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Trade Liberalization and Firm Productivity: Evidence from Chinese Manufacturing Industries

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Abstract

This paper examines the impact of tariff reduction following China's World Trade Organization (WTO) entry on the productivity of Chinese manufacturing firms using a firm-level panel database that comprises all of China's manufacturing firms with an annual turnover above 5 million yuan and that spans the period of 2000–2006. An instrumental variable estimator is used to account for the endogeneity of the tariff reduction. The results indicate that China's trade liberalization in the five years following its WTO entry has led to a 0.94% annual increase in total factor productivity for Chinese manufacturing firms. However, the overall productivity gain from the tariff reduction is a net result of a productivity depressing effect of output tariff reduction and a productivity enhancing effect of input tariff reduction. Both effects have diminished in magnitude over the years after China joined the WTO. Firm heterogeneity and turnover plays an important role in generating gains from trade liberalization. The surviving firms have managed to cope with and take advantage of lower tariffs. The extent to which the tariff reduction affects Chinese firms' productivity is also dependent on the ownership structure of the firms with foreign-invested firms being the clear winner.

1. Introduction

China's entry to the World Trade Organization (WTO) in 2001 has been one of the most significant economic events in recent world history. The trade liberalization that it engendered has produced deep and far-reaching implications both within China and around the world. The Chinese economy has prospered in the decade that followed China's WTO entry despite concerns at the time that domestic Chinese firms may not be able to withstand the competition from foreign-produced goods and services, which was expected to intensify as a result of the liberalization measures that China committed to implement. Notwithstanding the obvious intellectual and policy interest, there has been little economic research to empirically substantiate the nexus between China's WTO entry and the performance of Chinese industries.

Reducing import tariffs can raise the level of a country's welfare by making imports—both final goods and intermediate inputs—cheaper and by making the domestic product market more competitive with lower-priced foreign produced goods. Numerous studies have subjected this central tenet of international economics to rigorous empirical investigation (Pavcnik, 2002; Schor, 2004; Trefler, 2004; Amiti and Konings, 2007; Fernandes, 2007; Topalova and Khandelwal, 2011).

The common approach of these authors has been to relate measures of the productivity of domestic firms or industries to reduction in tariffs as a result of trade

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liberalization or a major reform that liberalizes a country's international trade regime. These studies generally affirm the industrial productivity enhancing benefits of trade liberalization, which they attribute to either a more competitive marketplace as a result of the easy entry of foreign competition, the availability of cheaper and greater variety of imported intermediate inputs, or both.

Our approach is similar to that of these earlier authors, but we place greater emphasis on the endogeneity of trade liberalization. Both economic theory and empirics have suggested that changes in a country's international trade regime do not take place in isolation and are subject to the influence of various interest groups that are likely to be affected by the trade liberalization (Mayer, 1984; Trefler, 1993; Goldberg and Pavcnik, 2005; Karacaovali, 2011). In particular, less productive industries and unions that represent comparatively fewer productive workers will lobby against policies that are to subject them to more import competition. The unique institutional setting in China where the government can be closely involved in the business operation of enterprises, particularly state-owned enterprises, lends additional relevance to the endogeneity concern. Therefore, properly addressing the endogeneity of trade liberalization becomes imperative for any effort to assess whether trade liberalization leads to productivity improvement.

It is against this intellectual and institutional backdrop that we situate our investigation. We use a firm-level database that comes from China's industrial census for 2000–2006 to investigate how the sharp tariff reductions in the aftermath of China's WTO entry have affected Chinese manufacturing firms' productivity. Our main strategy to deal with the endogeneity of trade liberalization is instrumental variable estimation. The instrument we adopt for China's import tariff reductions is the Philippines' tariff reductions in the years before and following its entry to WTO from 1993 to 1999, corresponding to Chinese tariffs 6 years later respectively. The different ways and time in which the two episodes of trade liberalization were implemented, the two countries' distinct institutional environment in which the forces of political economy unfold, and the two countries' contrasting relative influence in the global economy as indicated by their size lend validity to the Philippines' tariffs as an instrument for Chinese tariffs.

We measure the performance of Chinese industry by both estimated total factor productivity (TFP) and other performance measures such as labor productivity. We also use a Chinese input–output table to construct input tariffs so that we can estimate and compare the effects of reductions of both output and input tariffs.

We find a positive overall effect of trade liberalization on Chinese firms' productivity: a 1% reduction in tariffs has led to a 0.94% annual increase in TFP for Chinese manufacturing firms. However, this is a result of two opposing effects of the trade liberalization taking place separately through the channels of output and input tariff reductions. Our results indicate a negative impact of the output tariff reductions on Chinese firms' productivity, which is in contrast to what most other studies have found for other countries. A potential explanation is that monopolistic domestic firms may experience a negative productivity shock when they are forced to reduce output as import competition intensifies (Graham, 1923; Markusen, 1981; Ethier, 1982; Grinols, 1991; Rodrik, 1988).

In contrast, through the intermediate inputs channel, lower input tariffs have significantly boosted the productivity of Chinese firms and increased their profit margin. That is, input tariff reductions help to raise the productivity of Chinese manufacturing firms, which may have been caused by access to greater varieties and higher quality of intermediate inputs (Markusen, 1989; Ethier, 1982; Grossman and Helpman, 1991). However, we are unable to substantiate the concrete mechanisms through which input tariff reductions have affected Chinese firms' productivity owing to lack of data to do so. Our results are robust to various alternative measurement considerations.

We also find that firm heterogeneity plays an important role in how the tariff reductions have affected Chinese firms' productivity: firms that have managed to survive have experienced a smaller negative productivity shock from the output tariff reduction; foreign-invested firms have benefited from both output and input tariff reduction. Overall the productivity effect of tariff reduction has diminished after China joined the WTO.

The rest of the paper is structured as follows: we review the related literature in section 2. In the following section, we describe China's efforts in liberalizing its foreign trade regime. In section 4 we lay out the empirical strategy and discuss the various methodological issues. Section 5 describes the data. We then discuss the results in section 6 before we conclude.

2. The Literature

The Theoretical Foundation

Various theories have advanced the case for trade liberalization raising the productivity of firms in countries that have undergone such liberalization. Krugman (1979) shows that trade liberalization—gaining access for domestic firms to foreign markets—can lead to productivity gains for domestic firms as they increase sales, expand production scale and ride down the cost curve, or the scale effect (Feenstra, 2004). There is also a selection effect: some domestic firms will exit, releasing factors of production to be used in the expansion of the surviving domestic firms, but in Krugman's model, firms are symmetric so that selection takes place on a purely random basis.

Melitz (2003) takes the selection effect to a new level by introducing firm heterogeneity. Since firms are endowed with different productive capability, more productive firms will be more likely to take advantage of the access to foreign markets as a result of trade liberalization. The more productive firms will thus expand, drawing resources from unproductive firms by raising factor prices. Rising costs will then force the unproductive firms to exit. This reallocation of market shares then leads to rising industry productivity.[1]

These studies presume that positive turnover—exit of inefficient firms—is frictionless. If there are, for example, institutional barriers to such turnover so that inefficient firms do not exit in the aftermath of trade liberalization but are forced to reduce production scale and operate suboptimally, this can lead to productivity losses if there are economies of scale in these firms' production. Graham (1923) used this argument as a reason for protection. Other authors (Markusen, 1981; Ethier, 1982; Grinols, 1991; Rodrik, 1988) have also analyzed and affirmed this potential negative effect of trade liberalization on domestic firms' productivity.

Thirdly, there are what Tybout and Westbrook (1995) call "residual effects", such as learning-by-doing and technical innovation. The model of Aw et al. (2011) is premised on the notion that the returns to exporting and R&D, two investments the firms in their structural model make, increase in the current productivity levels of the firms. Since the firms are heterogeneous in their productivity, they self-select into these two activities: more productive firms are more likely to export and conduct R&D. At the same time, exporting and R&D raise these firms' future productivity. Thus, when access to export market increases, in addition to the usual productivity gains from larger market size, the productivity of the firms increases further because of the investments in exporting and R&D. They confirm this result using Taiwanese plant level data for the Taiwanese electronics industry.[2]

Finally, trade liberalization may induce restructuring of production within a firm that is exposed to international trade. Trefler (2004) suggests the possibility of plant rationalization in response to tariff cuts—firms reorganize their plants in order to produce fewer product lines. The model of Bernard et al. (2010) generalizes Melitz (2003) to a multiproduct setting. One implication of their model is that trade liberalization prompts affected firms to drop their least successful products. They suggest that reallocation may not just take place between firms but also within firms, between products and export destinations.

The Empirical Evidence

Numerous studies have examined the trade liberalization and productivity nexus under the guidance of the above theories. Head and Ries (1999) examine how the free trade agreement between Canada and USA affected the plant scale of Canadian industries. They find that while the tariff reductions in the USA increased plant scale by 10%, the tariff reductions in Canada reduced plant scale by 8.5%. So the net positive effect is quite small. Trefler (2004) finds that the Canada–USA free trade agreement had reduced plant scale in terms of employment and output and the number of plants was also reduced, but these short-term losses were compensated by a significant long-run labor productivity gain. He attributes the productivity gain to reallocation of market shares towards more efficient firms and increasing technical efficiency.[3] Furthermore, Lileeva and Trefler (2010) show that Canadian plants that were induced to start exporting increased their labor productivity compared with non-exporters. They also find that those new exporters engaged in more product innovation had higher adoption rates for advanced manufacturing technologies. These eventually contributed to the plants' productivity growth.[4]

Our study is closest to Trefler (2004), Amiti and Konings (2007), Fernandes (2007) and Topalova and Khandelwal (2011). All these authors use data on tariff reductions rather than a general event of trade liberalization to examine the impact of trade liberalization on industrial productivity. Trefler (2004) further examines the impact on Canadian industries of both tariff reductions in Canada and the USA associated with the Canada–USA free trade agreement. The results affirm his earlier findings that trade liberalization comes with short-run adjustment costs in the form of displaced workers and contracting plants, which are likely outweighed by lower prices and more efficient plants in the long-run.

Amiti and Konings (2007) use Indonesian plant level data to investigate how import tariff reductions in Indonesia affected the productivity of Indonesian firms. A novel feature of their study is that they are able to separately identify the impact of output and input tariff reductions. The impact of the latter is distinct from that of the former in the mechanism through which the impact takes place. Lower input tariffs make available to domestic industries cheaper and greater varieties of inputs that enhance these industries' productivity. Their results indicate that trade liberalization through both types of tariff reduction raises domestic Indonesian industries' productivity.

Fernandes (2007) and Topalova and Khandelwal (2011) confirm the positive impact of tariff reductions on industrial productivity for Columbia and India respectively. De Loecker (2011) shows that the elimination of nontrade barrier (import quotas) can also generate productivity gains. Controlling for firm-level demand and thus mark-up, his results indicate that elimination of all import quotas could increase Belgian textile firms' physical productivity by 2%.

Our research is related to Yu (2010), who also studies the impact of input and output tariff reduction on Chinese firms' productivity using the same firm-level database and product-level international trade transaction data. While the product-level transaction and tariff information allows him to construct firm-level tariff measures, merging the firm-level and product-level transaction data also forces him to drop the majority of the observations from the firm-level database from his analysis. Our use of industry-level tariffs allows us to retain all but the firm observations that are outliers. Yu finds a positive effect on Chinese firms' productivity of both output and input tariff reductions. He uses the tariff rates prevailing before his sample period as instruments for input and output tariffs.

3. China's WTO Entry and Tariff Reductions

China started negotiations to join the then General Agreement on Trade and Tariffs in 1986. When it became a member of WTO in December 2001, China committed to a broad range of reforms to open up its economy. These reforms included extending the right to engage in international trade to a much broader range of domestic enterprises than just state-owned foreign trade companies and significant tariff reductions. In fact tariff reductions started well before China's entry into WTO. From 1992 to 1999, China reduced the average nominal tariff from 43% to 17%. China's promise in the agreement to join THE WTO to further lower average industrial tariffs to 9.4% by 2005 had already been achieved by 2004 (Naughton, 2007). Compared with other developing countries, China agreed to much more significant tariff reductions in negotiating its accession to WTO.

Table 1 tabulates the average import tariff rates for Chinese manufacturing industries by the two-digit international standard industrial classification (ISIC). Both output and input tariff rates are reported. Our tariff data are obtained from the World Integrated Trade Solution (WITS) database. We use the effective rates of tariff (denoted as AHS (effectively applied tariffs) tariff in WITS) at four-digit level under ISIC Rev. 3. The tariff rates at the two-digit ISIC level reported in Table 1 are averaged from the four-digit rates. Since China's National Bureau of Statistics (NBS) uses its own system of industry classification, we use a concordance between the NBS system of industry classification and the ISIC classification when merging the tariff database with the Chinese firm-level database.

To impute the input tariff rate, we use the following formula: $\tau_i^{in} = \sum_j \theta_{ij} \tau_j^{out}$, where τ_i^{in} is industry i's input tariff rate, θ_{ij} is the share of industry i's input usage that is attributable to industry j, and τ_j^{out} is industry j's tariff rate. In other words, the input tariff rate of an industry is computed as the weighted average of the output tariff rates of its upstream industries. We obtain the weights from the Chinese input–output table for 2002.

In the year after China's accession to WTO, the average output tariff rate dropped from 16.7% to 12.7% and the average input tariff rate fell from 8.1% to 5.9%. The most protected industries in 1999 were food and beverage and vehicles with output tariff rates of 32.5% and 31.3% respectively. In 2005 the two rates fell to 16.4% and 14.6% respectively. Food and beverage and apparel, with an output tariff rate of about 16.5%, were the most protected industries in 2005. For input tariffs, food and beverage, textile, apparel, leather, vehicles and other transport equipment faced the highest

Table 1. Chinese Industry Output and Input Tariffs: 1999–2005

	Output tariffs							*Input tariffs*						
Industry	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
Food and beverage (15)	32.47	34.68	32.48	24.48	22.26	19.95	16.43	12.53	13.88	13.11	9.84	9.24	8.75	7.12
Textile (17)	25.38	23.62	21.87	17.87	15.12	12.52	10.77	12.52	12.23	11.46	9.11	8.02	7.01	6.34
Apparel (18)	26.26	24.66	22	20.13	18.8	17.33	16.53	12.69	12.28	11.48	9.56	8.59	7.66	7.13
Leather (19)	20.67	20.3	18.88	15.95	15.09	13.96	13.73	12.16	11.91	11.19	9.57	8.9	8.24	7.85
Wood (20)	11.96	12.9	12.19	7.32	5.76	4.36	3.98	6.64	7.31	6.82	4.97	4.45	4	3.82
Paper (21)	17.83	18.15	16.76	11.11	9.14	7.34	5.96	8.24	8.43	7.77	5.53	4.8	4.15	3.6
Printing (22)	17.77	17.29	14.35	10.88	8.68	7.71	6.73	7.94	7.97	7.32	5.16	4.39	3.71	3.21
Petroleum (23)	6.45	6.4	6.03	5.53	5.58	5.58	5.59	4.09	4.15	4.04	1.45	1.39	1.22	1.25
Chemicals (24)	13.23	13.21	12.26	9.99	9.18	8.51	7.62	6.89	6.92	6.47	4.86	4.52	4.2	3.91
Rubber and Plastics (25)	17.04	17.43	16.56	13.47	12.87	12.2	12.04	8.14	8.32	7.8	6.2	5.74	5.37	5.21
Non metal (26)	18.47	18.37	18.02	14.43	13.59	12.66	12.4	5.05	5.07	4.8	3.72	3.45	3.2	3.1
Basic metal (27)	8.98	8.96	8.11	6.05	5.69	5.52	5.55	3.94	3.93	3.63	2.81	2.66	2.57	2.55
Fabricated metal (28)	14.66	14.6	13.96	11.46	10.71	10.28	10.26	6.66	6.68	6.26	4.7	4.35	4.13	4.09
Machinery (29)	13.93	13.87	13.45	9.87	9.13	8.64	8.54	7.31	7.3	6.93	4.97	4.54	4.26	4.19
Electrical (31)	15.43	15.49	14.95	10.55	9.61	9.02	8.93	7.61	7.61	7.14	5.23	4.81	4.49	4.41
Communication equipment (32)	15.27	15.36	14.71	7.98	6.43	5.98	5.63	8.45	8.48	7.98	4.27	3.67	3.4	3.29
Precision instrument (33)	13.71	13.69	12.89	9.33	8.85	8.63	8.5	7.53	7.54	7.09	4.41	3.96	3.71	3.61
Vehicles (34)	31.32	32.34	28.98	20.52	17.9	15.93	14.63	13.27	13.25	12.06	9.03	8.1	7.31	6.84
Other transport equipment (35)	20.11	19.85	18.75	15.09	12.74	12.5	11.58	10.31	10.3	9.69	7.06	6.18	5.75	5.39
All (average)	17.94	17.95	16.69	12.74	11.43	10.45	9.76	8.52	8.61	8.05	5.92	5.35	4.9	4.57

Source: Authors' own calculation using the WITS database and China Input–Output Table 2002.

rates in 1999. While the import tariff rates applicable to their inputs had been substantially reduced, these industries still faced the highest tariff barriers when importing production inputs in 2005.

4. Empirical Strategy

Econometric Specification

To identify the effects of input and output tariff reduction on the productivity of Chinese firms, we specify the following equation to estimate:

$$tfp_{ijt} = \alpha + \gamma_1 \tau^{out}_{j,t-1} + \gamma_2 \tau^{in}_{j,t-1} + \beta HHI_{jt} + \varepsilon_{ijt} \quad (1)$$

where tfp_{ijt} is the logarithm of TFP of firm i in a four-digit ISIC industry j at year t. The industry-level output tariff, $\tau^{out}_{j,t}$, and the industry-level input tariff, $\tau^{in}_{j,t-1}$, are entered with a one-year lag to accommodate that it may take time for tariff reductions to affect firms' performance.

We deflate all the monetary variables using deflators that are available and other authors have also used, but the TFP estimates we obtain may still contain the influence of the firms' pricing power. As a way to control for an industry's ability to mark up on its costs, we include HHl_{jt}, the Herfindhal index, as a control variable. The coefficient of HHl_{jt} captures the extent to which industry concentration affects mark-up or how competition drives productivity gain, which will generate opposite signs for the coefficient. Thus, *a priori*, we do not know what the sign of the coefficient should be.

Our primary estimator for the firm-level TFP is the Olley and Pakes (1996) estimator. Since this has become a standard methodology in estimating TFP, we will not elaborate on the estimation algorithm. More details can be found in the Appendix. Besides the Olley–Pakes approach, we have also estimated firm-level productivity using alternative estimators.

We are mainly interested in the estimates of 1 and 2, the impact of output and input tariff on a firm's TFP. It should be noted that they capture the impact on the *average existing* firm. In other words, they represent the net impact of tariffs on firm TFP through all the channels discussed earlier: scale, within and between-firm reallocation, entry and exit, technical innovation, learning by doing and other rationalizations of firm operation including change of product mix. Because of the short time span of our panel data, the effects we identify here are likely to be dominated by short-run forces.[5]

We expect lower input tariffs to have a clear, positive effect on Chinese firms' productivity. The impact of output tariffs is less clear cut. The pro-competition effect is likely to take time to materialize; China's complex institutional environment may impede the selection/reallocation process, whether within firms or between firms, from proceeding smoothly; the benefits from learning by doing and technical innovation also require time to realize. While the productivity and efficiency enhancing effect takes time to come to fruition, the short-run adjustment costs are likely to be immediate. Facing greater competition as a result of trade liberalization, inefficient firms may see their production scale contracting and productivity falling. Institutional barriers to exit prevent resources from being released by the inefficient firms to be absorbed by efficient ones. These negative consequences of trade liberalization will likely dominate our results given the short time span of our firm-level panel data.

Endogeneity of Trade Policy

An obvious challenge for estimating γ_1 and γ_2 is the potential endogeneity of trade liberalization. Facing the prospect of reduced profits, the incumbent firms and their various stakeholders have every incentive to lobby against reducing tariffs on the products they sell. In addition, they also have every incentive to lobby for reducing the tariffs on their intermediate inputs, which helps to increase their profits. We can think of the error term of equation (1) as having the following components:

$$\varepsilon_{ijt} = \delta_j + \mu_t + \lambda_{jt} + \gamma_{ijt}$$

where δ_j and μ_t are time invariant industry specific characteristics and economy-wide shocks respectively, which we can control for using fixed effects. Given our large sample size, we assume that a single firm cannot influence industry-level policy so that firm-specific characteristics, γ_{ijt}, are uncorrelated with the tariff variables, which vary only at the industry level. Thus the endogeneity problem is caused by cov($\tau_{j,t-1}$; λ_{ij}) $\neq 0$. That is, a tariff change in a given year may be correlated with the shock an industry is subject to in the following year when the effect of the tariff change makes itself felt.

Now we can imagine that there is a Philippine equivalent of equation (1), also plagued by the endogeneity of the tariff variables. For ease of notation, we add a superscript to the variables to indicate their nationality: $\text{cov}\left(\tau^m_{j,t-1}; \lambda^m_{jt}\right) \neq 0, m =$ China, Philippines.

Our main identification strategy to deal with the endogeneity of trade liberalization is to use the Philippine tariffs of the same year in relation to the country's entry to WTO as instruments for Chinese tariffs so that our identification is premised on:

$$\text{cov}\left(\tau^{\text{Philippines}}_{j,t-6}; \tau^{\text{China}}_{j,t-1}\right) \neq 0$$

$$\text{cov}\left(\tau^{\text{Philippines}}_{j,t-6}; \lambda^{\text{China}}_{j,t}\right) = 0.$$

The *t*–6 subscript of the Philippine tariff reflects the fact that the Philippines is a founding member of WTO and became a member in 1995 whereas China's membership became official in 2001. Thus we use, for example, the Philippine tariffs of 1995 as instruments for Chinese tariffs in 2001.

In illustrating the progressive liberalization tradition of the General Agreement of Tariffs and Trade (GATT) and WTO and the way member countries' trade liberalization is scheduled over time, Cottier (2006, p. 2) states

> Both in tariffs and services, schedules of countries are structured in a similar manner [according to the Harmonized System (HS) and the United Nations (UN) classifications, respectively] but are highly individualised. . . . The schedules implicitly reflect the status of social and economic development and the levels of domestic regulation achieved in a Member State.

Thus, we expect the Philippines and China to follow similar schedules of tariff reduction since the two countries were at similar level of economic development on the eve of their entry to WTO,[6] and their comparative advantage in international trade resides with labor-intensive industries. We thus expect the identification assumption in equation (3) to hold.

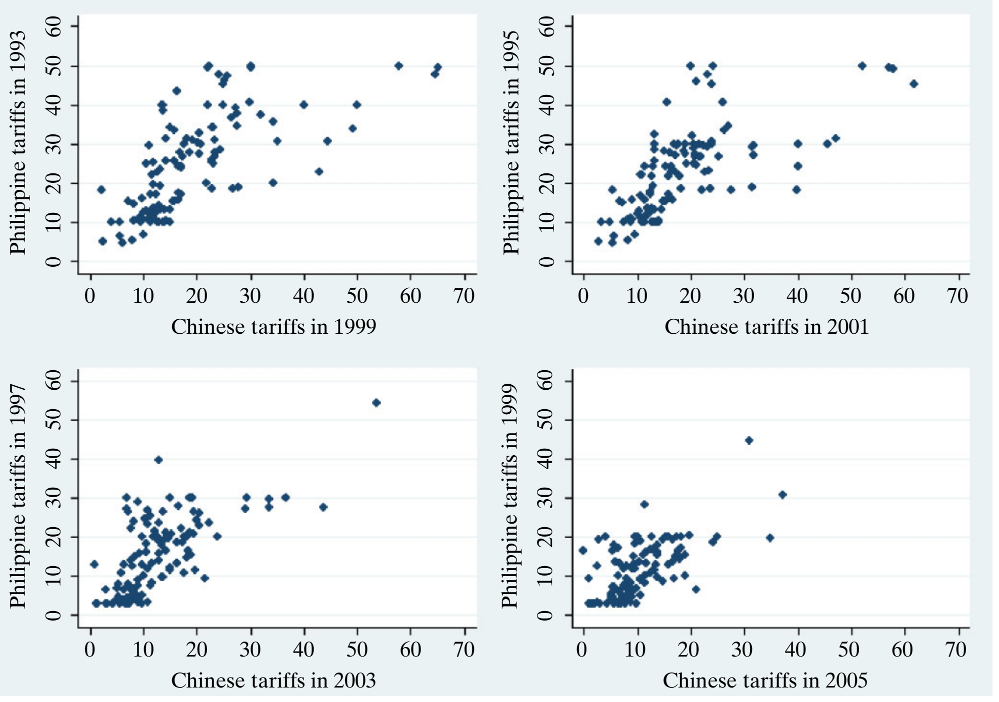

Figure 1. Cross-Industry Comparison of Chinese and Philippine Tariffs

In Figure 1 we plot the Chinese effective tariffs in 1999, 2001, 2003 and 2005 against the corresponding Philippine tariffs six years earlier respectively. There is clearly a positive relationship between the two: industries that were highly protected in the Philippines were likely to be highly protected in China as well.[7] Over time, both countries' tariffs have been significantly reduced and the correlation has also become weaker. Figure 2 tracks the trends of aggregate level of tariffs—average tariffs of 90 four-digit industries—in China (for 1999–2005) and the Philippines (for 1993–1999). It shows that tariff reductions in the two countries followed a similar time path, with China starting with lower level of tariffs, but in the end converging to the same level of overall tariff protection as Philippines.

The two episodes of trade liberalization are also different in important ways. The Philippines joined WTO as a member of GATT[8] after ratifying the Uruguay Round Agreements, whereas China joined as an accession member and had to go through an arduous process of negotiation. More importantly, as part of China's WTO entry commitment, China's tariff is "entirely bound and applied rates are generally at or close to bound rates" (WTO Trade Policy Review: China 2006[9]). The Philippines, in contrast, only committed to bind tariff rates for 2,800 industrial tariff lines at "ceiling rates", which accounted for 50% of its total tariff lines.[10] In other words, half of the tariff lines were not bound and thus could be raised in future round of trade negotiations; for the half that were bound, they were set at levels much higher than the applied rates. With these differences, we would expect the lobbying for protection to be more intense in China as the resulting tariffs would be bound and irreversible compared with those in the Philippines.

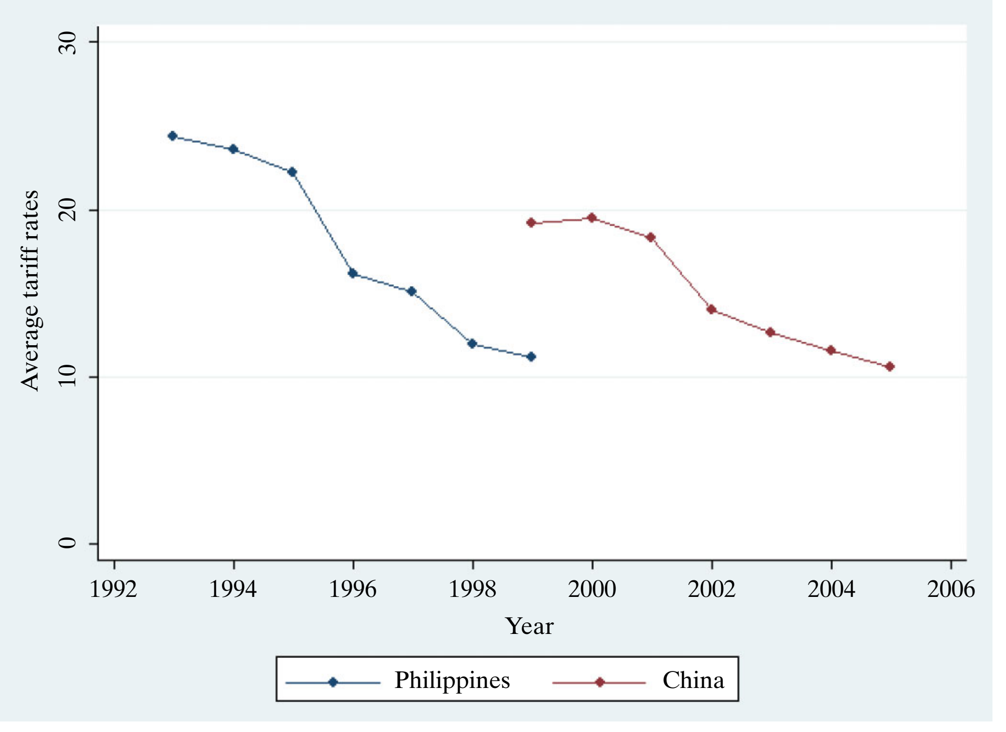

Figure 2. Trends of Chinese and Philippine Tariffs

The institutional environment in which lobbying took place was also different between the two countries. The Philippines was a democracy where interest groups self-organized into constituencies to influence the policy making process. On the eve of China's WTO entry, China had completed a *de facto* privatization of most small and medium size state-owned enterprises (SOEs), and what SOEs remained were mainly large ones controlled by the central and local governments. These large SOEs wielded strong influence in the process of policy making, including that of trade policy. Moreover, the government-enterprise link is not limited to SOEs. Through a large scale nation-wide survey, Gan et al. (2008) finds that the government retains substantial control in about half of privatized Chinese SOEs.

The fact that the two trade liberalization events are five years apart also weakens the correlation between the extent of tariff reduction in the Philippines and the shock a Chinese industry experiences. Finally, China was a much bigger country than the Philippines when it joined WTO. Therefore, the tariff reductions China decided to make would have global implications. For example, the impact on the countries' terms of trade of their trade liberalization would be different, and China was particularly unusual, for a country of its size, in the extent to which it was integrated into the world economy. One would expect such differences to have been factored into the political economy of tariff policy making in China.

In sum, the two incidents of trade liberalization are sufficiently different in their institutional setting and economic implications so that we believe the factors that gave rise to lobbying in the Philippines were not the same as those that influenced the political economy encompassing China's accession to the WTO.

5. The Data

Our main firm-level data source is China's industrial census database compiled by the National Bureau of Statistics (NBS) of China. It contains annual balance sheet and income statement data for all Chinese industrial firms with an annual turnover of at least five million yuan. The data set we use for the current study spans the period of 2000–2006 and only includes manufacturing firms. The original dataset consists of 361 four-digit manufacturing industries under Chinese Industrial Classification (CIC). Since the CIC classification was revised by the NBS in 2002, we employ the concordance developed by Brandt et al. (2012) to make industry assignment consistent before and after 2002. Furthermore, to make it compatible with our tariff data, which is available by the ISIC, we use a concordance between CIC and ISIC Rev. 3, which NBS developed, to assign each firm an ISIC four-digit code.

To deflate monetary variables, we use several price deflators. Capital is deflated by country-level fixed capital investment price deflator and intermediate inputs are adjusted by price indices of raw material and power. Both of these are publicly available at the website of the NBS. Total output of each firm is deflated by two-digit industry-level deflators constructed by Brandt et al. (2012).[11]

We rid the sample of observations containing incomplete and inaccurate information (e.g. negative values for capital or labor). While the database is supposed to cover firms with an annual turnover over five million yuan, there is a sizable number of firms in the database that report turnover well below that threshold. We drop firms that report annual turnover below two million yuan. In addition, to mitigate the impact of extreme values on the regression results, we drop 0.1% of the extreme values at both ends of the distributions of output, capital stock, materials and labor. We do this for the large and medium and small size firm groups separately. A small number of firms in the database have switched their industry affiliation at the two-digit ISIC level. We drop these firms from our analysis as well. The final data set is an unbalanced panel with about 600,000 observations for seven years.

Summary statistics of the variables used in our regressions are presented in Table 2.

6. The Results

Trade Liberalization and Firm's TFP: Baseline Results

We report the baseline results in Table 3. In column (1), we regress the logarithm of TFP on the two tariffs variables using a firm fixed effects estimator. The coefficients of output and input tariffs are –0.0135 and –1.59 respectively and only the latter is statistically significant. The input tariff coefficient estimate implies that firm productivity will increase by 1.59% with a 1% reduction in input tariffs. The standard errors are clustered by firm.[12] The specification and the results of column (1) are similar to those of other recent papers (Amiti and Konings, 2007; Fernandes, 2007; Topalova and Khandelwal, 2011) except that the output tariff coefficient in our case is not precisely estimated.

The instrumental variable (IV) estimates are reported in column (2) of Table 3. The sign of the output tariffs coefficient has now been reversed and the coefficient is now precisely estimated. The estimate suggests that a 1% reduction in output tariffs will lead to a nearly 0.316% decline in Chinese firms' productivity. In contrast, the estimate of the coefficient of input tariffs remains negative and becomes larger. The implied marginal effect of input tariff reduction is quite large: reducing input tariffs by

Table 2. Descriptive Statistics

Variable	*Mean*	*Std Dev.*	*N*
log(output)	10.494	1.226	586,641
log(labor)	5.231	1.026	586,641
log(capital)	9.193	1.236	586,641
log(intermediate)	10.055	1.248	586,641
Profits/sales ratio	0.024	0.107	586,641
log(TFP) (OP)	0.703	0.254	586,641
log(TFP) (OLS)	0.723	0.251	606,708
log(TFP) (OP w/o SOE)	0.716	0.273	579,318
log(output per worker)	5.245	0.994	613,310
Output tariff (AHS)	0.134	0.082	586,641
Input tariff (AHS, I/O Table 2002)	0.063	0.029	586,641
Input tariff (AHS, I/O Table 2007)	0.075	0.035	591,128
Output tariff (MFN)	0.137	0.084	591,128
Intput tariff (MFN, I/O Table 2002)	0.063	0.029	591,128

Note: The unit for all value variables is thousand yuan. AHS = effectively applied tariffs; I/O = input and output; MFN, most-favored nation; OLS = ordinary least squares; OP = Olley-Pakes; SOE = state-owned enterprise; TFP = total factor productivity.

1% can lead to a 1.713% increase in TFP. Both coefficients are estimated with high degree of precision.

The differences between the ordinary least squares (OLS) fixed effects estimates in column (1) and the IV estimates are what the endogeneity of tariff reductions would have predicted. Firms that have experienced (unobserved) negative productivity shocks are likely to lobby for greater protection or smaller output tariff reductions on one hand, and greater input tariff reductions on the other. These productivity shocks, left unaccounted for, create downward bias to the output tariffs coefficient and upward bias to the input tariffs coefficient.

The first-stage results of the IV estimation, which affirm that the Philippine tariffs are highly correlated with the Chinese tariffs, are included in the Appendix. The instruments pass the Stock–Yogo test with F statistics much higher than the critical values suggested by Stock and Yogo (2002). The Hausman test of endogeneity also confirms that we cannot reject the null of the Chinese tariffs being endogenous.

While there is no shortage of theoretical conjecture on it, to the best of our knowledge, ours is the first to find and report evidence for a productivity depressing effect of reduction of output tariffs. When imported final goods become cheaper, domestic firms' sales can be curtailed, pushing them to move back up their average cost curves. Our results suggest that this negative effect may dominate the "pro-competitive" effect of greater competition, at least in the short-run. In contrast, the large productivity boosting effect of lower input tariffs indicates that Chinese firms do benefit from cheaper foreign produced intermediate goods.

From 2001 to 2005, China's average output tariffs were reduced from 16.69% to 9.76% and the average input tariffs fell from 8.05% to 4.57%. Combining these tariff reductions and our IV estimates of the marginal effects on Chinese firms' productivity, we obtain a net negative coefficient of −3.78, indicating an annual productivity increase of 0.94% as a result of trade liberalization following China's entry into the WTO.

Table 3. Baseline Results and Robustness Checks

	(1) OLS	(2) IV	(3) Fixed-effects	(4) One-step	(5) OP w/o SOE	(6) Labor Productivity	(7) I/O table 2007	(8) MFN tariff
Output tariff	–0.0126	0.357***	0.293***	0.421***	0.334***	0.390***	0.362***	0.452***
	[0.0146]	[0.0420]	[0.0417]	[0.0496]	[0.0477]	[0.0493]	[0.0467]	[0.0573]
Input tariff	–1.556***	–1.673***	–1.414***	–1.468***	–1.772***	–1.408***	–1.625***	–2.386***
	[0.0574]	[0.115]	[0.114]	[0.139]	[0.128]	[0.138]	[0.108]	[0.166]
HHI	0.079	–0.028	0.0157	–0.0506	0.0659	0.211***	0.0430	0.0187
	[0.0471]	[0.0513]	[0.0513]	[0.0602]	[0.0544]	[0.0547]	[0.0543]	[0.0553]
Observations	573,663	573,663	606,721	613,211	579,318	613,310	591,128	591,128

Notes: The dependent variable is log(TFP) except for column (6), for which the dependent variable is log(output per worker). All regressions include firm and year fixed effects. The weak identification F statistics are significantly higher than the critical values of Stock and Yogo. Robust standard errors clustered by firm in brackets. If standard errors were clustered at industry–year level, all the coefficients from column (2) to (8) remain significant with $p < 0.05$, except output tariff from column (2) to (4) were significant with $p < 0.1$. HHI = Herfindhal index; I/O = input and output; IV = instrumental variable; MFN, most-favored nation; OLS = ordinary least squares; OP = Olley-Pakes; SOE = state-owned enterprise; TFP = total factor productivity.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Finally, we have included the Herfindhal index (HHI) as a control for market share concentration in an industry. In the various cases of IV estimation, it is only statistically significant when we use labor productivity as the productivity measure. Its positive sign suggests that more concentrated industries have higher labor productivity or greater mark-up.

Robustness Check

For a robustness check, we use alternative ways to obtain the firm-level TFP measure, alternative productivity and tariff measures. These results are reported in the rest of the columns of Table 3.

Alternative TFP measures For column (3), the dependent variable, firm-level TFP, is estimated as the residual from estimating the production function using a fixed effects estimator instead of using the Olley–Pakes approach. The results obtained using this alternative TFP measure are similar to those in column (2).

A critique of the two-step approach—first estimating TFP and then regressing TFP on tariffs—that we have been using so far has to do with the underlying assumption that tariffs are uncorrelated with input usage when estimating the production function in the first step.[13] So we adopt a one-step approach by including the tariff variables in the production function estimation so that we estimate both the production function parameters and the coefficients of the tariff variables at once. The results are reported in column (4). Again they do not deviate from the baseline results.

The Olley–Pakes approach is premised on firms maximizing their profits, which motivates the increasing, one-to-one mapping between productivity shocks and firm investment so that the productivity shocks can be represented by a function of investment and other state variables. This assumption may not accurately characterize the investment decision of Chinese state-owned enterprises, whose management can be heavily influenced by government officials for political purposes. To address this concern, we exclude state-owned enterprises from the Olley–Pakes estimation and use the resulted production function parameters to derive firm-level TFP estimates. The results are reported in column (5) and they are in line with those of the baseline case.

Some authors of this literature have used labor productivity as the productivity measure. To compare our results with theirs, we use labor productivity, defined as total output divided by number of workers, as the productivity measure and dependent variable while controlling for capital per worker and material use per worker. The fixed effects estimates of this specification are reported in column (6) of Table 3. They are similar to those in the previous columns.

Alternative tariff measures We have used the Chinese input–output table for 2002 to construct the input tariffs. Since our firm-level data span the period from 2001 to 2006, and the input–output relations may have changed Chinese industries since 2002, we use the Chinese input–output table for 2007 to construct the input tariffs as a robustness check.[14] The results, reported in column (7) of Table 3, are again similar to those of the baseline case.

Finally, we use most-favored-nation (MFN) tariffs instead of effective tariffs to measure tariff reductions.[15] In reality, MFN tariffs are normally higher than their corresponding effective tariffs, but the results we report in the last column of Table 3, obtained using the MFN tariffs, show that the different tariff measures do not generate results that substantially deviate from the baseline case.

Table 4. The First and Long-difference Models: IV Estimation

	(1) One-year diff.	(2) Six-year diff.	(3) One-year diff	(4) Six-year diff.
	Full sample		Balanced sample	
$D(-1)$ Output tariff	0.385***		0.180*	
	[0.0681]		[0.108]	
$D(-1)$ Input tariff	−2.780***		−1.857***	
	[0.312]		[0.437]	
$D(-1)$ HHI	−0.150***		−0.0166	
	[0.0553]		[0.0920]	
$D(-6)$ Output tariff		0.336***		0.355***
		[0.0803]		[0.0846]
$D(-6)$ Input tariff		−1.508***		−1.566***
		[0.220]		[0.231]
$D(-6)$ HHI		0.729***		0.761***
		[0.184]		[0.204]
Observations	415,582	23,788	118,626	197,71

Notes: The dependent variables are one-year change in log(TFP) for columns (1) and (3) and six-year change in log(TFP) for columns (2) and (4). All regressions include firm and year fixed effects. The weak identification F statistics are significantly higher than the critical values of Stock and Yogo. Robust standard errors clustered by firm in brackets. HHI = Herfindhal index; TFP = total factor productivity.
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

TFP growth: short and long-differences We estimate equation (1) using difference estimators rather than the fixed effects estimators as another robustness check. We first estimate the one-year difference version of equation (1) using both all the firms in the sample and a subsample that only contains firms that appear in all seven years, from 2000 to 2006, i.e. the balanced sample. The difference between the full and the balanced sample is that firms that exit and those that enter during the sample period are only included in the full sample. In other words, the full sample estimates will reflect the effects of tariffs on the firms averaged over these three types of firms, whereas the balanced sample is populated by firms that have managed to remain in operation over the seven-year period. To the extent that trade liberalization may be responsible for firm turnover, we should expect the results obtained using the two samples to be different. These results are reported in columns (1) and (3) in Table 4.

The full sample estimates are similar to what we obtained using the fixed effects estimator and reported in Table 3 except that the productivity enhancing effect of input tariff reduction is now larger in magnitude. With the balanced sample, the impact of input tariff reduction is similar to that of the baseline case, but the productivity depressing effect of output tariff reduction has become much weaker. This is consistent with our conjecture that the tariff reductions may have contributed to firm turnover—the most negatively affected firms may have exited.

One potential concern for the first difference estimator and the fixed effects estimator is the issue of autocorrelation of the error term. For example, if the error term of equation (1) follows an AR(1) process, then the error term of the first-difference specification is necessarily autocorrelated. We address this issue by estimating a long difference version of equation (1). Our effective sample spans seven years, 2000–2006, thus the longest difference we can take is a six-year one. The long difference results are reported in columns (2) and (4) corresponding to the full and balanced samples respectively.

The two sets of results are quite similar to each other. This is not surprising, as the full sample, after the six-year differencing is undertaken, is mostly populated by firms that survived through the sample period, but more importantly, the results are very close to those of the baseline case.

WTO Membership, Firm Heterogeneity and Tariff Reduction

WTO membership Reducing tariffs is only part of China's commitment to liberalizing its trade and investment regime as a member of the WTO. Apart from the tariff reductions, China agreed to phase in numerous other measures to liberalize its economy so as to align its economic institutions with international norms. These measures were meant to deepen China's integration with the global economy by further removing barriers to international trade and investment. Therefore we expect these liberalization measures to interact with tariff reduction in affecting Chinese firms' productivity. To investigate how the impact of tariff reduction on firm productivity may have changed after China's WTO entry, we allow the impact to vary before and after 2001, the year in which China officially became a member of the WTO. The results are reported in Table 5.

For the full sample, the productivity depressing impact of output tariff reduction diminishes after China becomes a WTO member. For the pre-WTO period, i.e. 2000 and 2001, we obtain an estimate of the coefficient of output tariff of 0.305, similar to what we have found so far, but in the post WTO period, this point estimate has been reduced by 0.078. The productivity boosting effect of input tariff reduction remains robust and has not changed after China's WTO accession. Now turning to

Table 5. Tariff Reduction and WTO Membership: Fixed Effects IV Estimation

	(1) All	(2) Balanced
Output tariff × WTO	–0.0778***	–0.149***
	[0.0194]	[0.0307]
Output tariff	0.305***	0.175***
	[0.0430]	[0.0633]
Input tariff × WTO	–0.0200	0.308***
	[0.0482]	[0.0773]
Input tariff	–1.801***	–1.075***
	[0.118]	[0.169]
HHI	0.0325	0.194**
	[0.0523]	[0.0908]
Observations	586,641	138,397

Notes: The dependent variable is log(TFP) for both columns. All regressions include firm and year fixed effects. Robust standard errors clustered by firm in brackets. TFP = total factor productivity; WTO = World Trade Oraganization.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

the results based on the balanced sample, we can see that (1) the productivity reducing effect of output tariff in the pre-WTO period is much smaller than that of the full sample regression; (2) the effect essentially disappears in the post-WTO period. In contrast, the firms in the balanced sample also experience a smaller boost from input tariff reduction than those in the full sample do, and the effect also diminishes over time.

For both sets of results, the productivity depressing impact of output tariff is significantly reduced after China joins the WTO than before. It is possible that other liberalizing measures help to unleash the benefits of tariff reduction. For example, removing entry and exit barriers may have allowed for reallocation of resources from the less efficient firms that have ill-adapted to the new, more competitive environment to those that have thrived in such an environment.

The sharp contrast between the full and balanced sample results ties the effect of trade liberalization to firm turnover, which in turn may be driven by firm heterogeneity. The negative impact of tariff reduction, for example in the form of reduced production scale, has less impact on the firms that have managed to survive through the years and thus adapt themselves to the new and more liberalized business environment.

Ownership differences China's unique institutional setting makes ownership structure an important factor that influences how Chinese firms react and adapt to the productivity shocks brought about by the trade liberalization. We explore the implications of this dimension of Chinese firm heterogeneity by estimating the productivity–tariff reduction nexus for four major ownership groups individually. These are state-owned or controlled, privately owned domestic firms, other domestic Chinese firms and foreign and overseas-invested Chinese firms. For each ownership category, we compare the results from using both the full sample and the balanced sample. The results are reported in Table 6.

There is significant variation in the extent to which the tariff reductions have affected the productivity of the firms of different ownership structure. First of all, the productivity reducing effect of the output tariff reduction is largely limited to domestic Chinese firms. For the foreign and overseas Chinese-invested firms, the tariff reductions have had no impact, according to the results based on the full sample, and a positive effect, based on the balanced sample, on their productivity. Moreover, there is no change in both the effects of the input and output tariff reductions before and after China's WTO entry.[16]

Among domestic Chinese firms, the productivity effect of the tariff reductions also varies by firm ownership. While all of them experience negative productivity shocks engendered by the tariff reductions, both the state-owned or controlled and the other domestic firms, most of which are collectively owned or publicly listed, have seen the negative productivity shocks fade away in the post-WTO period, but for privately owned Chinese firms, the negative shocks remain undiminished after 2001. In the case of the other domestic-owned firms that have survived for the entire period, the negative impact of output tariff reduction all but disappears.

One potential explanation is that while the state-owned and the other domestic firms have been restructured with the help of the state in many areas including preferential access to the capital market, the private Chinese firms still face various kinds of discrimination, which may have hampered their abilities to adapt to the new challenges and opportunities posed by the new and more liberalized foreign trade regime.

Table 6. Tariffs Reduction, WTO and Firm Ownership: Fixed Effects IV Estimation

	(1) All	(2) Balanced	(3) All	(4) Balanced	(5) All	(6) Balanced	(7) All	(8) Balanced
	State-owned		Other domestic		Private		Foreign & HMT	
Output tariff × WTO	–0.195***	–0.363***	–0.127***	–0.147***	0.0900**	0.0754	–0.0687	–0.100
	[0.0507]	[0.0773]	[0.0299]	[0.0447]	[0.0421]	[0.0788]	[0.0479]	[0.0659]
Output tariff	0.474***	0.489***	0.288***	0.230**	0.637***	0.420***	–0.150	–0.439**
	[0.120]	[0.129]	[0.0687]	[0.0974]	[0.0900]	[0.162]	[0.137]	[0.189]
Input tariff × WTO	0.312**	0.910***	0.0435	0.336***	–0.482***	–0.179	–0.00962	–0.0876
	[0.148]	[0.225]	[0.0774]	[0.121]	[0.0925]	[0.164]	[0.119]	[0.162]
Input tariff	–1.311***	–1.274**	–1.821***	–0.931***	–3.089***	–1.847***	–1.181***	–1.340***
	[0.494]	[0.581]	[0.218]	[0.299]	[0.235]	[0.392]	[0.256]	[0.334]
HHI	0.167	0.00233	0.134	0.407***	–0.0405	0.601**	–0.239*	–0.233
	[0.193]	[0.313]	[0.0823]	[0.155]	[0.0739]	[0.258]	[0.139]	[0.198]
Observations	47,505	17,477	185,773	51,225	190,132	22,735	141,837	44,490

Notes: The dependent variable is log(TFP). All regressions include firm and year fixed effects. The balanced sample only includes firms that appear in all seven years, from 2000 to 2006. Robust standard errors clustered by firm in brackets. HHI = Herfindahl index; HMT = Hong Kong, Macau and Taiwan; TFP = total factor productivity; WTO = World Trade Organization.
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

7. Conclusion

China's accession to WTO has been a watershed event in the world economy. Despite its far reaching ramifications, there has been little empirical evidence on how the trade liberalization that China has committed to has affected the performance of Chinese industrial firms. Understanding this issue is essential to the case for free trade both from policy and academic perspectives.

A challenge facing such investigations is the need to account for the endogeneity of trade liberalization. Trade policy is not made in vacuum, but instead reflects the complex interaction between various stakeholders and the government. There is no reason to believe that China is an exception in this regard. Chinese firms, through their influence over local and central governments, have incentives to turn the making of trade policy in their favor. That export has been an important driver of China's economic growth and employment creation over the decade after 2001 only accentuates the relevance of this concern for the potential distorting effect of the endogeneity on the econometric evidence obtained without properly accounting for it. We deal with this issue with an instrumental variable approach.

A novel feature of our study is the use of a new instrument for trade liberalization. We use the tariffs of the Philippines in the years before and after its entry to WTO in 1995 as an instrument for China's import tariffs in the years before and after China's entry to WTO in 2001. The two countries had a similar level of economic development at the time of their entry to WTO and thus were subject to a similar process of progressive liberalization of their tariff structures. The two episodes of trade liberalization are also different in important ways: the liberalization commitments of the two countries were different; the institutional environment in which the political economy of trade policy making unfolds was different between the two countries, and the influence of the two countries' integration into the world economy on the rest of the world was also distinct. These considerations have led us to have confidence in the validity of the instrument.

Using a firm-level panel database that comprises all of China's manufacturing firms with an annual turnover above five million yuan and spans the period of 2000–2006, we have obtained results that represent clear departures from those in the literature. Overall, our results indicate that trade liberalization has led to a 0.94% annual increase in TFP for Chinese manufacturing firms. However, this is a result of two opposing effects of the trade liberalization working differently through two different channels: a productivity depressing effect of output tariff reduction more than offset by a productivity boosting effect of input tariff reduction. The results are robust to alternative productivity and tariff measures and alternative econometric specifications.

We have also found how the tariff reductions have not affected all Chinese firms' productivity equally: firms that have managed to survive have experienced a smaller negative productivity shock from the output tariff reduction; foreign-invested firms have benefited from both output and input tariff reduction. Overall the productivity effect of tariff reduction has diminished after China joined the WTO.

While we have found some robust evidence to show that the overall impact of China's trade liberalization in the first decade following China's WTO entry has been a positive one, our results also show that the trade liberalization–productivity nexus is quite complex. In particular, the dislocation that the trade liberalization engenders through greater competition and how the Chinese firms respond and adapt to such shocks certainly warrant more research.

Appendix

Production Function Estimation

To measure firm-level TFP, we follow the methodology of Olley and Pakes (1996) which uses firm's investment as a proxy variable for unobservable productivity shocks and hence corrects for simultaneity in the estimation of production function parameters. Consider a Cobb–Douglas production function, by taking the natural logarithm we have the estimation equation as:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + e_{it} \quad \text{(A1)}$$

where the subscripts denote logarithm of the corresponding variables. As well addressed in the literature, there is simultaneity problem for the estimation of equation (1). Specifically, the error term e_{it} consists of two components: a white noise η_{it} and a time-varying productivity shock ω_{it}. The latter, which is unobservable by econometricians, is often positively correlated to input choices such as labor and material since more productive firms are likely to hire more workers and use more materials. OLS estimation, in this case, would lead to upward biased coefficients of labor and material. The idea of Olley–Pakes methodology is that, one can use firms' investment as a proxy variable for the productivity shock. A key assumption is that firm's investment must be a monotonically increasing with respect to its capital and productivity. Moreover, a firm's productivity is assumed to follow a Markov process. Under mild conditions, firm's investment can be written as a monotonically increasing function of capital and productivity. By taking inversion, the unobservable productivity can be written as $\omega_{it} = \omega_t(I_{it}, k_{it})$. The estimation of Olley–Pakes methodology consists of two steps. In the first step, the coefficients of labor and intermediate inputs can be identified using semiparametric estimation. In the second stage, the coefficient of capital is recovered. The estimates of production parameters using OLS estimation and Olley–Pakes methodology are presented in Table A1.

First Stage Regression Results

As a baseline model, we estimate equation (1) using our proposed instrumental variables and compare the results with those obtained from previous studies in the literature. Table A2 presents the first stage regression results. The dependent variables for columns (1) and (2) are Chinese output tariffs and input tariffs respectively. The two Philippine tariff variables are statistically significant in both first stage regressions.

Foreign Direct Investment (FDI)

As an additional robustness check, we included industry FDI in our baseline regressions. The industry FDI variable was constructed as the share of foreign-invested firms in total industry sales at the 4-digit level, the same level of aggregation at which we constructed the tariff measures. The results obtained by including industry FDI in the regressions are reported in Table A3 here. The coefficients of our main interest, those on the two tariff variables, have barely changed after industry FDI was included in the regressions. However, industry FDI did show up significant in a number of cases.

Table A1. Olley–Pakes Estimates of Production Function Parameters

Industry	*Labor*	*Capital*	*Materials*	*Observations*
Food and beverage (15)	0.044	0.021	0.939	62,614
Textile (17)	0.051	0.007	0.927	56,301
Apparel (18)	0.090	0.035	0.876	23,679
Leather (19)	0.067	0.021	0.913	12,682
Wood (20)	0.052	0.017	0.935	9,410
Paper (21)	0.045	0.017	0.940	20,090
Printing (22)	0.058	0.051	0.890	11,943
Petroleum (23)	0.022	0.016	0.944	5,119
Chemicals (24)	0.033	0.031	0.931	62,875
Rubber and Plastics (25)	0.042	0.024	0.930	28,473
Non metal (26)	0.042	0.014	0.939	61,362
Basic metal (27)	0.062	0.021	0.920	26,915
Fabricated metal (28)	0.040	0.043	0.922	28,237
Machinery (29)	0.029	0.030	0.929	54,478
Electrical (31)	0.029	0.031	0.948	24,763
Communication equipment (32)	0.063	0.032	0.907	17,379
Precision instrument (33)	0.036	0.016	0.932	7,159
Vehicles (34)	0.033	0.038	0.933	14,283
Other transport equipment (35)	0.045	0.025	0.924	9,119

Notes: All coefficient estimates are statistically significant at the 1% level, with the standard errors clustered by firm. Three industries, Tobacco (16), Computing Machinery (30) and Furniture (36), are dropped from the table as their production function estimates are either statistically insignificant or unreasonable. They account for 1,281, 718 and 16,109 observations respectively.

Table A2. First Stage Results of IV Estimation

	(1) *Chinese output tariffs*	*(2)* *Chinese input tariffs*
Philippine output tariffs	0.245*	–0.018
	[0.126]	[0.016]
Philippine input tariffs	0.415	0.428***
	[0.279]	[0.046]
Observations	728	728
R^2	0.43	0.72

Notes: Robust standard errors clustered by industry in brackets. IV = instrumental variable.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table A3. Baseline results and robustness checks with FDI

	(1) *OLS*	(2) *IV*	(3) *Fixed-effects*	(4) *One-step*	(5) *OP w/o SOE*	(6) *Labor productivity*	(7) *I/O table 2007*	(8) *MFN tariff*
Output tariff	−0.0125	0.361***	0.273***	0.402***	0.308***	0.383***	0.335***	0.418***
	[0.0146]	[0.0420]	[0.0408]	[0.0485]	[0.0463]	[0.0485]	[0.0454]	[0.0555]
Input tariff	−1.561***	−1.676***	−1.396***	−1.450***	−1.747***	−1.401***	−1.624***	−2.338***
	[0.0578]	[0.114]	[0.113]	[0.138]	[0.126]	[0.137]	[0.108]	[0.162]
HHI	0.0827*	−0.0308	0.0288	−0.0379	0.085	0.215***	0.0643	0.039
	[0.0471]	[0.0512]	[0.0508]	[0.0598]	[0.0539]	[0.0547]	[0.0537]	[0.0546]
FDI	0.00726	−0.00331	0.0191**	0.0186**	0.0261***	0.0072	0.0306***	0.0274***
	[0.00738]	[0.00755]	[0.00755]	[0.00896]	[0.00855]	[0.00895]	[0.00848]	[0.00848]
Observations	573,663	573,663	606,721	613,211	579,318	613,310	591,128	591,128

Notes: The dependent variables are log(TFP) except for column (6), for which the dependent variable is log(output per worker). All regressions include firm and year fixed effects. FDI was constructed as the share of foreign-invested firms in total industry sales at the 4-digit level. The weak identification F statistics are significantly higher than the critical values of Stock and Yogo. Robust standard errors clustered by firm are in brackets. If standard errors were clustered at industry-year level, all the coefficients from columns 2 to 8 remain significant with p-values < 0.05, except output tariff from columns 2 though 4 were significant with p-values < 0.1. FDI = foreign direct investment; HHI = Herfindhal index; I/O = input and output; IV = instrumental variable; MFN, most-favored nation; OLS = ordinary least squares; OP = Olley-Pakes; SOE = state-owned enterprise; TFP = total factor productivity.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

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Notes

1. In Melitz and Ottaviano (2008) the selection effect works differently: increased competition from imports does not affect factor market given their constant elasticity of substitution (CES) specification of demand but raises overall demand elasticity. The downward shift of the distribution of mark-ups then forces inefficient or low productivity firms to exit. Bernard et al. (2007) blend Melitz's mechanism into a two-good, two country Heckscher–Olin framework. They show that trade liberalization engenders a stronger selection or reallocation effect in the industry that enjoys an *ex ante* endowment-driven comparative advantage than in the other.
2. Krugman (1987) shows that patterns of comparative advantage can be path-dependent: industries' productivity increases in past production experience, thus entrenching their cost advantage. By implication, for those industries that expand as a result of trade liberalization, productivity will also increase. Young (1991) also examines how trade liberalization affects growth and technical progress. His results show that a less developed country may experience a lower rate of technical progress because freer trade leads them to specialize in goods/industries that have exhausted potential gains from learning by doing; whereas the opposite is true with

developed countries. Nevertheless, less developed countries may still see their welfare improving with trade liberalization by benefiting from the higher rate of technical progress in developed countries through international trade.

3. Pavcnik (2002) finds the reallocation effect of trade liberalization for Chilean manufacturing industries. The paper shows that more productive firms gain market shares and production resources when trade opens.

4. Similarly, Bustos (2011) studies the impact of the free trade agreement between Argentina and Brazil, and finds that the reductions in Brazil's tariffs increased the technology spending of Argentinean firms.

5. Unlike Trefler (2004), but similar to Amiti and Konings (2007) and many others, we are only examining the impact of Chinese tariff reductions, not that of tariff reductions by China's trade partners.

6. China's gross domestic product (GDP) per capita in constant year 2000 prices was US$1,200 in 2001, and that of the Philippines in 1995 was close to US$900 (World Development Indicators).

7. The industries that lie far out in the northeast corner of the figures, i.e. those that are highly protected in both countries, include distilling, rectifying and blending of spirits (1551), manufacture of wines (1552), manufacture of sugar (1542), and manufacture of motorcycles (3591).

8. The Philippines joined GATT in 1979.

9. Accessed at www.wto.org/english/tratop_e/tpr_e/tp262_e.htm.

10. Tariff Commission of the Philippines (http://www.tariffcommission.gov.ph/tariffbinding.html).

11. Ideally, when computing productivity, firm-level price deflators should be used to isolate physical efficiency from mark-ups (Bartelsman and Doms, 2000; Foster et al., 2008; De Loecker, 2011). However, we are not able to do so because of data availability.

12. We also clustered standard errors by industry–year as a robustness check for the baseline regressions. The results remain significant. See the note of Table 3 for details.

13. See, for example, Fernandes (2007). Saxonhouse (1977) also suggested using the one-step approach, instead of the two-step approach, to address the heteroscedasticity issue that arises from using the latter.

14. China's Input–Output Table is only available for 2007 after 2002.

15. The tariff rates we have used are what WITS calls "the lowest available" tariff rates. That is, if a preferential tariff rate exists, it will be used as the effective tariff rate; otherwise the MFN rate will be used.

16. Topalova and Khandelwal (2011) also find that the tariff reductions in India have had no impact on the productivity of foreign-invested firms in India.