade liberalization since the late 1990s. In this paper, I investigate the impact of trade liberalization on firm productivity by using both Chinese manufacturing firm-level data and highly disaggregated Chinese import data from 1998-2002. For this purpose, a firm's total factor productivity (TFP) was calculated by adopting an augmented Olley-Pakes (1996) semi-parametric methodology to correct the simultanity bias from reverse causality and selection bias from firms' exits. Even when controlling for the endogeneity, trade liberalization increases firm productivity. Moreover, the effects of trade liberalization on exporting firms are found to be smaller than that on non-exporting firms. The finding is robust to different measures of TFP.

JEL: F1, L1, O1, O2

Keywords: Trade Liberalization, Productivity, Chinese Plants

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"Productivity isn't everything, but in the long run it is almost everything"

–Paul Krugman (1998)

1 Introduction

This paper investigates the effect of trade liberalization on Chinese firms' productivity. In the past three decades, China has experienced dramatic trade liberalization as well as productivity gains. Average unweighted tariffs decreased from around 55% in the early 1980s to about 13% in 2002. Simultaneously, China's average annual increase in total factor productivity (TFP) in the first two decades since economic reform in 1978 was around 4%, though this pace seems to have slowed down after that (Zheng *et al.*, 2008). It is interesting to see whether or not China's trade liberalization has boosted its productivity. Although economists have paid some attention to this issue, the research is far from conclusive and deserves further exploration.

First, much of the existing work on measuring TFP is imprecise and biased. TFP is usually measured as the Solow residual, defined as the difference between the observed output and its fitted value calculated via OLS. However, this method suffers from many problems, including simultanity bias and selection bias. The first bias comes from the fact that a profit-maximizing firm would respond to productivity shocks by adjusting its output, which, in turn, requires re-allocating its inputs. Since such a productivity shock is observed by firms and not by econometricians, this create an endogeneity issue. Moreover, all firms covered in the samples are those that have relatively high productivity and survived during the period of investigation. Those firms that have low productivity, shut down, and left the market were not observed nor included in the samples. From another perspective, ignoring the firms' entry and exit from the market causes the samples not to be randomly selected. Hence, related estimates suffer from selection bias.

Second, the measures on trade liberalization in most existing works have been incomplete. Much of the literature has used output tariffs as an indicator of trade liberalization. Recently, Amiti and Konings (2007) took a step forward to take input tariffs into account. However, a tariff is just one of the many instruments in trade policies, which has already been reduced to a very low level after the Uruguay Round of the WTO in 1994. Other trade policy instruments, such as various non-tariff-barriers (NTBs), also play important roles in protecting domestic import-competing industries. Restricting the scope to tariffs only is insufficient in understanding the impact of trade liberalization on productivity.

Last but not least, the existing literature has faced an empirical challenge in using China's data. Holz (2004) emphasized the bias of using China's aggregated data since there is a mismatch between disaggregated and aggregated statistical data. This is consistent with Krugman's (1994) complain that it is a challenging job to explain China's economic growth due to its low quality data. He argued that the economic growth in emerging markets indeed came from its unusual high savings rate. Later, Young (2003) argued that China's TFP growth rate was quite modest and perhaps negative in the post-Mao era . However, his work is based on aggregated industrial data, which would create some bias as well.

In this paper, to mitigate such estimation bias, the effect of China's trade liberalization on its productivity was estimated by precisely measuring TFP, by choosing an appropriate indicator of trade liberalization, and by using the most disaggregated firm-level data.

First, to address the two empirical challenges (*i.e.*, simultanity bias and selection bias) caused by OLS, I adopt the Olley-Pakes (1996) approach. This approach was also revised by imbedding a survival probability model to control for the selection bias problem.

Second, as stated above, trade liberalization also includes various cuts in NTBs. However, the NTBs data are very difficult to access, especially for developing countries like China. The import penetration ratio, which is defined as industrial imports over its outputs, is the economic consequence of both tariffs and NTBs. Compared to tariffs, the import penetration ratio is a better instrument for measuring trade liberalization. In this paper the import penetration ratio is used to measure trade liberalization. Finally, the samples in this paper are a rich firm-level panel, covering more than 150,000 manufacturing firms per year from 1998-2005. For each firm, the coverage is more than 100 financial variables listed in the main accounting sheets of all SOEs, and those non-SOEs firms, whose sales are more than five million *yuan* per year.

The estimation results suggest that trade liberalization boosts firm productivity. After controlling for potential endogeneity, the effect of trade liberalization on firm productivity to exporting firms is smaller than non-exporting firms. These results are robust regardless of different econometric specifications.

This paper joins the growing amount of literature on the nexus between trade liberalization and productivity. To measure productivity, papers such as Trefler (2004) emphasized labor productivity, although most studies have concentrated on TFP. In the early stage, researchers usually rely on industrial level data to measure TFP. These include, among others, Tybout, de Melo, and Corbo (1991), Levinsohn (1993), Harrison (1994), and Head and Ries (1999). Most recent studies, such as Pavcnik (2002) and Amiti and Konings (2007), consider firm productivity by using plants' data. However, most of these above-mentioned works only use tariffs to measure trade liberalization. Only a few exceptions, like Harrison (1994), include the import penetration ratio as a robustness check.

The rest of the paper is organized as follows: Section 2 reviews China's trade liberalization in the last decade. Section 3 introduces the methodology of estimations accordingly. Section 4 describes data used in this paper. The main estimation results and sensitivity analysis are also discussed in Section 4. Finally, the conclusion is presented in Section 5.

2 China's Trade Liberalization

In the past three decades, China has experienced dramatical trade liberalization. As a result, China changed from an almost fully isolated economy to become the third largest open economy today. China's openness ratio (*i.e.*, the sum of exports and imports relative to GDP) increased from around 10% in the early 1970s to 64% in 2007. The "open-door" policy has become one of the two most fundamental doctrines of the Chinese government after 1978.[1] During the last three decades, China has proceeded with its trade liberalization by setting up export-processing zones to absorb foreign direct investments (FDI), by acceding to the WTO, and by significantly cutting tariffs.

Before 1978, China's foreign trade was completely monopolized by 12 national foreign trade companies (FTCs). They imported products at world prices, and sold them domestically at projected prices. The government then cross-subsidized between such FTCs. As a result, China was insulated from the world economy (Naughton, 2006). Like many other East Asian countries, the Chinese government set up export-processing zones (EPZs) in 1978 to launch trade liberalization. The first wave of the EPZs formation saw the setting up of four special economic zones (SEZs) in the early 1980s, which allowed export-processing duty-free imports. The second wave mainly opened up two eastern coastal provinces (*i.e.*, Guangdong and Fujian) by allowing foreign firms to sign "export-processing" contracts with domestic firms. In the early 1990s, China experienced its third wave of dramatic proliferation of SEZ by generalizing the open-door policy to many other eastern coastal

[1] The other fundamental doctrine is the "deepen economic reform" policy.

provinces. China then set up 18 economic and technical development zones (ETDZs), in which foreign investors are encouraged to set up joint ventures with rural collectives and various subsidiaries. By the end of 2003, China had already more than 100 investment zones that enjoy various special foreign trade policies.

Before the economic reform, tariffs did not play an important role since FTCs had already served as an "air-lock" to insulate China from the world. In the 1980s, China began to set up a whole system of tariff rates. In 1992, China's unweighted average tariffs were 42.9%, which was similar to the level of other developing countries. Shortly after the Uruguay Round of the WTO, China experienced huge tariff reductions due, in large part, to the WTO accession application. China cut its tariffs from 35% in 1994 to around 17% in 1997. After that, from 1998-2002, China's unweighted (weighted) average tariffs did not decrease much. The largest adjustment was in 2001, in which the average tariff rates decreased from 16.4% to 15.3%.

[Insert Figure 1 Here]

Besides tariffs, China also used various NTBs to protect its import-competing industries. According to UNCTAD's classification, the NTBs include many types of measures, such as price control measures, quantity control measures, customs charges and taxes, financial measures, technical measures, monopolistic measures, and miscellaneous measures. According to Fujii and Ando's (2000) calculation, China maintained a large number of NTBs in various products. For example, the core non-tariff measures (NTMs) was 51.9% for wood products, whereas 55.1% for chemicals in 1996.

Moreover, to fully join into the world trading system, China applied to re-join the GATT in 1986. It took China 15 years to accede to the WTO in 2001, as its 143rd member. Although such a long march was not expected, China's trade policies were changed many times to fit this largest trading organization. China's inward foreign direct investment (FDI) increases dramatically after Deng Xiaoping's southern China tour in 1992. In 2007, China's FDI reached \$74.7 billion, which was 17 times higher than that in 1991. According to *The Economist*[2], it is predicted that China's inward FDI will become the third largest, followed by the U.S. and the U.K., in 2011.[3]

Following trade liberalization, China also maintains a huge volume of processing exports (*i.e.*, China imports the parts or raw materials from abroad and exports the finished products to other countries). According to *China's Statistical Yearbook*, the value of China's processing export is much higher than that of its ordinary export since the 1990s. Although the level of processing trade has been decreasing over the years, in 2006, China's processing export still accounted for around 52% out of its total export.

[Insert Figure 2 Here]

3 The Econometric Methodology

In this section, the measurement of TFP is first introduced, followed by the empirical investigation of the effect of trade liberalization on productivity.

3.1 Measuring Total Factor Productivity

The literature on TFP usually suggests a Cobb-Douglas production function to introduce technology improvement.[4] Following Amiti and Konings (2007), we consider a form as follows:

$$Y_{it} = \pi_{it}(\tau_{jt}) M_{it}^{\beta_m} K_{it}^{\beta_k} L_{it}^{\beta_l}, \tag{1}$$

[2] source: The *Economist (*Sep. 5, 2007), via http://www.economist.com.

[3] However, since China also has a remarkable growth rate of its economy scale, the ratio of FDI over GDP is only 2.1%, which is lower than many OECD countries (WDI, 2007).

[4] An alternative specification is to use a trans-log production function, which also leads to very similar estimation results.

where Y_{it}, M_{it}, K_{it}, L_{it} is firm i's output, materials, capital, and labor at year t, respectively. Firm i's productivity, π_{it}, is affected by trade policy, τ_{jt}, in its industry level j in year t. To measure firm's TFP, one needs to estimate (1) by taking a log function first:

$$\ln Y_{it} = \beta_0 + \beta_m \ln M_{it} + \beta_k \ln K_{it} + \beta_l \ln L_{it} + \epsilon_{it}, \tag{2}$$

Traditionally, the TFP is measured by the estimated Solow residual between the true data on output and its fitted value, $\ln \hat{Y}_{it}$. That is:

$$TFP_{it} = \ln Y_{it} - \ln \hat{Y}_{it}. \tag{3}$$

However, this approach suffers from two problems: simultanity bias and selection bias. As first suggested by Marschak and Andrews (1944), at least some parts of TFP changes could be observed by the firm early enough so that the firm could change its input decision to maximize profit. From another perspective, the firm's TFP could have reverse endogeneity in its input factors. The lack of such a consideration would make the firm's maximized choice biased. In addition, the firms' dynamic behavior also introduces selection bias. In a panel data set, the firms observed are those that have already survived. On the other hand, firms with low productivity that collapsed and exited from the market are not included in the data set. This means that the samples covered in the regression actually are not randomly selected which in turn cause estimation bias.

Econometricians tried hard to address these empirical challenges, but were not successful until the pioneering work by Olley and Pakes (1996). In the beginning, researchers used two-way (*i.e.*, firm-specific and year-specific) fixed effects to mitigate simultanity bias. Although the fixed-effect approach controls for some unobserved productivity shocks, it does no offer much help in dealing with reverse endogeneity. So this approach still seems unsatisfactory. Similarly, to mitigate selection bias, one may estimate a balanced panel by dropping those observations that disappeared during the period of investigation. The problem is that a substantial part of information contained in the data set is wasted, and the firm's dynamic behavior is completely unknown.

Fortunately, the Olley-Pakes (1996) methodology makes a significant contribution in addressing these two empirical challenges. By assuming that the expectation of future realization of the unobserved productivity shock, υ_{it}, relies on its contemporaneous value, the firm i's investment is modeled as an increasing function of both unobserved productivity and log capital, $k_{it} \equiv \ln K_{it}$. Following previous works, such as van Biesebroeck (2005) and Amiti and Konings (2007), the Olley-Pakes approach is revised by adding the firm's export decision as an extra argument of the investment function since most of the firms' export decisions are determined in the previous period (Tybout, 2003):

$$I_{it} = \tilde{I}(\ln K_{it}, \upsilon_{it}, EF_{it}), \tag{4}$$

where EF_{it} is a dummy to measure whether firm i exports in year t. Therefore, the inverse function of (4) is $\upsilon_{it} = \tilde{I}^{-1}(\ln K_{it}, I_{it}, EF_{it})$.[5] The unobserved productivity also depends on log capital and the firm's export decision. Accordingly, the estimation specification (2) can now be written as:

$$\ln Y_{it} = \beta_0 + \beta_m \ln M_{it} + \beta_l \ln L_{it} + g(\ln K_{it}, I_{it}, EF_{it}) + \epsilon_{it}, \tag{5}$$

where $g(\ln K_{it}, I_{it}, EF_{it})$ is defined as $\beta_k \ln K_{it} + \tilde{I}^{-1}(\ln K_{it}, I_{it}, EF_{it})$. Following Olley-Pakes (1996) and Amiti-Konings (2007), fourth-order polynomials are used in log-capital, log-investment, and the firm's export dummy to approximate $g(\cdot)$.[6] In addition, since my firm data set is from 1998 to 2005, I include a WTO dummy (*i.e.*, one for year after 2001

[5] Olley and Pakes (1996) show that the investment demand function is monotonically increasing in the productivity shock υ_{it}, by making some mild assumptions about the firm's production technology.

[6] Using a higher order polynomials to approximate $g(\cdot)$ does not change the estimation results.

and zero for before) to characterize the function $g(\cdot)$ as follows:

$$g(k_{it}, I_{it}, EF_{it}, WTO_t) = (1 + WTO_t + EF_{it}) \sum_{h=0}^{4} \sum_{q=0}^{4} \delta_{hq} k_{it}^{h} I_{it}^{q}. \tag{6}$$

After getting the estimated coefficients $\hat{\beta}_m$ and $\hat{\beta}_l$, I calculate the residual R_{it} which is defined as $R_{it} \equiv \ln Y_{it} - \hat{\beta}_m \ln M_{it} - \hat{\beta}_l \ln L_{it}$.

The next step is to obtain an unbiased estimated coefficient of β_k. To correct the selection bias as mentioned above, Amiti-Konings (2007) suggested estimating a probability of a survival indicator on a high order polynomial in log-capital and log-investment. Precisely, one can estimate the following specification:

$$R_{it} = \beta_k \ln K_{it} + \tilde{I}^{-1}(g_{i,t-1} - \beta_k \ln K_{i,t-1}, \hat{p}r_{i,t-1}) + \epsilon_{it}, \tag{7}$$

where $\hat{p}r_i$ denotes the fitted value for the probability of the firm 's exit in the next year. Since the specific "true" functional form of the inverse function $\tilde{I}^{-1}(\cdot)$ is unknown, it is appropriate to use fourth-order polynomials in $g_{i,t-1}$ and $\ln K_{i,t-1}$ to approximate that. In addition, (7) also requires the estimated coefficients of the log-capital in the first and second term to be identical. Therefore, non-linear least squares seem to be the most desirable econometric technique (Pavcnik, 2002, Arnold, 2005). Finally, the Olley-Pakes (OP) type of TFP for each industry j is obtained once the estimated coefficient $\hat{\beta}_k$ is obtained:

$$TFP_{ijt}^{OP} = \ln Y_{it} - \hat{\beta}_m \ln M_{it} - \hat{\beta}_k \ln K_{it} - \hat{\beta}_l \ln L_{it}. \tag{8}$$

3.2 Econometric Model

In this section, I estimate the equation as follows:

$$\ln TFP_{ijt}^{OP} = \alpha_0 + \alpha_1 \ln imp_{jt} + \alpha_2 EF_{it} + \alpha_3 (\ln imp_{jt} \times EF_{it}) + \alpha_4 exit_{it} + \boldsymbol{\theta} \mathbf{X}_{it} + \varpi_i + \eta_t + \mu_{ijt}, \tag{9}$$

where $\ln TFP_{ijt}^{OP}$ is the logarithm of firm i's Olley-Pakes type TFP in industry j in year t whereas $\ln imp_{jt}$ denotes the logarithm of import penetration ratio for industry j in year t. EF_{it} is a dummy for exporting firm i in year t whereas $exit_{it}$ denotes a dummy for firm i's exit in year t.[7] $\mathbf{X}_{it}$ denotes other control variables for firm i in year t such as Foreign-Direct-Investment (FDI) dummy, Stated-Own-Enterprises (SOE) dummy, and if so, whether it is controlled by the central government. The error term is decomposed into three components: (1) firm-specific fixed effects ϖ_i to control for time-invariant factors; (2) year-specific fixed effects η_t to control for firm-invariant factors like Chinese *yuan* real appreciation; and (3) an idiosyncratic effect μ_{ijt} with normal distribution $\mu_{ijt} \sim N(0, \sigma_{ij}^2)$ to control for other unspecified factors.[8]

From (9), the import penetration ratio in industry j has two following effects on productivity of firm i within industry j:

$$\partial \ln TFP_{ijt}^{OP} / \partial \ln imp_{jt} = \alpha_1 + \alpha_3 EF_{it}, \tag{10}$$

where parameter α_1 measures the impact of trade liberalization, which is measured by industry j's import penetration, on non-exporting firm i in that industry. In contrast, the effect of trade on an exporting firm's productivity is $\alpha_1 + \alpha_3$. Previous works, such as Levinsohn (1993) and Harrison (1994), emphasized that the high import penetration ratio, an indicator of trade liberalization, made domestic firms face more intense competition from foreign firms. Therefore, it is reasonable to hypothesize that both α_1 and $\alpha_1 + \alpha_3$ are positive since tougher import competition would force both non-exporting and exporting firms to exert every effort to improve their efficiency and survival.

[7] The reason that I do not include a dummy for importing firm here is that my data set does not include information on importing firms.

[8] In this paper I only include firm-level fixed effects and year-specific fixed effects. The province-level fixed-effect is not included here since data on industry-level import penetrations and firm-level TFP do not uniquely match.

Moreover, the productivity of exporting firms is expected to increase less than those of non-exporting firms. Put another way, the coefficient α_3 is expected to be negative. This is possibly because more than half of exporting firms in China also import raw materials and parts from overseas, as has discussed in the previous section.[9] With trade liberalization, processing exporting firms are now able to acquire raw materials and parts from foreign producers at relatively lower costs. They would still enjoy a large price-cost markup by their access to low-priced imports. Therefore, the processing exporting firms have less incentive to adopt up-to-date technology to improve their efficiency, given the fact that they do not face strong competition.

4 Data

The sample used in this paper comes from two large data sets. The first is a rich firm-level panel that covers more than 150,000 manufacturing firms per year for the years 1998-2005.[10] Such data were collected from China's National Bureau of Statistics as an annual survey for manufacturing enterprises. It covers more than 100 financial variables listed in the main accounting sheets of all SOEs, and those non-SOEs firms, whose sales are more than five million *yuan* per year.[11]

Table 1 provides some basic statistical information about the Chinese plant data. Although this data set contains rich information, a few samples in the data set are noisy and misleading due, in large part, to the mis-reporting by some firms (See Holz, 2004, for a

[9] Of course, some firms also import parts and raw materials from abroad but only sell their products in the domestic market. Such importing firms still face tough import competition for their final outputs in China and hence only enjoy reasonable markup from lower cost on raw materials. Put another way, such non-exporting firms still bear relatively large price pressure, compared to exporting firms.

[10] Following Levinsohn and Petrin (2003), plants were treated as firms. In the present paper, I do not capture scope economics due to their multi-plant nature. This remains a topic for future research.

[11] Indeed, aggregated data of the industrial sector in the annual *China's Statistical Yearbook* by the Natural Bureau of Statistics (NBS) is compiled from such a data set.

discussion about possible problems of using China's data). For example, data information for some family-based firms, which usually did not set up a formal accounting system, is based on a unit of 1,000, whereas the official requirement is a unit of 10,000. Following Jefferson, Rawski, and Zhang (2008), the observations were dropped if (1) the number of employees hired for a firm is less than eight people;[12] (2) the ratio of value-added relative to the sales is less than zero or higher than one. After this filter, 28,875 observations were dropped from the original data set. As seen in Table 1, FDI-type firms[13] account for more than two-thirds out of all plants in each year. In contrast, SOE-type firms account for around one-third.

[Insert Table 1 Here]

The previous TFP literature suggests that output should also be measured in physical terms. Recent papers, such as Felipe, Hasan, and McCombie (2004), have emphasized the estimation bias of using monetary terms to measure output when estimating the production function. In that way, what one actually did is to estimate an accounting identity. To get a precise measure of TFP, one should work on physical data, or at least, deal with deflated terms of output. However, like the problems that many previous studies have encountered, the data on physical output is infeasible. I therefore deflate each firm's output following Amiti and Konings (2007). The statistical information is reported in Table 2.

[Insert Table 2 Here]

[12] Levinsohn and Petrin (2003) suggest covering all Chilean plants with at least 10 workers instead.

[13] Here a firm is classified as a FDI-type one if it, by nature, belongs to one of the followings: (1) Equity joint venture; (2) Wholly foreign-owned venture; (3) Contractual joint venture; or (4) Foreign-owned limited liability corporation.

Column (2) of Table 3 reports the estimated firm's survival probability in the next year by industry.[14] They are varied from 0.97 to 0.99 with the mean of .978, which suggests that the firm exits are not so severe during this period. The rest of Table 3 presents the difference of the estimated coefficients for labor, materials, and capital by using both the OP methodology and the usual OLS approach. A total of 39 manufacturing industries were covered, and coded from 6 to 46 according to China's industrial classifications (GB/T4754-2002). Compared to OLS estimates, as seen from the bottom line of Table 3, the inputs' coefficients for all manufacturing industries estimated by the OP approach seem much lower. This suggests that, without controlling for simultanity bias and selection bias, the estimated industrial TFP using the OLS approach has a downward bias, which could partially explain why some previous researchers did not find large productivity growth in China (*e.g.*, see Young (2003)).

[Insert Table 3 Here]

As introduced above, the import penetration ratio is an appropriate index to measure trade liberalization since it captures the effects from both tariffs and non-tariff barriers (NTB).[15] My import data are at the Harmonized System (HS) 10-digit level, which are from the General Administration of China's Customs. Although highly aggregated HS 2-digit import data are publicly available in various publications, such as *China Statistical Yearbook*, their disaggregated data are not. In this paper, I access HS 10-digit import data up to 2002.[16] To calculate industry j's import penetration ratio, the HS 10-digit

[14] Noted that here "firm's exit" means a firm either died and exited from the market or simply had an annual sale which is lower than the "large scale" (*i.e.*, 5 million sales per year) and dropped from the data set. Due to the restriction of the data set, I am not able to distinguish the difference between the two.

[15] Ideally, it would be a plus to use both tariffs and NTBs as alternative measures of trade liberalization. Unfortunately, I am currently not able to access to the data sets, though China's disaggregated tariff data in 2001 is accessble.

[16] An alternative source for such disaggregated data is the Center for International Data (CID) maintained

imports (IM) up to HS 4-digit industrial level, $\sum_i IM_i^j$, were first aggregated. The firm 's output, y_i, was simultaneously aggregated up to China's 2-digit sector classifications, $\sum_i y_i^j$. Finally, I obtained the industry j's import penetration ratio imp^j as $\sum_i IM_i^j / \sum_i y_i^j$ according to the concordance between HS 4-digit level and China's sector classifications two-digit level. For the readers' convenience, I report the industrial concordance in Table 4, in which only HS 2-digit level of the customs code are reported to save space.

[Insert Table 4 Here]

Figure 3 shows the average magnitudes of both the import penetration ratio and the industrial augmented OP-type TFP over 1998-2002. Although there are firm data for all industries, products for some industries are non-tradable, and, hence, there are no matching data on imports. If the industrial data on either TFP or import penetration ratio are unavailable, such an industry is dropped from the samples since there is no way to investigate the effect of its trade liberalization on its productivity. As a result, eight industries are dropped, and only 32 industries were covered in the data set.[17] Although most industries have both positive TFP and log of import penetration ratios, a few exceptions occur: industries like coal, foods, leather, petroleum, and smelting and pressing of furious metals have negative log of import penetration ratios, which suggest that imports from these industries are less than sales. On the other hand, the manufacture of smelting and pressing of furious metals also suffers from a negative TFP. Yet, overall, Figure 3 suggests that an industrial import penetration ratio is positively associated with its TFP.

[Insert Figure 3 Here]

by Robert Feenstra at the University of California-Davis.

[17] The eight industries dropped include extraction of petroleum and natural gas, mining and processing of ferrous metal ores, mining of other ores, recycling and disposal of waste, electrical power and heat power, production and supply of electric power and heat power, production and supply of gas, and production and supply of water.

5 Empirical Results

5.1 Main Estimation Results

Table 5 reports the estimation results for equation (9). To consider the effect of the import penetration ratios on TFP, I first run a regression on TFP of import penetration ratio, a dummy for export firms, and their interaction term as a benchmark. The estimated coefficient of α_1 in equation (9) is 0.019, which is significant at the conventional statistical level. This suggests that strong trade liberalization tends to result in high productivity gains. As discussed above, some firms could collapse and drop out next period due to bad operations or other reasons. Ignoring such behavior would cause a selection bias problem. Therefore, the firms' dynamic behaviors were taken into account for the estimations in Columns (2)-(5) by adding a variable to measure a firm's exit from the market next period. As shown in Table 5, firms that dropped out from the market have low productivity compared to those that did not.

After controlling for firm exits, Column (2) shows that trade liberalization's elasticity of firm TFP ($\hat{\alpha}_1$) is still positive. However, one needs to pay caution to the magnitude since the coefficient of $\hat{\alpha}_1$ in Column (2) while controlling for firm exits is smaller that without in Column (1): $0.005 < 0.019$. I suspect that this is due to the possible endogeneity of trade liberalization. In addition, the effect of trade liberalization on a firm's productivity in exporting firms is smaller than in non-exporting firms, since the interaction term, $\ln imp_{jt} \times EF_{it}$, is significantly negative. Given that the mean of the variable of exporting firms is 0.49, the net elasticity of firm's TFP with respect to trade liberalization for exporting firm is still positive ($0.005 - 0.007 \times 0.49 = 0.002$).

The economic meanings for these findings are threefold: First, trade liberalization introduces better technology and hence productivity gains for both exporting and non-exporting firms. This is because tougher competition from abroad induces more incentives for domestic firms to upgrade their technology adoption. Second, compared to non-exporting firms, exporting firms seem to enjoy few benefits from trade liberalization than do non-exporting firms. One possible reason is that most of the exporting firms also import products from abroad. Instead of introducing tougher competition, trade liberalization allows exporting firms to access raw materials at lower costs. Such exporting firms can still enjoy some profit margin without increasing their productivity. Put another way, trade liberalization, to some extent, hampers their incentive to adopt up-to-date technology.

In the absence of trade liberalization, other channels, such as preferential taxation reduction, might affect an exporting firm's productivity. The parameter α_2 in (9) investigates the effects on the exporting firm's productivity from such channels.[18] It turns out that $\hat{\alpha}_2$ is significantly positive, which suggests that exporting firms are associated with higher productivity even in the absence of strong import penetration.

Previous work also suggests that State-Owned Enterprises (SOEs) have relative low productivity compared to non-SOEs due to their low efficiency and impotent incentive systems (Wu, 2005). Therefore, a dummy of SOEs as a controllable variable in Column (3) is included. It turns out that the coefficient is significantly negative. Such a finding is broadly consistent with Jefferson *et al.* (2000), who find that Chinese SOEs are associated with relatively low TFP compared to those private firms in China. By definition, the SOEs are controlled by the government. However, the central government and the local government have different economic interests. For the purpose of self-promotion, the main objective of local government officials is to maximize gross local output (Wu, 2005). To do so, they are more likely to give incentives to SOEs, which, in turn, would lead to

[18] Mathematically, the parameter α_2 equals the partial derivative of log TFP with respect to the EF variable: $\partial \ln TFP_{ijt}/\partial EF_{it}$.

greater productivity and profits. As predicted, the interaction term between SOEs and the central-controlled dummy of Column (5) is shown to be significantly negative.

Finally, foreign-owned enterprises are expected to have high productivity due to their quick learning, better technology adoption, or higher quality inputs (Amiti and Konings, 2007). The FDI is included in Column (5), and it is positive as expected, though insignificant.

[Insert Table 5]

5.2 Choices of Depreciation Rates

An essential component in the calculation of the Olley-Pakes' TFP variable is to obtain data on investment, which is usually calculated by adopting the perpetual inventory method as follows:

$$I_{it} = K_{it} - (1 - \delta)K_{it-1}, \tag{11}$$

where I_{it}, K_{it} denotes investment and fixed capital in year t for firm i, respectively.[19] δ denotes a common depreciation rate across firms and years given that China did not change its depreciation rate over 1998-2002.[20]

The only problem left to calculate investment is the appropriate value for the depreciation rate. As recommended by Perkins (1988) and Wang and Yao (2003), a 5%

[19] Another way to form investment data is to use information on net physical capital by adopting the formula $I_{it} = K_{it} - NK_{it-1}$ where NK_{it-1} is firm i's net fixed assets in year $t-1$. Since only data on net physical capital for years 2000-2002 were accessed, the main estimations on raw physical capital data use such expression (11).

[20] Another assumption of Olley-Pakes approach is that a productivity shock should be increasing monotonically with investment conditional pre-determined capital. The investment proxy is only valid for .firms reporting nonzero investment. To avoid this possible challenge, the Levinsohn-Petrin (2003) approach is a useful alternative to calculate TFP. However, the Levinsohn-Petrin type TFP is found to similar to the OP type TFP in my data set, which are not report here to save space, though available upon request.

depreciation rate is a good choice, since this number is adopted to calculate SOEs' depreciation in China's Statistical Yearbook. However, some other researchers have different views on this number. Liang (2006) suspected that the number should be 4% instead. Amiti and Konings (2007) adopted 15% for Indonesia, another large developing country. China, indeed, may adopt a number up to 16% as its depreciation rate in some years in the 1990s (Wang and Yao, 2003). Therefore, the depreciation rate is allowed to show its flexibility to form the firm's investment level. Following Amiti and Konings (2007), 15% is adopted as a default number, but performed the robustness check by using 10%, 5%, and 4% as alternative depreciation rates. As seen in Table 6, the estimation results are robust to using different depreciation rates.

[Insert Table 6 Here]

5.3 Specifications of Periodic Differences

To reduce estimation bias caused by unobserved firm heterogeneity, estimations in Tables 5-6 control for the firm-specific and year-specific fixed effects by adopting the firm annual level data. However, some unobserved factors would change according to firms and the relevant year. One possible example is that taxation reduction policies in special economic zones (SEZs) vary by year, affecting the productivity of firms based in these zones. The regular two-way fixed effects seem not be able to fully control for this omitted-variable problem.

To address this empirical challenge, alternative econometric specifications with data on periodic differences were considered, and are reported in Table 7. Since the samples cover 1999-2002, several specifications from one to three periodic difference(s) were considered.[21]

[21] Although the data covers the years 1998-2002, to calculate the investment, one needs to use one-year lag data. Accordingly, only the data for the years 1999-2002 are covered in the estimations.

The periodic differences of import penetration ratio and the exporting firm's dummy have expected positive signs, which are consistent with the findings in Tables 5 and 6.

The only surprising finding is that the coefficients of the interaction term of the import penetration ratio and the dummy for exporting firms are significantly positive in one (two) periodic difference(s) estimates. The positive term of $\hat{\alpha}_3$ suggests that the effect of trade liberalization on a firm's productivity for exporting firms are higher than those for non-exporting firms, which seems inconsistent with the estimates of the three periodic differences, as well as the previous findings in Table 5. Since most measurement errors and possible serial correlations are controlled by the fixed-effect econometric method, there is suspicion that such inconsistency mainly comes from reverse causality, which will be addressed shortly.

Finally, for each case, the interaction term of the province and year fixed-effects are included to control for those unobserved factors that vary by firm and year. The estimation results are not sensitive no matter whether such fixed effects are considered. One exception is the one-period difference: the sign of change in the import penetration ratio in Column (2) is negative, but insignificant.

[Insert Table 7 Here]

5.4 Endogeneity

Trade liberalization is not exogenously given, but affected by firm productivity. With better performance, some firms have stronger incentive to expand their economic scale, which, in turn, requires more inputs from the international market. The strong demand from firms leads to a greater import penetration ratio for each industry. One needs to control for the endogeneity of trade liberalization in order to obtain accurate estimated effects of trade liberalization on TFP. Otherwise, the related estimates would be suspect. The instrumental variable (IV) estimation is a powerful econometric method that can address this problem.[22]

In the paper, provincial government savings is chosen as the instrument for import penetration. The economic rationale is as follows. As many economists like Krugman (1998) emphasized, trade deficit means, in essence, government deficit. To reduce the sizable government deficit, the government usually appreciates its currency to generate more trade deficit. With a greater trade deficit, the government can finance government deficits from foreigners. Put another way, more government savings tends to lower trade deficits. Given that other factors remain constant, an incremental amount of government savings is correlated with lower import penetration.

Several tests were performed to verify the quality of the instrument. First, Anderson's (1984) canonical correlation likelihood-ratio test is conducted to check whether or not the excluded instrument (*i.e.*, government savings) is correlated with the endogenous regressors (*i.e.*, import penetration ratio). The null hypothesis that the model is under-identified is rejected at the 1% level. Second, I also take another step to see whether or not government savings is weakly correlated with import penetration. If so, then the estimates will perform poorly in this IV estimate. Luckily enough, the Cragg and Donald (1993) F-statistics provide strong evidence to reject the null hypothesis that the first stage is weakly identified at a highly significant level. Third, the Anderson and Rubin (1949) χ^2 statistics reject the null hypothesis that the coefficient of the endogenous regressor is equal to zero. In short, such statistical tests give sufficient evidence that the instrument is well performed, and therefore, the specification is well indicated.

[22] The IV approach is a good way to control for endogeneity issues. Wooldridge (2002, Chapter 5) provided a careful scrutiny of this topic.

[Insert Table 8 Here]

Estimates in Table 8 show that, after controlling for endogeneity, trade liberalization still has a positive effect on a firm's productivity. In all estimations, the coefficients $\hat{\alpha}_1^{IV}$ are quite stable and much higher than its counterparts $\hat{\alpha}_1$ without controlling for the endogeneity shown in Table 5. The interaction term of the import penetration ratio and the exporting firm dummy, $\hat{\alpha}_3^{IV}$, is still significantly negative, which is consistent with previous findings. The effect of trade liberalization on an exporting firm productivity turns out to be still positive $(0.072 - 0.014 * 0.57 = 0.06)$. In addition, such a net effect is higher than that, without controlling endogeneity, 0.001, as obtained in Table 5. This implies that the implicit *negative* reverse causality undercuts the effect of trade liberalization on firm productivity. After controlling for endogeneity, industrial trade liberalization appears to have a sizable effect on firm productivity. In particular, a 10% increase in log industrial import penetration leads to a 0.6% increase in a firm's log of productivity.

5.5 Alternative Measure of Firm Productivity

As discussed above, the augmented Olley-Pakes approach to calculate the TFP is able to deal with both the simultanity bias and selection bias. The approach is based on an assumption that capital is more aggressively responsive to the unobserved productivity shock compared with labor. Put another way, labor input here is assumed to be exogenous to the productivity shock. However, China is a labor-abundant country and hence labor costs are relative low. When facing a productivity shock, China's firms are more likely to adjust their labor input to re-optimize their production behavior. This is consistent with the idea suggested by papers such as Blomström and Kokko (1996) that labor would embody more productivity improvements than capital.

The Blundell-Bond (1998) system GMM approach is a good alternative to handle with this potential empirical challenge. By assuming that the unobserved productivity shock depends on its previous-period realizations, the system-GMM approach models TFP to be affected by all types of firm's inputs in both current and past realizations.[23] In particular, this model has a dynamic representation as follows:

$$\begin{aligned}\ln y_{ijt} &= \gamma_1 \ln L_{it} + \gamma_2 \ln L_{i,t-1} + \gamma_3 \ln K_{it} + \gamma_4 \ln K_{i,t-1} + \gamma_5 \ln M_{it} \\ &\quad + \gamma_6 \ln M_{i,t-1} + \gamma_7 \ln y_{i,t-1} + \varsigma_i + \zeta_t + \omega_{it}, \qquad (12)\end{aligned}$$

where ς_i is firm i's fixed effect and ζ_t is year-specific fixed effect. The idiosyncratic term ω_{it} is serially uncorrelated if there is no measurement error.[24] One can obtain consistent estimates of the coefficients in (12) by using a system-GMM approach (Blundell and Bond, 1998). The idea is that labor and material inputs are not taken as exogenously given. Instead they are allowed to be changed over time as is the evolution of capital. Although the system GMM approach still faces a technical challenge to control for the selection bias of firm exits, it is still worthwhile to use the system-GMM approach to estimate firm TFP as a robustness check.

Table 9 reports the estimated effects of trade liberalization on system-GMM type firm's TFP. The key coefficients $\hat{\alpha}_1, \hat{\alpha}_2$, and $\hat{\alpha}_3$ are highly close to those estimated by the augmented Olley-Pakes approach as shown in Table 5. Both exporting and non-exporting firms benefit from trade liberalization, although exporting benefit less. The

[23] Note that first-difference GMM introduced by Arellano and Bond (1991) also allows a firm's output to depend on its past realization. However, such an approach would lose the instruments for the factor inputs because lag of output and factor inputs are correlated with past error shocks and the autoregressive error term. In contrast, by assuming that the first difference of instrumented variables is uncorrelated with the fixed effects, the system-GMM can introduce more instruments and hence dramatically improve efficiency. I thank Linda Yueh for her correctly pointing out this view.

[24] As discussed by Blundell and Bond (1998), even if there are transient measurement error in some of the series ($i.e.$, $\varpi_{it}\tilde{}MA(1)$), the system GMM approach can still reach consistent estimates of the coefficients in (12).

negative significant coefficient of $\hat{\alpha}_4$ also suggests that firms that exit from the market are those with low productivity. SOEs firms, as usual, have lower productivity than those non-SOEs. The only striking finding of Table 9 is that those SOEs controlled by the central government seem to have higher productivity than those controlled by the local governments. This unexpected result may come from the fact that the system-GMM type TFP did not control for firm's exit behavior. Generally speaking, the estimation results are robust to different ways of calculating a firm's productivity.

[Insert Table 9 Here]

6 Concluding Remarks

In this paper I estimate the effect of trade liberalization on firm productivity by using Chinese plant level data. After controlling for firms' exits and the endogeneity of trade liberalization, the effect of trade liberalization on firm productivity is significantly positive. More interestingly, the effect on exporting firms is smaller than on non-exporting firms. Such a finding is consistent with the stylized fact that the processing exports is still dominant in China's trade pattern today.

The present paper enriches our understanding of China's TFP. Possibly due to poor data quality and methodology restriction, previous works found mixed findings on China's productivity improvement. By using more reliable and disaggregated firm-level data on Chinese plants, I found that China's TFP had increased during the last decade. The augmented Olley-Pakes' empirical methodology was applied to deal with the usual problems of estimating TFP: simultanity bias and selection bias.

It is worthwhile to point out that although exporting firms benefit less from trade liberalization in terms of productivity improvement compared to non-exporting firms, exporting firms show a positive increase in productivity. In this sense, the finding of this paper is in line with previous studies, like those of Bernard and Jensen (1999), who showed that good firms export in the U.S. because they have high productivity. However, this result is not necessarily applicable for China since China's economic reform, to some extent, is unique. In any case, whether or not good firms lead to exports in China is a possible future research topic.

References

[1] Arellano, Manuel and Stepen Bond (1991), "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations," *Review of Economic Studies* 58, pp. 277-97.

[2] Amiti, Mary, and Jozef Konings (2007), "Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia," *American Economic Review* 97 (5), pp. 1611-1638.

[3] Arnold, Jens Metthias (2005), "Productivity Estimation at the Plant Level: A Practical Guide," mimeo, Bocconi University.

[4] Bernard, Andrew, and Bradford Jensen (1999), "Exceptional Exporter Performance: Cause, Effect, or Both?" *Journal of International Economics* 47, pp.1-25.

[5] Bernard, Andrew, and Bradford Jensen (2004), "Why Some Firms Export?" *Review of Economics and Statistics* 86(2), pp.561-569.

[6] Blomström, Magnus and Ari Kokko (1996), "The Impact of Foreign Investment on Host Countries: A Review of the Empirical Evidence," World Bank Policy Research Working Paper, No. 1745.

[7] Blundell, Richard and Stepen Bond (1998), "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models," *Journal of Econometrics* 87, pp. 11-143.

[8] China's National Bureau of Statistics, *China Statistical Yearbook (2007)*, China Statistics Press.

[9] Felipe, Jesus, Hasan, Rana, and J.S.L, McCombie (2004), "Correcting for Biases When Estimating Production Functions: An Illusion of the Laws of Algebra?" CAMA Working Paper Series, No. 14, Australia National University.

[10] Fujii, Takamune and Mitsuyo Ando (2000), "Quantifying the Economic Impact of Removing Non-Tariff Measures: Tariff Equivalent Approach," mimeo.

[11] Harrison, Ann (1994), "Productivity, Imperfect Competition and Trade Reform," *Journal of International Economics* 36, pp.53-73.

[12] Head, Keith, and John Ries (1999), "Rationalization Effects of Tariff Reduction," *Journal of International Economics* 47(2), pp. 295-320

[13] Holz, Carsten (2004), "China's Statistical System in Transition: Challenges, Data Problems, and Institutional Innovations," *Review of Income and Wealth* 50(3), pp. 381-409.

[14] Holz, Carsten and Yi-Min., Lin (2001), "The 1997-1998 Break in Industrial Statistics: Facts and Appraisal," *China Economic Review* 12(4), pp. 303-316.

[15] Jefferson, Gary, Rawski, Thomas, and Yuxin Zheng (1996), "Chinese Industrial Productivity: Trends, Measurement Issues, and Recent Developments," *Journal of Comparative Economics* 23(2), pp.146-180.

[16] Jefferson, Gary, Rawski, Thomas, Wang Li, and Zheng Yuxin (2000), "Ownership, Productivity Change, and Financial Performance in Chinese Industry," *Journal of Comparative Economics* 28 (4), pp. 786-813.

[17] Jefferson, Gary, Rawski, Thomas, and Yifan Zhang (2008), "Productivity Growth and Convergence across China's Industrial Economy," *China Economic Quarterly* (in Chinese) 7(3), pp.809-826.

[18] Krugman, Paul (1994), "The Myth of Asia's Miracle," *Foreign Affairs* 73(6), pp. 62-78.

[19] Krugman, Paul (1998), "The Age of Diminished Expectations," The MIT Press, Cambridge.

[20] Liang, Hong (2006), "China's Investment Strength is Sustainable," Goldman Sachs Global Economic Paper, No. 146.

[21] Levinsohn, James (1993), "Testing the Imports-as-Market-Discipline Hypothesis," *Journal of International Economics* 35(1), pp. 1-22.

[22] Levinsohn, James and Amil Petrin (2003), "Estimating Production Functions Using Inputs to Control for Unobservable," *Review of Economic Studies* 70(2), pp. 317-341.

[23] Marschak, Jacob and Andrews, William (1944), "Random Simultaneous Equations and the Theory of Production," *Econometrica* 12(4), pp 143-205.

[24] Melitz, Marc (2003), "The Impact of Trade on Intra-industry Reallocations and Aggregate Industry Productivity," *Econometrica* 71(6), pp. 1695-1725.

[25] Naughton, Barry (2006), *The Chinese Economy: Transition and Growth*, MIT press, Cambridge.

[26] Olley, Steven and Ariel Pakes (1996), "The Dynamics of Productivity in the Telecommunications Equipment Industry," *Econometrica* 64(6), pp. 1263-1297.

[27] Pavcnik, Nina (2002), "Trade Liberalization, Exit, and Productivity Improvements: Evidence from Chilean Plants, " *Review of Economic Studies* 69(1), pp. 245-276.

[28] Perkins, Dwright (1988), "Reforming China's Economic System," *Journal of Economic Literature* 26(2), pp. 601-645.

[29] Rodrik, Dani (2006) "What's So Special About China's Exports?" NBER Working Paper No. 11947, National Bureau of Economic Research.

[30] Rumbaugh, Thomas and Blancher, Nicolas (2004), "International Trade and the Challenges of WTO Accession", in Eswar Prasad, eds., *China's Growth and Integration into the World Economy, Prospects, and Challenges*, International Monetary Fund.

[31] Trefler, Daniel (2004), "The Long and Short of the Canada-U.S. Free Trade Agreement," *American Economics Review* 94(3): 870-895.

[32] Tybout, James, Jaime de Melo, and Vittorio Corbo (1991), "The Effects of Trade Reforms on Scale and Technical Efficiency: New Evidence from Chile," *Journal of International Economics* 31(3), 231-250.

[33] Tybout, James (2003), "Plant and Firm-Level Evidence on "New" Trade Theories," In *Handbook of International Trade*, ed. James Harrigan and Kwao Choi, pp. 388-415. New York: Blackwell Publishing Ltd.

[34] Van Biesebroeck, Johannes (2005), "Exporting Raises Productivity in Sub-Saharan African Manufacturing Firms," *Journal of International Economics* 67(2), pp. 373-391.

[35] Wang, Yan, and Yudong Yao (2003), "Sources of China's Economic Growth 1952-1999: Incorporating Human Capital Accumulation," *China Economic Review* 14(1), pp. 32-52.

[36] Wooldridge, Jeffrey M.(2002), *Econometric Analysis of Cross Section and Panel Data*, MIT Press.

[37] World Bank (2007), The World Development Indicator (WDI) CD-ROM.

[38] Wu, Jinglian (2005), "Understanding and Interpreting Chinese Economic Reform," Thomson, Mason, Ohio.

[39] Young, Alwyn (991), "Learning by Doing and the Dynamic Effects of International Trade," *Quarterly Journal of Economics* 106(2), pp. 369-405.

[40] Young, Alwyn (2003), "Gold into Base Metals: Productivity Growth in the People's Republic of China during the Reform Period," *Journal of Political Economy* 111(6), pp. 1220-1261.

[41] Zheng, Jinghai, Hu, Angang, and Arne Bigsten (2008), "Can China's Growth be Sustained? A Productivity Perspective", *World Development,* forthcoming.

Table 1: Basic Chinese Plants Data

Year	1998	1999	2000	2001	2002
Raw Observations	154,882	154,882	162,883	169,031	140,741
Filtered Observations	146,490	149,557	156,400	164,037	137,060
FDI Firms	107,178	107,178	119,556	131,168	100,630
SOE Firms	49,098	49,098	51,363	35,327	27,304

Table 2: Summary Statistics (1998-2002)

Variables	Obs.	Mean	Std. Dev.	Min	Max
Raw Fixed Assets	323,849	44,654.62	645,868.4	-5,659	1.34e+08
Operational Fixed Assets	221,732	44,573.17	695,733.8	-47,238	1.31e+08
Depreciation	221,732	18,663.7	359,921.8	0	7.15e+07
Net Fixed Assets	221,732	33,087.29	392,579.8	-9,059	6.44e+07
Output[a]	323,849	56,212.92	464,044.1	0	7.90e+07
Materials[a]	221,616	48,099.08	340,671.7	0	3.89e+07
Year	323,849	2,000.374	1.149	1,999	2,002
Dummy of Exporting Firm	323,849	.490	.4999	0	1
Log Real Sale	323,849	4.847	1.735	-4.624	13.565
Log Employment	323,849	2.734	2.687	0	12.178
Log Real Materials	323,849	3.245	2.617	-4.963	12.943
WTO Dummy	323,849	.227	.419	0	1
Real Capital	323,849	458.832	6,531.45	-60.524	1,387,515
Dummy of Exit Next Year	323,849	.007	.083	0	1
Log Real Capital	323,849	4.166	1.782	-4.649	14.143
Lag of Real Capital	323,849	4.038	1.778	-4.620	14.009
Real Investment (depre.=15%)[b]	323,849	122.129	2,367.73	-250,643.5	677,841.1
Real Investment (depre.=10%)	323,849	102.329	2,194.49	-272,286	664,302.4
Real Investment (depre.= 5%)	323,849	82.528	2,044.45	-293,928.5	650,763.6
Real Investment (depre.= 4%)	323,849	78.56798	2,017.695	-298,257	648,055.9
Harmonious System 8-Digit	323,849	5.31e+07	2.59e+07	2,032,900	9.62e+07
Import Penetration Ratio	323,849	40.149	714.282	.0002	111,664.1
Log Import Penetration Ratio	323,849	1.576	2.276	-8.415	11.623
Dummy of SOE	323,849	.250	.433	0	1
Dummy of central-control SOE	323,849	.014	.117	0	1
FDI	323,849	.074	.261	0	1
ln(TFP) − Olley-Pakes	323,849	1.841	1.295	-8.517	8.142

Notes: (a) Observations of output, materials, and value-added are dropped from the data set if negative. (b) I obtain different real investment by allowing different depreciation rates (depre.), respectively.

Table 3: Total Factor Productivity of Chinese Plants

Industry (code)	Est. Prob.	Labor OLS	Labor OP	Materials OLS	Materials OP	Capital OLS	Capital OP
Mining & Washing of Coal (6)	.983	.092	.062	.431	.468	.382	.237
Extraction of Petroleum & Natural Gas (7)	.989	.099	.048	.239	.210	.646	.592
Mining & Processing of Ferrous Metal Ores (8)	.984	.125	.087	.466	.442	.299	.184
Mining & Processing of Non-Ferrous Metal (9)	.971	.112	.126	.474	.484	.303	.154
Mining & Processing of Nonmetal Ores (10)	.982	.131	.106	.473	.494	.213	.109
Processing of Food (13)	.972	.170	.147	.508	.521	.304	.202
Manufacture of Foods (14)	.974	.155	.141	.569	535	.359	.283
Manufacture of Beverages (15)	.975	.150	.124	.463	.476	.410	.264
Manufacture of Tobacco (16)	.970	.076	.078	.214	.224	.777	.510
Manufacture of Textile (17)	.983	.137	.120	.341	.345	.296	.228
Manufacture of Apparel, Footwear & Caps (18)	.988	.132	.104	.294	.287	.296	.276
Manufacture of Leather, Fur, & Feather (19)	.982	.139	.107	.371	.385	.265	.212
Processing of Timber, Manufacture of Wood, Bamboo, Rattan, Palm & Straw Products (20)	.983	.148	.109	.457	.453	.238	.141
Manufacture of Furniture (21)	.988	.142	.102	.427	.434	.294	.222
Manufacture of Paper & Paper Products (22)	.981	.114	.086	.366	.378	.346	.226
Printing, Reproduction of Recording Media (23)	.983	.128	.098	.502	.514	.381	.265
Manufacture of Articles For Culture, Education & Sport Activities (24)	.990	.141	.111	.291	.286	.343	.348
Processing of Petroleum, Coking, &Fuel (25)	.979	.109	.084	.343	.295	.469	.350
Manufacture of Raw Chemical Materials (26)	.980	.140	.114	.366	.378	.352	.253
Manufacture of Medicines (27)	.986	.119	.090	.359	.342	.404	.285
Manufacture of Chemical Fibers (28)	.975	.155	.099	.301	.279	.371	.309
Manufacture of Rubber (29)	.980	.135	.115	.315	.336	.367	.267
Manufacture of Plastics (30)	.985	.120	.106	.360	.352	.350	.268
Manufacture of Non-metallic Mineral goods (31)	.981	.111	.095	.389	.395	.334	.207
Smelting & Pressing of Ferrous Metals (32)	.975	.148	.108	.419	.383	.339	.249
Smelting & Pressing of Non-ferrous Metals (33)	.981	.133	.099	.369	.332	.319	.246
Manufacture of Metal Products (34)	.986	.140	.117	.358	.354	.316	.252
Manufacture of General Purpose Machinery (35)	.985	.159	.109	.423	.401	.203	.190
Manufacture of Special Purpose Machinery (36)	.982	.174	.116	.502	.472	.271	.226
Manufacture of Transport Equipment (37)	.985	.133	.102	.414	.415	.377	.309
Electrical Machinery & Equipment (39)	.989	.211	.126	.715	.761	.045	.152
Manufacture of Communication Equipment, Computers & Other Electronic Equipment (40)	.990	.118	.094	.341	.345	.350	.328
Manufacture of Measuring Instruments & Machinery for Cultural Activity & Office Work (41)	.986	.175	.100	.370	.338	.329	.361
Manufacture of Artwork (42)	.987	.202	.111	.708	.466	.185	.208
Recycling & Disposal of Waste (43)	.987	.201	.187	.335	.354	.272	.268
Electric Power & Heat Power (44)	.994	.190	.082	.384	.316	.403	.379
Production & Supply of Gas (45)	.990	.079	.039	.366	.330	.432	.382
Production & Supply of Water (46)	.998	.069	.049	.324	.299	.523	.221
All industries	.978	.150	.097	.439	.406	.307	.214

Notes: I do not report standard errors for each coefficient to save space, which are available upon request.

Table 4: Concordance of Products

Industry (code)	HS 2-Digit Customs Code
Mining & Washing of Coal (6)	27
Extraction of Petroleum & Natural Gas (7)	27
Mining & Processing of Ferrous Metal Ores (8)	26
Mining & Processing of Non-Ferrous Metal (9)	25, 26
Mining & Processing of Nonmetal Ores (10)	25,71
Processing of Food (13)	02,03,04,07,11,15,17,20,23
Manufacture of Foods (14)	04,17,19,21,22,23,25,76
Manufacture of Beverages (15)	09,20,22
Manufacture of Tobacco (16)	24
Manufacture of Textile (17)	50,51,52,53,54,56,60
Manufacture of Leather, Fur, & Feather (19)	41,42,43,64,67
Processing of Timber, Manufacture of Wood, Bamboo, Rattan, Palm & Straw Products (20)	44,45,46
Manufacture of Furniture (21)	94
Manufacture of Paper & Paper Products (22)	48
Printing, Reproduction of Recording Media (23)	49
Manufacture of Articles For Culture, Education & Sport Activities (24)	32,92,95,96
Processing of Petroleum, Coking, Processing of Nuclear Fuel (25)	27
Manufacture of Raw Chemical Materials & Chemical Products (26)	28,29,31,32,33,34,38,39,40,54,55
Manufacture of Medicines (27)	30
Manufacture of Chemical Fibers (28)	47,54,55
Manufacture of Rubber (29)	40,64
Manufacture of Plastics (30)	30,39,64
Manufacture of Non-metallic Mineral Products (31)	13,25,68,69,70
Smelting & Pressing of Ferrous Metals (32)	72
Smelting & Pressing of Non-ferrous Metals (33)	28,74,75,76,78,80,81
Manufacture of Metal Products (34)	72,76,82,83,86
Manufacture of General Purpose Machinery (35)	84
Manufacture of Special Purpose Machinery (36)	84
Manufacture of Transport Equipment (37)	86,87,88,89
Electrical Machinery & Equipment (39)	85,94
Manufacture of Communication Equipment, Computers & Other Electronic Equipment (40)	85
Manufacture of Measuring Instruments & Machinery for Cultural Activity & Office Work (41)	90,91
Manufacture of Artwork (42)	96,97
Recycling & Disposal of Waste (43)	
Electric Power & Heat Power (44)	
Production & Supply of Gas (45)	27
Production & Supply of Water (46)	

Table 5: Benchmark Estimation Results

Dependent variable ($\ln TFP_{ijt}^{OP}$)	(1)	(2)	(3)	(4)	(5)
Import Penetration ($\ln imp_{jt}$)	.019**	.005**	.005**	.005**	.005**
	(9.49)	(3.56)	(3.56)	(3.59)	(3.59)
Exporting Firm (EF_{it})	.838**	.049**	.049**	.049**	.049**
	(276.97)	(13.89)	(13.95)	(13.87)	(13.87)
$\ln imp_{jt} \times EF_{it}$	-.015**	-.007**	-.007**	-.008**	-.008**
	(-13.54)	(-7.85)	(-7.89)	(-7.95)	(-7.95)
Firm Exit in Next Year		-.162**	-.162**	-.162**	-.162**
		(-4.69)	(-4.69)	(-4.70)	(-4.70)
SOE_{it}			-.017*	-.015*	-.015*
			(-1.94)	(-1.68)	(-1.68)
$(\text{SOE}\times\text{Central-Control})_{it}$				-.095**	-.095**
				(-7.16)	(-7.16)
FDI_{it}					.003
					(.32)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
R-square	.695	.852	.852	.852	.852

Following Amiti-Konings (2007), the depreciation rate is taken as 15% to measure investment by using the perpetual inventory method. Dependant variables are logarithm of TFP_OP. Robust t-values corrected for clustering at the firm level in parentheses. *(**) means significant at the 10(5) percent level. They are 301,111 observations for each estimate.

Table 6: Alternative Investment Measures

Dependant variable $\ln(\text{TFP}_{ijt}^{OP})$	(1) D.Rate(15%)	(2) D.Rate(10%)	(3) D.Rate(5%)	(4) D.Rate (4%)
Import Penetration ($\ln imp_{jt}$)	.005**	.006**	.005**	.005**
	(3.59)	(3.58)	(3.58)	(3.45)
Exporting Firm(EF_{it})	.049**	.049**	.049**	.051**
	(13.87)	(13.98)	(13.95)	(15.66)
$\ln imp_{jt} \times EF_{it}$	-.008**	-.007**	-.006**	-.006**
	(-7.95)	(-7.25)	(-7.25)	(-6.61)
Firm Exit in Next Year	-.162**	-.168**	-.168**	-.135**
	(-4.70)	(-4.84)	(-4.84)	(-4.05)
SOE_{it}	-.015*	-.012	-.012	-.012
	(-1.68)	(-1.30)	(-1.30)	(-1.36)
$(\text{SOE}\times\text{Central-Control})_{it}$	-.095**	-.088**	-.089**	-.086**
	(-7.16)	(-6.62)	(-6.62)	(-6.42)
FDI_{it}	.003	-.005	-.004	-.004
	(.32)	(-0.48)	(-0.48)	(-0.48)
Firm Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	301,111	300,842	300,842	302,202
R-square	.852	.851	.851	.857

Notes: Depreciation rate n% means taking a n% depreciation rate to measure investment by using perpetual inventory method (n takes 15, 10, 4, and 5, respectively). Robust t-values corrected for clustering at the firm level in parentheses. *(**) means significant at the 10(5) percent level.

Table 7: Alternative Econometric Specifications

Dependant variable:	1-period Difference		2-period Difference		3-period Difference	
$\ln(\text{TFP}_{ijt}^{OP})$	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \ln imp_{jt}$	.003	-.002	.012**	.008**	.005*	.005*
	(1.61)	(-.93)	(5.51)	(3.67)	(1.92)	(1.92)
ΔEF_{it}	.051**	.133**	.018**	.052**	.007	.017**
	(12.39)	(26.42)	(4.90)	(12.53)	(1.50)	(3.42)
$\Delta(\ln imp_{jt} \times EF_{it})$	.028**	.022**	.013**	.009**	-.009**	-.007*
	(7.42)	(5.87)	(3.86)	(2.51)	(-2.27)	(-1.93)
Firm Exit in Next Year	-.133**	-.134**	-.169**	-.197**	-236**	-.237**
	(-3.86)	(-3.88)	(-2.77)	(-3.23)	(-4.89)	(-4.92)
ΔSOE_{it}	.101**	.126**	.117**	.101**	-.097	-.097
	(3.72)	(4.60)	(4.23)	(3.59)	(-1.41)	(-1.41)
$\Delta(\text{SOE}\times\text{Central-Control})_{it}$	.067**	.077**	.123**	.105**	-.084	-.082
	(4.86)	(5.43)	(5.31)	(4.46)	(-1.20)	(-1.18)
ΔFDI_{it}	.001	.004	.003	.002	-.003	-.005
	(.09)	(.43)	(0.36)	(0.29)	(-.22)	(-.42)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	No	Yes	No	Yes	No
Province×Year Fixed Effects	No	Yes	No	Yes	No	Yes
Observations	152,495	152,495	78,447	78,447	31,200	31,200
R-square	.689	.671	.594	.593	.004	.008

Notes: ΔImp_{it} denotes n-period difference for import penetration (n=1,2,3). Similarly, ΔFX_{it}, $(\Delta(\ln imp_{ijt}\times\text{EF}_{it}), \Delta\text{SOE}_{it}, \Delta(\text{SOE}\times\text{Central-Control})_{it}, \Delta\text{FDI}_{it})$ denotes n-period difference for dummy of exporting firm (interaction term of import penetration and exporting firm's dummy, dummy of stated-own enterprises, whether the SOE is directly controlled by the central government, and foreign direct investment, respectively). Robust t-values corrected for clustering at the firm level in parentheses. *(**) means significant at the 10(5) percent level.

Table 8: Estimates with Controlling for Endogeneity

Dependant variable: $\ln(\text{TFP}^{OP}_{ijt})$	(1)	(2)	(3)	(4)	(5)
$\ln imp_{jt}$	.067**	.072**	.072**	.072**	.072**
	(6.41)	(6.95)	(6.91)	(6.93)	(6.93)
EF_{it}	.048**	.048**	.049**	.049**	.049**
	(9.83)	(10.03)	(10.05)	(10.05)	(10.05)
$\ln imp_{jt} \times EF_{it}$	-.013**	-.014**	-.014**	-.014**	-.014**
	(-7.15)	(-7.61)	(-7.60)	(-7.61)	(-7.61)
Firm Exit in Next Year		-.159**	-.159**	-.159**	-.159**
		(-8.67)	(-8.67)	(-8.68)	(-8.68)
SOE_{it}			-.012*	-.012	-.012
			(-1.64)	(-1.63)	(-1.63)
$(\text{SOE}\times\text{Central-Control})_{it}$				-.005	-.005
				(-.36)	(-.36)
FDI_{it}		.000	-.000		-.000
		(.02)	(-.01)		(-.01)
Firm-Specific Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year-Specific Fixed Effects	Yes	Yes	Yes	Yes	Yes
F-statistics	2104.72‡	2088.07‡	2091.26‡	2094.28‡	2094.17‡
Anderson Likelihood-ratio χ^2 statistic	2078.28‡	2062.09‡	2065.23‡	2068.17‡	2068.09‡
Cragg-Donald χ^2 statistic	2104.83‡	2088.22‡	2091.44‡	2094.46‡	2094.38‡
Anderson-Rubin χ^2 Statistic	41.78‡	49.29‡	48.65‡	48.90‡	48.89‡
Prob.>F or Prob.>χ^2	.000	.000	.000	.000	.000
R^2	.53	.53	.53	.53	.53

Notes: The logarithm of import penetration ratio ($\ln\text{imp}_{jt}$) is taken as an endogenous variable whose instrument is government saving at province j in year t. There are 137,312 in each estimation. Robust t-values corrected for clustering at the firm level in parentheses. *(**) means significance at the 10(5) percent level. ‡ means significance at 1 percent level. The Hansen over-identification test is included but not reported here since the estimation is exactly-identified.

Table 9: Benchmark Estimation Results

Dependent variable ($\ln TFP_{ijt}^{BB}$)	(1)	(2)	(3)	(4)	(5)
Import Penetration ($\ln imp_{jt}$)	-.003**	.004**	.004**	.004**	.004**
	(-2.41)	(3.63)	(3.64)	(3.64)	(3.64)
Exporting Firm (EF_{it})	.613**	.044**	.044**	.044**	.044**
	(304.09)	(20.63)	(20.68)	(20.70)	(20.70)
$\ln imp_{jt} \times EF_{it}$	-.007**	-.003**	-.003**	-.003**	-.004**
	(-10.99)	(-5.28)	(-5.32)	(-5.30)	(-5.30)
Firm Exit in Next Year		-.196**	-.196**	-.196**	-.196**
		(-5.76)	(-5.76)	(-5.76)	(-5.76)
SOE_{it}			-.006	-.007	-.007
			(-1.17)	(-1.24)	(-1.24)
$(\text{SOE}\times\text{Central-Control})_{it}$				.016**	.016**
				(2.03)	(2.03)
FDI_{it}					-.001
					(-.26)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
R-square	.829	.895	.894	.894	.894

Notes: Dependant variable $\ln TFP_{ijt}^{BB}$ is a logarithm of TFP which is calculated by using the Blundell-Bond approach (1998). Robust t-values corrected for clustering at the firm level in parentheses. *(**) means significant at the 10(5) percent level.

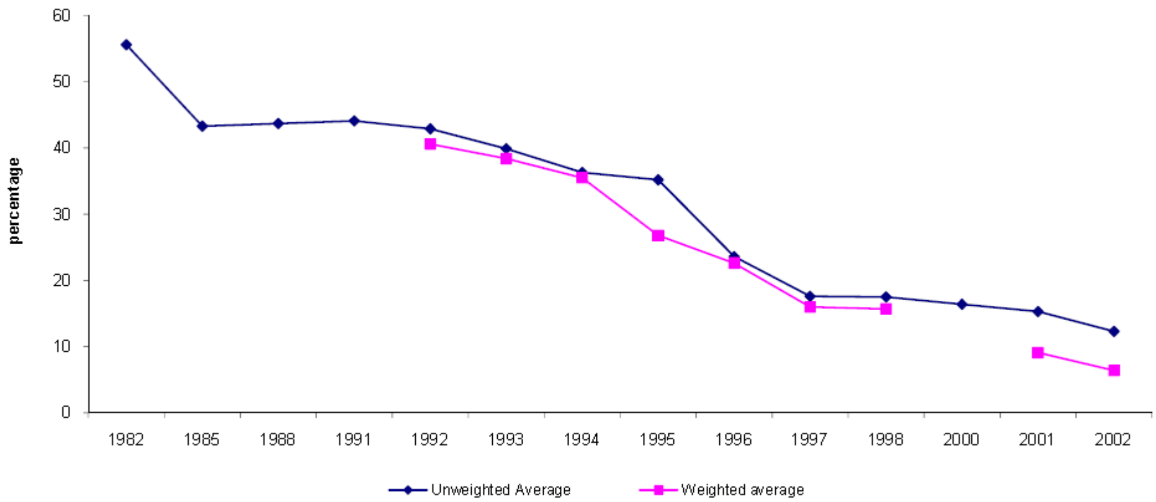

Figure 1: China's Unweighted and Weighted Tariffs

Sources: Data are from Rumbaugh and Blancher (2004).

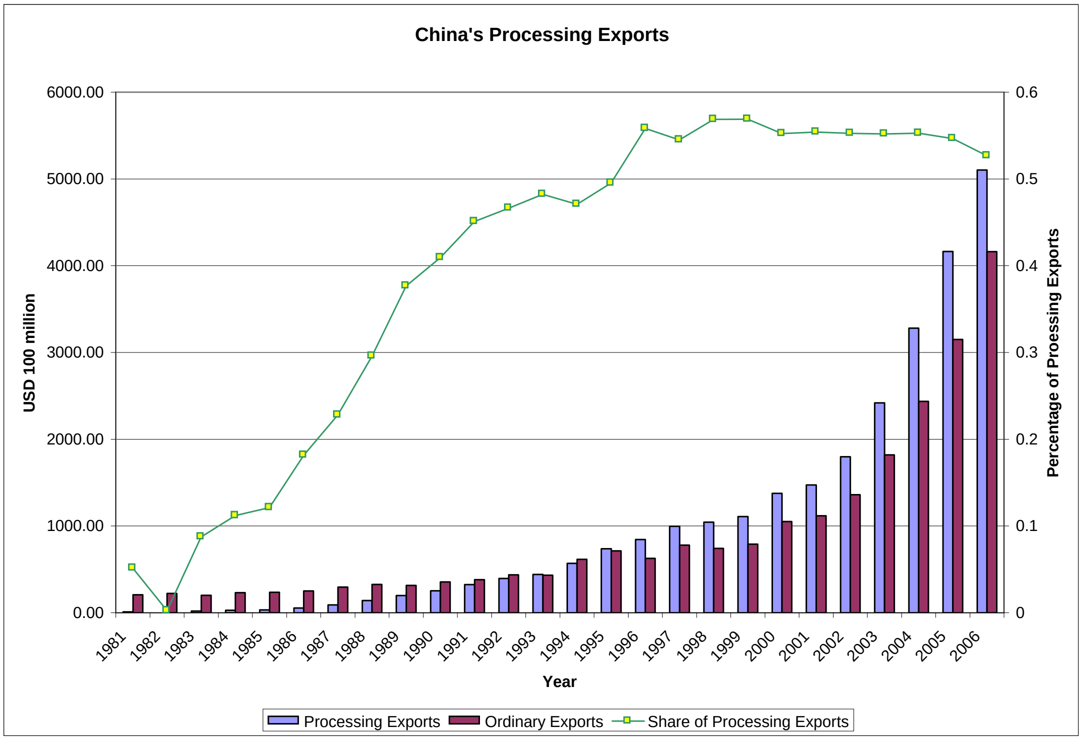

Figure 2: Evolution of China's Processing Trade

Sources: China Statistical Yearbook (2007).

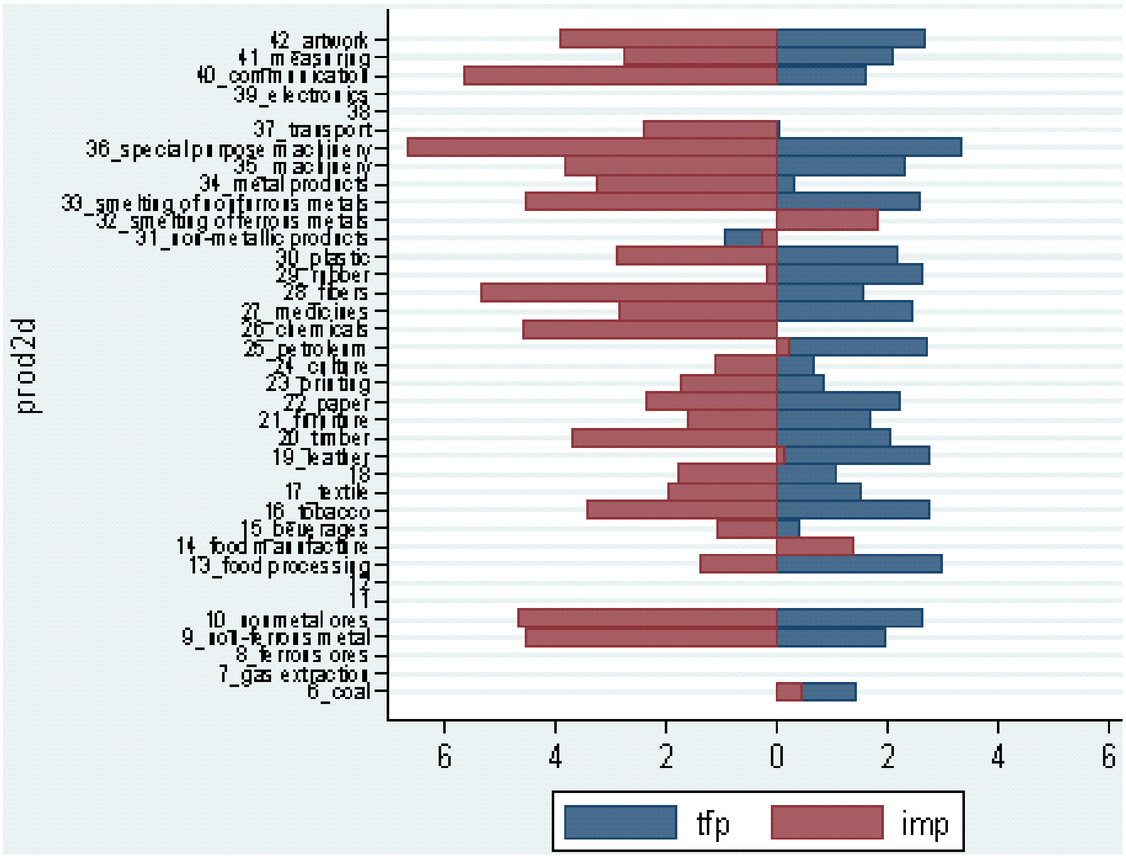

Figure 3: TFP and Import Penetration Ratio by Industry

Notes: This figure plots the average number of log import penetration ratio and TFP by industry over 1998-2002. An industry with blank bar means that import penetration ratio or (and) TFP is (are) unavailable for such an industry in the data set. As seen from the figure above, for some industries such as the manufacture of foods (14) and smelting & pressing of ferrous metals (32), their magnitudes of TFP are much smaller than those of log import impetration ratio.