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WTO Accession and Firm-level Productivity in Chinese Manufacturing

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A major motivation of China's policy-makers for accession into the WTO at the end of 2001 was the potential to boost the impact of reforms. Drawing on a unique firm-level data set that covers all state-owned firms and non-state owned firms with sales above 5 million RMB and spans the period 1998-2007, the primary purpose in this paper is to analyze the effect of several important dimensions of China's trade liberalization on firm and industry level productivity. An important dimension to these effects is the heterogeneity we observe across firms in terms of initial productivity and ownership. There are also important industry dimensions to these impacts as well that may be linked to the forces of entry and exit.

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1. Introduction

[Intro (Sec. 1) and literature review (Sec. 2) still need to be completed and integrated]

A major motivation of China's policy-makers for entry into WTO at the end of 2001 was the potential impact on firms and industry. Constrained in their efforts to restructure major segments of industry by domestic political economy considerations, it was hoped that mandated reforms required by WTO accession would be an important catalyst to change. Drawing on a unique firm-level data set that spans the period 1998-2007, our primary purpose is to analyze the effect of several dimensions of China's WTO entry on firm and industry level productivity. We measure the magnitude of the effect and investigate the channels through which WTO may have mattered.

Entry into WTO required a large reduction of import tariffs, as well as the elimination of numerous non-tariff barriers (NTBs). Trade liberalization was accompanied by a lessening of restrictions on foreign direct investment (FDI). In estimating the effects we focus primarily on the role of import tariff reductions, which are observed most accurately. To the extent that changes in NTBs and FDI restrictions are correlated with tariff reductions, their effects will be subsumed in the tariff liberalization effects.

In principle, import tariffs could matter in two ways: first, through their effect on prices of imports that compete with locally manufactured goods in the domestic market; and second, through the prices (as well as quality and variety) of imported intermediate goods. In general, we expect these effects to be heterogeneous across firms.

Theory of heterogeneous effects (Ederington and McCalman, 2008)

Estimate heterogeneous effects of competition by final good imports ... (Ederington and McCalman, 2009; Lileeva and Trefler 2010, Schor 2004).

Channels for productivity growth: trade volumes & firm selection (Fernandez 2007), more efficient allocation of resources (Hsieh and Klenow, 2009), pressure by demanding (foreign) clients (Javorcik, 2004), complementarities with other industrial policy reforms (Topalova and Khandelwal, 2010).

Liberalization of intermediate goods imports has a direct impact on the product scope of domestic firms (Goldberg, *et al.*, 2010) and firm-level productivity (Amiti and Konings, 2007).

There are two important features of China's export regime that we need to control for. WTO entry guaranteed domestic firms permanent access to overseas markets on terms that China had previously enjoyed only on an annually-renewable basis as a "Most Favored Nation." While the reduction of the import tariffs is a gradual process, on the export side no gradual tariff reduction took place, but the resolution of uncertainty might not have been instantaneous. In addition, this change affects not all firms and introduces an important source of heterogeneity. A second dimension of firm-difference that we need to control for is the presence of many export processors. As part of a policy of encouraging exports, these firms enjoyed duty-free access to raw materials and intermediates all along on goods destined for export. Joint ventures and wholly-owned subsidiaries received similar treatment with respect to the importation of capital goods at the time of their establishment.

The data we use cover all State-owned firms, and non-state owned firms with sales larger than 5 million RMB (or slightly less than $US 600,000 in 2007). This provides an unbalanced panel of firms that increases from 150,000 observations in 1998 to slightly less than xx firms in 2007. For each firm, we have detailed information on gross output, value-added, employment and wages, the capital stock, exports, profits, etc.

By constructing a consistent industry classification over time, accounting for the important reforms in 2003, we obtain a measure of inward tariff protection at the industry that is comparable over the 1992 to 2007 period. Using the Chinese input-output table for 2000 allows us to construct estimates of import tariffs on intermediate goods by sector. On the limited sample of exporters, approximately half of all firms, we are able to construct a firm-level rate of tariff protection that varies within an industry.

Since WTO likely affected sector-level productivity through exit and entry of firms, we also carry out decomposition exercises that provide estimates of the contribution of productivity growth in surviving firms, and entry and exit to overall productivity growth. Entry and exit will matter insofar as productivity levels in these firms differ from existing averages.

The remainder of the paper is organized as follows. In Sections 2 and 3 we provide in turn an overview of the literature and the empirical specification we adopt and of China's gradual trade liberalization process. The data is described next, in Section 4. The relationship between tariff reductions and productivity is explored at the industry level in Section 5.

Subsequently, we use the firm-level data in Section 6 to identify which channels provide explanatory power for the sectoral effects. We conclude in Section 7.

2. Literature and empirical model

Several papers have studied the impact of trade liberalization on the price-cost margins. Tybout (2003) reviews the evidence, which uniformly points towards lower margins following liberalization, and critically discusses the "Hall"-methodology that these studies employ.

A second channel through which trade liberalization is expected to have an effect is size rationalization: smaller firms will be forced to exit and production at higher scale will be more efficient. This is the channel that often dominates in computational general equilibrium (CGE) models of trade reform, but the recent focus on firm heterogeneity has diminished interest for this channel. In a recent study, Baldwin and Gu (2008) find an effect of the Canada-U.S. FTA on the size of production runs within Canadian plants, pointing to an important within-plant scale effect.

A third line of research looks for a direct link between productivity and trade liberalization. In a first stage, some productivity measure is constructed, which in the second stage is regressed on measures of trade liberalization, trade flows or tariff levels. In most studies, the second stage regression is run in levels, as in Pavcnik (2002) for Chile,[1] but often firm-fixed effects are included. Trefler (2004) even uses double (time) differences. Studies differ in the use of tariff rates or trade flows as measures of trade liberalization, in the way productivity is constructed, and most importantly in the extent to which they are able to control for demand side factors in the regression. Identification always comes from differences across industries in the extent of the liberalization, i.e. the different pattern of changes in protectionism across industries.

A similar methodology is followed by Schor (2004) for Brazil, and Amiti and Konings (2007) for Indonesia, but they include the level of tariff protection on a sector's intermediate inputs in the regression. Both studies find that tariff reductions on imports are more effective in boosting productivity than tariff cuts on outputs. In particular, separate effects by productivity decile in Schor (2004) highlight the relatively stable and positive effect on productivity of cuts in

[1] Other studies that follow the same basic set-up are Eslava, Haltiwanger, Kugler and Kugler (2004) and Fernandes (2007) for Colombia, and Sivadasan (2009) and Topalova and Khandelwal (2010) for India.

input tariffs. Output tariff reductions, however, boost productivity at the bottom of the distribution, but diminish it at the top.

Heterogeneous effects of trade liberalization can be rationalized by a model of endogenous technology adoption, as in Ederington and McCalman (2009), which formalizes an earlier critique of Rodrik (1992). Heterogeneous firms decide when to adopt a technology improvement, which depends crucially on their expected market share as the fixed costs of adoption have to be recovered. As trade liberalization increases the expected degree of competition, and reduces the firm's expected market share, some less productive firms will postpone adoption. Firm characteristics that are related to fast technology adoption and indirectly to high productivity levels will enhance the productivity boosting effects of trade liberalization. Ederington and McCalman (2009) finds support for this effect in the case of Colombia, but note that the effects are in the opposite direction of those in Schor (2004): “An increase in tariff barriers should result in larger firms, exporting firms and younger firms having higher productivity growth”. (p. 18)

Lileeva and Trefler (2010) study the issue of firm heterogeneity in the context of Canadian exporters entering the U.S. market following the Canadian-U.S. FTA. The productivity effects they find are reminiscent of those in Ederington and McCalman (2009). Plants that *ex-ante* had a low probability of entering the U.S. market but did enter after the drop in tariffs saw a productivity boost, with no effect on any plant that had an initial entry probability above 50 percent. By and large, the affected plants tend to be smaller and of lower productivity level. The mechanism that Lileeva and Trefler (2010) see responsible for this heterogeneous effect is a lowering of the thresholds for entry into the export markets in the Melitz model, which will only affect low productivity producers.

The dependent variable in much of the analysis, productivity growth for industry *s*, is calculated as

$$\Delta \ln P_{st} \equiv \Delta \ln Y_{st} - \quad \Delta \ln L_{st} - \quad \Delta \ln M_{st} - (1 - \quad - \quad) \, \Delta \ln K_{st} \, , \qquad (1)$$

deducting the share-weighted growth in inputs from output growth. is the industry-specific average wage share in output in the two years over which the growth rate is calculated, and similarly for the material share . We will use both one or three year intervals. If we use a value

added production function, the material input is omitted and value added is used instead of gross output in the first term.

Productivity growth will be the dependent variable in regressions of the following form:

$$\Delta \ln P_{st} = \beta_1 T_{st-k} + \beta_2 \Delta T_{st} + \sum_t \alpha_t + \varepsilon_{st} . \tag{2}$$

Protectionism (T) is measured using the import tariff or the effective rate of protection, which tends to be higher and declines more as tariffs are generally lower for inputs. Variable construction is detailed in the data section below. Throughout the entire paper we will use the same two explanatory variables: lagged and first differenced rates of protectionism. The first coefficient will inform us to what extent the cross-sectoral pattern of the dependent variable is associated with initial rates of protection. The second coefficient captures the association between tariff declines and changes in the dependent variable, controlling for both the initial rate of protectionism and an unobserved but constant industry effect.

Equation (2) can also be estimated using the dependent variable in levels and including industry fixed effects. This will be particularly useful when we estimate variations on (2) using alternative dependent variables—such as trade flows, prices, or contributions of a specific group of firms to sectoral productivity growth—where the level has a more intuitive interpretation than the growth rate. We can also run the regression at the firm level, in which case we include firm fixed effects in the specification in levels.

3. Liberalization of China's Foreign Trade and Investment Regime

3.1 Trade policy instruments

In the late 1970s China embarked on a radical economic reform path that opened its economy to the rest of the world. Beginning in 1980 with the establishment of the four Special Economic Zones (Shenzhen, Xiamen, Zhuhai, and Shantou) and in 1984 with the setting up of Economic and Technical Development Zones in fourteen coastal cities, China encouraged foreign direct investment (FDI) as a means of developing a manufacturing export sector through the importation of much-needed capital, managerial know-how, and technology. Outside of these zones it allowed for the importation and licensing of new technologies and capital goods as part of a policy of modernizing existing domestic enterprises. China concurrently began to reduce

tariff and non-tariff barriers to trade, and to extend direct trading rights to firms, culminating in its entry into the World Trade Organization (WTO) in 2001.

These trade reforms complemented a wide-ranging series of domestic economic reforms that reintroduced household farming in agriculture, expanded autonomy and increased incentives in China's state-enterprise sector, liberalized domestic markets, and allowed entry of new firms into most sectors. Its Soviet-style planned economy was gradually scrapped in favor of a market-based economy with mixed ownership.

China's renewed openness combined with domestic economic and institutional reform initiatives served as important catalysts to economic growth which has averaged nearly 8 percent per annum in terms of GNP per capita. In 2009 China became the largest exporter in the world; its imports are only bested by the United States. In 2008, the last year before the crisis, merchandise imports and exports combined totaled $2.56 trillion (USD), slightly more than 8 percent of world trade, with another $760 million worth of goods passing through Hong Kong. More than 80 percent of China's exports consist of manufactured goods, which now extend to an increasingly sophisticated array of products from apparel to machine tools to televisions.

Figure 1 displays China's trade flows over the 1989-2009 period. The increase in trade following its WTO accession in 2001 is particularly remarkable. The gap that has opened up between its exports and imports since 2005 is well known. While its overall trade surplus maxed out in 2008 at $298 billion, 11.6% of total trade, its bilateral surplus with the United States at $198 billion (including Hong Kong trade) has become a particularly contentious issue.

[Figure 1 approximately here]

From the onset of the reforms to 2008, FDI inflows into China have totaled $900 billion. The FDI series in Figure 1 demonstrate that a lot of capital flowed into China in the second half of the 1990s, but inflows stalled with the uncertainty surrounding its WTO accession talks. Following entry, inflows resumed briskly, surging to $108 billion in 2008. Much of this investment has come from Asia—notably from firms in Hong Kong, followed by Taiwan, Japan, and Korea—who have looked to outsourcing to China as a way to reduce manufacturing costs in

an increasingly competitive international environment. This has made China an integral part of global supply chains.[2]

The reduction in tariffs does not reflect the full degree of liberalization however. As part of a policy of encouraging FDI, China allowed the duty-free importation of raw materials and parts and components involved in export processing. Foreign-invested firms have also been allowed to import capital goods duty-free. Exemption of import duties was further expanded in the late-half of the 1990s to certain type of domestic firms and organization. Smuggling and "leakage" of duty-free imports throughout the rest of the domestic economy likely extended some of the benefits to other firms. Branstetter and Lardy (2008) report that in 2000 less than 40 percent of all imports were subject to tariffs. This low number helps to explain why tariff revenue as a percentage of the value of imports is so much lower than the average statutory tariff rate.

The benefits of lower import protectionism were reinforced through reforms that simultaneously increased the number of firms with direct import and export rights – one form of nontariff barriers. Previously, much of foreign trade was monopolized by a relatively small number of state-owned trading companies. Increasing entry is likely to reduce distribution margins, but also to facilitate direct contacts between firms and customers and suppliers, which might generate spillovers.

In principle, barriers of this form can either complement or substitute for tariff protection. Failure to control for them can act as important source of unobserved heterogeneity at the sector-level that may bias our results. For example, lingering (or increasing) licensing requirements for imports may block the benefits of tariff reduction, and thus lead to an underestimate in the impact of the latter. On the other hand, a simultaneous reduction in licensing requirements may lead us to an overestimate of the impact of tariff reduction.[3]

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[2] Currently, more than half of China's imports and exports are tied to foreign-invested enterprises (FIEs), the rest coming from domestically owned firms. Much of this FDI is from Asia, which helps explain an important regional dimension of China's trade. Currently, nearly two-thirds of China's imports are from Asia, largely in the form of intermediate and capital goods, and, to a lesser extent, raw materials. Half of Chinese exports go to Asia. Overall, China runs a trade deficit with Asia, but a larger and rapidly expanding trade surplus with the United States. The latter has grown with the rapid increase in the outsourcing of manufacturing in Asia to China, and the decline in the trade surplus of other major Asian economies with the United States.

[3] On the import side, import licenses extended to more than 35 commodities and over 350 tariff lines (HS 8-digit level) prior to WTO entry at the end of 2001. Both the number of commodities and tariff lines dropped sharply through 2005, with import licenses applied to only 3 commodities and 83 tariff lines. In the case of export licenses,

Yet another dimension of the opening up of the economy, was a lessening of restrictions on FDI. It started even before WTO entry negotiations commenced and was part of a wider policy agenda. As much as possible, China has insisted on FDI inflows to take the form of joint ventures, in order for local firms to benefit maximally from access to intellectual property. Wholly-owned subsidiaries were allowed in sectors were Western firms would be unwilling to enter otherwise or if strong foreign competition is particularly desirable.

Firms from Hong Kong, Macau, and Taiwan have become particularly important in export processing. Entry of foreign firms is also tied to export success in many sectors.

FDI influences tariff effects as foreigners producing locally will not import final goods and advanced manufacturing operations can help locals improve productivity.

Finally, expanded access to overseas markets increased the value of this more liberalized environment. With respect to the US, this came in the form of China's new status as an MFN (most favored nation). One of the benefits of China's accession to WTO is that it no longer had to go through the annual process of having MFN status renewed.[4] At the firm level, this may have helped to reduce firm uncertainty regarding future market access. Having statutory market access and making discriminatory treatment impossible changes incentive to invest in production capacity and export infrastructure. The atation). One of ther.i(l)-2(8ei2(he)4ke)4(t)-2(0)por3(t)f-2(si)-fst

3.2 Quantifying the tariff reduction

China's foreign trade liberalization has been well-documented. An important observation make by Branstetter and Lardy (2008) is that even before China's accession to WTO at the end of 2001, China's manufacturing sector already experienced a high degree of openness. Beginning in the early 1990s, China began to lower their domestic tariffs. From an average of 43.2 percent in 1992, by 2001 the average tariff at the 8-digit HS level fell to 15.3. This was accompanied by a reduction in the imports regulated by non-tariff barriers through licenses and quotas (Branstetter and Lardy, pg. 635).

Import tariffs are reported at the 8-digit HS classification system. To use these in the firm and industry level analysis, we map them into China's Industrial Classification (CIC) system at the 4-digit level.[5] To avoid a bias in the sectoral average by the low trade volumes in heavily protected product lines, we use unweighted averages. Input tariffs are a weighted average of output tariffs, using industry-input shares from the 2002 Input-Output table. Reflecting the higher level of aggregation of the Chinese IO table, our input tariffs are effectively at the 3-digit level.[6]

[Figure 2 approximately here]

Figure 2 summarizes the evolution of average input and output tariffs over the entire 1992-2007 period. Two patterns stand out. First, output tariffs tend to be substantially higher than input tariffs. The large difference is reflective of very different treatment of final goods from raw materials, intermediates inputs, and capital imports. By the end of the period, the average difference has declined to less than four percentage points.

Second, tariff reduction has proceeded in two spurts—with large and widespread reductions between 1992 and 1997 and in 2002—and more heterogeneous and gradual reductions in the 1997-2001 and 2002-2007 periods. In addition, the ratio of value added to total

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[5] We build on an HS-CIC concordance table created by the NBS, which we extended to CIC sectors and HS codes not included in the original table. We also correct about 100 mistakes in the original concordance. Changes in the HS system in 2002 affecting nearly ten percent of all product lines and in the CIC system in 2003 required us to construct multiple concordances between goods (HS) and sectors (CIC).

[6] We have used annual circulars released by MOFTEC and the Ministry of Commerce on the licensing of imports and exports to construct measures of non-tariff barriers at the 4-digit CIC level. Utilizing our mapping between the HS and 4-digit CIC systems, we calculate the percentage of 8-digit HS product lines covered by licensing requirements. This can again be constructed at the output and input level.

output has gradually increased over time. This contributes to a gradual reduction in tariff protection, which becomes apparent in years where average tariffs are fairly constant. Tariff reductions became more predictable as negotiations proceeded and after WTO entry the subsequent reductions followed a predetermined pattern.

The average evolution hides important variation across industries that we can use to identify effects. The extent of heterogeneity in protectionism is illustrated in Figure 3 which graphs the smoothed histogram density for the industry-level effective rate of protection for four years. The evolution of the distribution over time highlights the important tariff compression, in addition to the average decline. The compression was even stronger for input tariffs due to their higher level of aggregation and the fact that they were lower to begin with.

[Figure 3 approximately here]

3.3 Directed tariff reductions

Under its WTO accession agreement, China agreed to lower most of its tariffs on manufactured products to below 10 percent. Given that the initial rate of protectionism varied widely across sectors, this implies very different degrees of trade liberalization.

In Table 1, we summarize the explanatory power of several types of variables for the cross-industry pattern in import tariffs in 1992. The best predictors are a set of dummies for the type of goods (capital, intermediates, durables, etc.), based on the BEC classification. Just X dummy variables explain 45 percent of the variation in tariff rates across sectors. A second set of variables with high predictive power are measures of R&D, sales, and advertising intensity for the U.S. from an FTC report (cite). A third important variable is ownership: sectors with a high fraction of state owned enterprises (SOEs) receive less protection. This surprising patter remains even after controlling for the type of goods, as above.

[Table 1 approximately here]

These patterns hold also in later years, but the predictive power declines as tariff protection converges across sectors. For the same reason, the predictive power of these variables is similar for the 1992 tariff levels, or for the changes between 1992 and 2007.

4. Data

We use annual firm-level data for 1998-2007 on all manufacturing firms that are identified as being state-owned, and non-state owned firms with sales above 5 million RMB. They are collected through annual surveys by the National Bureau of Statistics (NBS) and discussed in detail in Brandt, L, J. Van Biesebroeck, Y. Zhang (2009).

The sum of employment, sales, capital, and exports for these same firms matches almost perfectly the aggregates reported annually in the China Statistical Yearbook (TJNJ). Compared to the universe of firms observed in the 2004 Economic Census, our sample of "above-scale" industrial firms represent the bulk of industrial activity in China. In 2004, they accounted for 91 percent of the gross value of industrial output, 71 percent of employment, 97 percent of exports, and 91 percent of total fixed assets.

For the analysis in the paper, we focus on manufacturing firms. This provides an unbalanced panel of firms that increases in size from 148,586 firms in 1998 to 251,056 in 2005. We link firms over time mostly using firm identifiers. As IDs may change if a firm went through restructuring, or M&A activity, we have also used information on the firm's name, sector, and address to establish links over time firms. On average, we match between 5 and 7 percent of the firms on the basis of this information.

[In Appendix? Summary statistics]

[In Appendix? Description of firm linking]

[In Appendix? Entry-exit rates]

[In Appendix? Details on K-stock construction]

We use the following variables in the analysis. Annual employment, total expenditure on raw materials and intermediate goods, and gross value of industrial production is reported directly by all active firms. The few firms with fewer than eight employees are discarded as they fall under a different legal regime. Employee compensation consists of wages and supplementary benefits and insurance. Firms began to report retirement and health insurance in 2003, and housing benefits in 2004.[7]

[7] These measures of compensation likely underestimate total payments to labor. Labor's share of value added is only 28.3 percent on average, while the national income accounts suggest an overall share of labor of around 50 percent.

Each year, firms report the value of their fixed capital stock at original purchase prices and their capital stock at original purchase prices less accumulated depreciation, but not their investments. In Brandt, *et al.* (2009) we devised an algorithm to estimate the real capital stock using information on the reported capital stock in the first year we observe the firm, changes in the reported stock, annual investment rates at the industry-province level, and the firm's founding year.

All these variables are also observed for firms in 1995, but a change in the ID codes makes it impossible to link the data at the firm level. However, at the industry level we can extend our sample backward to include the 1995 information.[8] To account for a change in the Chinese Industry Classification (CIC) codes in 2003, we merged some industries to obtain a consistent classification of sectors over the entire sample period.

We use the official two-digit output price deflator for gross output, which is available for the entire time period. An input price deflator is constructed by weighing output prices by input shares from the 2002 Input-Output table.[9] Real value-added is constructed by double-deflating gross output and input costs using the appropriate deflators.

In the empirical analysis, we occasionally utilize information on a firm's registered type (*qiye dengji zhuce leixing*) to construct ownership categories. We group them in five categories: state, hybrid (township & village enterprises, local government owned, etc.), private, Hong Kong, Macao or Taiwan (HMT), and foreign owned. When ownership is mixed, we use the following order to categorize firms: foreign, HMT, state, hybrid, private. The results in Figure 4 illustrate the relative decline in importance of state-owned and, especially, hybrid firms and the ascent of private ownership. Foreign firms have become especially important for foreign trade, accounting for almost 50 percent of all exports in 2007.

[Figure 4 approximately here]

The correct share for manufacturing is likely to be intermediate and in Brandt, *et al.* (2009) we experimented with adjustment factors.

[8] The data we have for 1992, 1993, and 1996 do not contain information on value added or input use, making it impossible to construct productivity estimates and extend the data set further.

[9] In the 1998-2003 period, we can construct a more disaggregate deflator using output reported at "reference prices." Results in Brandt, *et al.* (2009) illustrate that the difference is minor.

5. Correlation between Productivity Growth and Tariff Reduction at the Industry Level

The correlation between productivity growth and tariff reductions at the industry level is strong and robust. There are several possible explanations for such a pattern. A causal effect of trade liberalization on restructuring-driven productivity advances, as envisioned by some Chinese leaders, is one possibility. The reverse causation, where tariffs are lowered selectively only when industries are showing promise for future growth, is another plausible explanation. Many channels will be explored in the following section using more detailed firm-level data, but a first objective is to illustrate the magnitude and pattern of the correlation.

The first set of results, in Table 2, reports estimates of equation (2) using single year differences for productivity and the two measures of trade protection. The first three columns are for a value added productivity growth concept, the last three use gross output. The regressions are run for the entire sample period, 1998-2007, and also for the pre and post WTO accession periods separately. Each of the twelve coefficients on lagged levels of protection are negative and nine are statistically significant. Especially in the post accession period or using the effective rate of protection, industries that receive more trade protection tend to enjoy lower productivity growth. All eight of these coefficients are estimated to be negative and significant.

[Table 2 approximately here]

The magnitude of the effect (-0.11) suggests that an industry enjoying an output tariff of one standard deviation above the mean, 21.7% instead of 12.7%, enjoys 1.0% higher total factor productivity growth in value added terms, compared to an average of 14.3%. The lower point estimate for gross output productivity growth (-0.07) corresponds to an even larger difference: 0.6% higher growth, which is almost one seventh of the average. The estimates on the effective rates of protection, which are somewhat higher and a lot more variable, translate into productivity growth advantages of 1.6% and 0.9% or one ninth to one fifth of average productivity growth.

Holding lagged protection fixed, the effects of changes in protectionism are also estimated to be negative in most cases. A large decline in protection is associated with higher productivity growth. In the post accession period, all four point estimates are negative, but only

for the effective rate of protection are they significantly different from zero. The magnitude of −0.33 means that a one standard deviation larger decline (in absolute values), i.e. a reduction of the effective rate of protection by 11.5% instead of the average of 2.5%, is associated with a 3.0% higher productivity growth. For the gross output measure, a one standard deviation reduction in the effective rate of protection is also associated with one fifth higher productivity growth.

One possible reason for the sensitivity in the estimates and the lack of significance is the delay it might take for tariff declines to register a productivity growth effect. Especially in the pre-accession period, when tariff reductions are less predictable, this is likely to be important. In the first panel of Table 3, we report estimates of equation (2) using non-overlapping three year intervals. Only results for the effective rate of protection are reported. Results using output tariffs are qualitatively similar; point estimates are higher, but estimated less precisely.

[Table 3 approximately here]

Every single coefficient is now estimated negatively and all but two are significantly different from zero. Especially the consistency over time is remarkable, as all coefficients are estimated using on a single three-year change. Estimated over the entire 1995-2007 period, a one standard deviation higher effective rate of protection at the beginning of a three year period, is associated with 3.1% lower productivity growth (compared to an average of 14%) using the value added measure and 1.0% (compared to an average of 4%) using the gross output measure.

Holding the initial rate of protection constant, lowering the effective rate of protection has large effects as well. A reduction by one standard deviation is associated by higher productivity growth of 4.8% or 1.1%, corresponding to around one third of the entire productivity growth performance. Clearly these are very big effects.

These effects can alternatively be estimated using productivity level as dependent variable and including industry-fixed effects. The coefficients will pick up the extent to which productivity deviations from the industry mean are correlated with tariff deviations. The estimates in the second panel of Table 3 are comparable to those obtained using productivity growth. They tend to be estimated larger in absolute sign, which is consistent with the lower standard deviation of tariff deviations within industry. We still find that years with high initial

protection are followed by periods of low productivity growth. And periods where productivity declined a lot in an industry are also periods with above average productivity growth.

To control more explicitly for industry-specific time trends in productivity growth that might simply pick up the secular decline in protection, we can adjust equation (2) in the spirit of Trefler (2004). Adding a full set of industry fixed effects in the regression, is similar to his double time difference estimation. The results in panel (c) of Table 3 indicate that deviations in productivity growth rate from the industry average, are still systematically related to deviations in initial tariff levels and tariff reductions. The negative estimates on the change in effective rate of protection now indicate that in periods where protection declined more than usual (for the sector), productivity growth is also higher than usual. Every single coefficient is estimated significantly different from zero, with productivity levels especially responsive in the post-2001 period, when tariff declines had become very predictable.

6. Channels

We now explore different possible explanations for the strong association between productivity growth and tariff declines. First, we establish that the tariff reductions had only a limited effect on import flows. There was an indirect effect of strengthened competition, which we can gauge from the large effects on prices. Second, we use the more detailed information at the firm level to quantify the effect of tariffs on firm-level productivity growth, restructuring at the extensive and at the intensive margin.

5.1 Competition from imports

One effect of the very large tariff reductions that stands out, is the surprisingly limited impact they had on trade flows. Large growth in domestic production lead to increased imports of raw materials, intermediates, and capital goods, but the increased inflow was only very weakly tied to reductions in trade protection. This stands in contrast with the large effects of this channel documented for India in Goldberg, *et al.* (2010).

Important to establish that the channel of any WTO effect can only be to a limited extent be the loss of market share to importers (which features in theory models). The regression results reported in Table 4, follow a similar form as in Tables 2 and 3, but using import levels as dependent variable rather than productivity. The analysis is still at the 4-digit CIC industry level

and we use trade information for the 2000-2006 period, which is aggregated up from firm-level reports.

[Table 4 approximately here]

The results in panel (a) illustrate that only ordinary trade is affected by tariff levels and tariff reductions, as expected, and that the effects are similar for the short period before WTO entry that we observe (2000-2002) and the period post accession. On average, industries that are protected by one percentage point higher import tariffs in the previous period experience 3.5% lower import inflows. Holding the level of protection constant, a fall in tariffs by one percentage point, is associated with an import increase of 6.1%.

The results in panel (b) further illustrate that the effects of tariff reductions are experienced quickly. A tariff reduction over a three-year period does not lead to a larger import response. If we measure trade liberalization by the effective rate of protection, which measures better to what extent local producers are protected, the effects are twice as large for a three-year change than on annual changes.

Finally, the results in panel (c) illustrate that it matters crucially what is held constant in this analysis—which contrasts with the much more robust results for productivity. Without year fixed effects, the past level of protection is still associated with lower imports, but the change in protection is not correlated with higher imports anymore. It suggests that periods with tariff decreases tend to be periods with low import levels across the board. Only when we control for year effects and identify the effects from the cross-industry patterns does the association between tariff declines and imports appear. In the third column, we additionally include industry fixed effects to identify effects only from the within-industry time pattern of protectionism. In light of the OLS estimate, the insignificant effect of the change in protection is as expected, but now even the level of protectionism becomes insignificant. Holding average imports for an industry constant, it is not the case that periods with high protectionism are followed by periods of low imports. These results demonstrate that the above results in panel (a) and (b) are driven entirely by the (constant) heterogeneity of industries.

The results on the right of panel (c) further show that it matters as well what type of imports we focus on.[10] The negative coefficients indicate that capital goods and intermediates are imported to a greater extent in industries with low levels or decreasing levels of protectionism. The estimates for material imports and the remaining "other" category, on the other hand, are more erratic.

Localizing of the supply chain is one explanation for the lack of imports. Brandt and Van Biesebroeck (2005) document this for the automotive industry, but the statistics in Table 5 illustrate that low and stable import levels are fairly ubiquitous. We have matched our firm-level sample to information on all trade transactions in customs records. Firms that are not observed importing directly are necessarily assigned an import value of zero. They might use no imports, or they might import indirectly through intermediates. At the end of the sample period, more than two thirds of all imports are accounted for. Given that some of the unmatched imports will be final goods imported by retail firms, indirect imports by manufacturing firms are likely to be very limited. The increasing importance of direct imports, which was part of China's WTO agreement, will even lead to an overestimate of the import growth.[11] In the case that the value of a firm's imported intermediates is larger than its input value, the percentage is capped at 1.

[Table 5 approximately here]

In the first panel (a) of Table 5, we see that the fraction of firms importing intermediate goods or materials directly is limited to 11.2% in 2000, rising to 12.9% in 2006 (after a peak of 13.3% in 2005). Included in these calculations are the products with 6-digit HS lines that fall into BEC (Broad Economic Categories) 22, 42 or 53 (intermediates) and BEC 21 or 31 (materials). Breaking the total down into by duty free imports, used by export processors, and ordinary trade, we notice that almost the entire increase is in ordinary trade.

Average imports as a share of intermediates used is even lower. It increases from 7.8% initially to 9.4% in 2006. In spite of the increased use of ordinary trade imports, duty free imports are still more than twice as important as ordinary trade imports at the end of the sample

[10] We use the BEC (Broad Economic Categories) classification of goods (from the WTO?) for this decomposition.

[11] As a condition of its WTO entry China agreed to liberalize its trade regime and allow, over time, all firms direct access to international markets. Hence, part of the increase in trade is not the result of tariff declines, but a switch from indirect to direct trade.

period. The reason is that export processors are importing a lot more of their intermediates than the average firm.

In panel (b), we separate out the share of imports for different ownership categories of firms. The first percentages illustrate the relative importance of the three categories in the full sample. In 2000 the hybrid group, which includes collective firms, accounted for 43.3% and state-owned enterprises for another 23.3%. In the subsequent six years, their combined total decreased to 27.6% and private firms made up 50.9% of all observations in 2006. These shifts matter, because the import intensity differs a lot between the different categories, even in 2006, as illustrated in the next columns. Not surprisingly, foreign firms (including those with owners in Hong Kong, Macau, and Taiwan) import a much higher fraction of intermediates, especially duty free. In contrast, private firms import least of all.

The last three columns illustrate that some convergence is taking place. The categories with the highest import intensity, see their imports fall, while private firms see their imports of intermediates, as a fraction of total input use, increase from 0.5% to 0.9%, almost a doubling. It is also interesting to note that the three categories of domestically owned firms, all import more through ordinary trade than duty free, and that this difference is even growing over time. Given that only ordinary trade is responsive to import tariff cuts, the behavior of these domestic firms will be of great importance in quantifying the effect of trade liberalization.

Domestic firms have responded to the tariff cuts by increasing the share of intermediate goods imported, albeit from a low base. Foreign-owned firms have responded by the growth of the domestic private sector by increasing local sourcing and reducing imports. The latter evolution is tied more to the general development of the manufacturing sector in China than to any particular WTO-induced policy. Foreign firms with a long-term view that want to remain competitive with domestic low-cost firms are forced to leverage China's low labor costs advantage in their entire supply chains, not just in the final assembly stage. At the same time, local private firms that compete abroad with export processors (often HMT firms), but lack the foreign contacts and brands, compete internationally on price and are sourcing a much greater fraction of their inputs locally.

It would be interesting to verify to what extent the cross-industry distribution of FDI inflows leads or lags the distribution of tariff cuts. A major difficulty is the lack of industry detail of FDI inflows in the official statistics.

5.2 Pricing to market

An important explanation for the limited response of trade flows to tariff cuts in China, is the large response on the price side. The effect on the domestic market has been a fall in prices almost one for one with the tariff cut, even though imports only account for 10-20% in most industries.

There is anecdotal evidence that in the relatively uncompetitive initial market situation, incumbents enjoyed a lot of market power, especially well-connected SOEs (cites). As import tariffs come down, these firms can lower prices to keep imports out. We illustrate this pattern for new car prices in Brandt and Van Biesebroeck (2005) and a similar phenomenon is documented in Salvo (2010) for the cement industry in Brazil.

We document this effect in Table 6, where we regress price change, separately for the output and input deflators, on the respective tariff changes. A reasonable prior for these coefficients would be the fraction of imports in the total basket of goods making up the industry-level price index. A coefficient of one would indicate that a tariff cut shows up one-for-one in the price index.[12]

[Table 6 approximately here]

All regressions are conducted at the 4-digit CIC level, the same unit of observation as for the productivity regressions in Tables 2 and 3. The three columns on the left are for annual changes in prices and tariffs and on the right we use two-year changes. The first column uses data for the entire time period, 1995 and 1998-2007 and we find a coefficient of 0.147, which is comparable to the import share of manufactures. Limiting the regression to the WTO period, 2001 to 2007, the coefficient rises to 0.460 even though we know that imports barely changes. After China's accession into the WTO, sectoral tariff declines are accompanied by sectoral price

[12] The price deflators used in the benchmark estimates are the 2-digit price deflators reported for the manufacturing subsectors in China's Statistical Yearbook.

declines of a magnitude far exceeding the share of imports. We find the same pattern using biannual changes, on the right, where the coefficient post WTO-entry is even 0.621.

The coefficients are estimated somewhat smaller when we use a more disaggregate price deflator, which we construct from firms' reports of output at reference prices.[13] We estimate a tariff decline of 1 percentage point to be associated with a price decline of 0.32% using one-year changes and 0.40% using two-year changes. The lower estimates might also be partly due to the shorter time period for which the detailed deflator is available.

In the second line of Table 6, results for similar regressions are reported, but using the input price deflator and input tariffs. Both prices and tariffs are constructed as weighted averages of output prices and tariffs, using the same sectoral input-output weights. If the weighting were random, the coefficients would not change. In contrast, the much higher point-estimates we obtain, suggests that sectors mostly producing intermediates have prices that co-vary very strongly with tariffs. Most coefficients are above one, and the results using the more detailed price deflators in the post-WTO period suggest that tariff changes show up one-for-one in price changes. This is the case even though we know, from the averages in Table 4, that imported intermediates always account for less than 10% of total input use.

Running these regressions in levels, using the level of the price deflator as dependent variable and augmenting the tariff level with industry fixed effects, produces very similar results. In that formulation, we can also include both the lagged level and change in tariffs as explanatory variables, as in Tables 2 and 3. Both variables were never significant at the same time, but the lagged level always had a strong positive coefficient, indicating that industries receiving a lot of protection tend to have high prices.

5.3 Firm-level productivity

To understand where the productivity effects at the industry level documented in Tables 2 and 3 come from, we run the same regression at the firm level. To facilitate the discussion and later robustness checks, we have chosen the specification as reported in Table 3(c), in levels with

[13] Details on the construction of these price deflators are in Brandt, *et al.* (2009) and we have made the deflators (and programs for their construction) available online. We average firm-specific reports on price changes by 4-digit sector after dropping outliers.

fixed-effects matching the unit of observation, industries or firms, and the effective rate of protection as explanatory variable.

The difference between the estimates using firms instead of industries as the unit of analysis are best illustrated graphically, see Figure 5. Productivity is measured using the index number method of Caves, Christensen, and Diewert (1982), which has the advantage of allowing for heterogeneity in production technology, but as main disadvantage the enforcement of constant returns to scale.[14] Below we provide a robustness check using the productivity estimation method of Olley and Pakes (1996).

[Figure 5 approximately here]

The coefficients on the lagged level of protection are plotted on the left, those on the change in protection on the right. As before, negative coefficients indicate that sectors that enjoy protection have lower productivity and sectors where tariffs come down also see productivity increase. The most striking pattern is the much larger coefficients at the industry level than at the firm level. Over the entire period, the coefficient on the lagged level is -0.196 at the industry level, but only -0.116 at the firm level. The coefficients on the differences are respectively -0.401 and -0.150, approximately only half as large at the firm level. In the post-WTO period, all coefficients are larger in absolute value, but the difference between the industry and firm level become even more pronounced. Both on the level and difference variables, the coefficient estimated at the firm level is approximately only one third of the coefficient at the industry level.

In Table 7, we report on a number of robustness checks that show that the pattern of stronger effects at the industry level and weaker effects at the firm level is very consistent. It is also not the case that the firm-level coefficients are estimated imprecisely. They are almost all significant at the 1% level. The difference is even higher for the productivity results obtained using the Olley-Pakes semiparametric estimation approach, which does not allow for within-sector heterogeneity in input coefficients. Allowing for firm-specific technology leads to a stronger association of tariff liberalization and productivity growth. As firms adjust are expected to adjust their capital or input intensity in response to tariff liberalization, it is not surprising that

[14] We refer to Van Biesebroeck (2007) for a detailed description of alternative approaches and the comparative advantage of each. In Brandt, *et al.* (2009) we report details on the productivity growth estimates using both the index number and Olley-Pakes based measures.

productivity measures that allows firms to operate with different technologies picks up a larger productivity growthpost liberalization.

[Table 7 approximately here]

In two of the panels, the firm-level estimates are very close to the industry level estimates. In Table 7(b), we only look at output (final good) tariffs as proxy for trade protection. The very strong effect on the lagged tariff level suggests that firms operating in sectors with high output tariffs are particularly unproductive, much more so than in sectors enjoying a high effective rate of protEct(og)10(i752495[5163)-19(r)4(r10(oodput)-2(t)-2(a)4(r)3(i)-2(f)3(f3(s)-1(a)4(r22 1 Tf12

Add here? Heterogeneity in terms of initial productivity

Add here? Heterogeneity in terms of ownership and productivity

Add in separate section? Heterogeneity by Industry Characteristics

5.4 Extensive margin restructuring

The second margin of adjustment that we look at to explain the positive effect of tariff cuts on industry-level productivity is the extensive--entry and exit—margin. We have already shown that in terms of relative importance of different ownership categories, the manufacturing sector has undergone massive restructuring. We now verify whether differences in the rate and the importance of firm turnover are related to the differing degrees of liberalization across sectors.

The way we investigate this channel is by first constructing the contribution of entry and exit at the sectoral level into sectoral productivity growth. The results are then used as dependent variable in similar regressions as before, using lagged and first differenced effective rates of protection as explanatory variables. As the dependent variable now has an explicit flow interpretation, we run the regression on a single time period at the time, identifying the coefficients solely of the cross-industry variation. Three different periods are looked at.

In the benchmark regression in panel (a) of Table 8, we use the value added productivity measure estimated using the index number method, effective rates of protection, the B-H-C decomposition method as improved by Haltiwanger (1997) for unbalanced panels, and the absolute rate of growth. In subsequent panels we vary the different assumptions to show robustness.

[Table 8 approximately here]

Over the entire 1998-2007 period and over the post-WTO interval of 2002-2007, sectors that initially received higher protection experience a lower productivity growth as a result of entry of more productive and exit of less productive firms. Each percentage point increase in the effective rate of protection is associated with 0.26% to 0.34% lower aggregate productivity growth from the net entry channel. At the same time, each percentage point reduction in ERP is associated with 0.5% extra productivity growth from this channel. Lowering trade protection strongly increases the productivity effect of extensive margin churn.

This effect is almost entirely due to the post-WTO period. In the 1998-2002 period, reductions in ERP did not have a significant effect on this margin of productivity growth. Output tariff reductions see a much stronger effect in the same direction. The alternative P-L decomposition in panel (d), Brandt, *et al.* (2009) describes these decompositions in detail, shows qualitatively and even quantitatively very similar effects. The effects are weaker using a gross output concept of productivity. It suggests that entrants tend to have a different (significantly higher) input elasticity for intermediates than incumbents, some of which shows up as higher productivity growth in the value added productivity numbers.

In the final column of each panel, I report the regressions including industry fixed effects. The point estimates are lower in absolute value and fail to be significant in most cases. The consistent negative estimates do suggest that the effects are not solely driven by persistent industry differences that happen to be correlated with tariffs.

5.5 Intensive margin restructuring

The above results were limited to entrants, exiters, and incumbents that remained in the same sector over the entire period. Firms that switched industries were dropped from the sample.

One might worry that sector switching is not a random occurrence. Bernard, Jensen, and Schott (2006) have demonstrated for the U.S. manufacturing sector that firms faced by increasing competition, are more likely to move to another sector. They move to sectors with fewer imports and with a higher capital-labor ratio, consistent with the view that they are trying to escape from imports from low-wage countries. In our sample, this does not seem to be the case.

Even though one third of surviving firms switch sector, over the 1998-2007 period, it does not seem systematically related to the degree of protectionism in the originating or destination sectors. The average ERP for firms that switch out of a sector was 40.2% initially, below the 43.3% average ERP for firms that remained in their sector. On average, they switch into sectors that have a 2007 ERP of 20.0%, versus 21.1% for firms that did not switch, which is a smaller difference than initially, both in absolute ERP and relative to the average.[15] This can be

[15] In contrast, firms that exit from the sample do come disproportionately from more protected sectors, although the difference is small: 1998 ERP of 48.3% versus an overall average of 46.4%. The corresponding statistics on ERP

seen directly, as firms that switch sectors see their ERP decline by an average of 20.1%, compared with an average decline of 22.2% for firms that do not switch. Finally, if firms that switched had remained in their original industry, they would have experienced a very similar ERP reduction, on average of 20.9%.

It is also not the case that firms that switch sectors have a vastly different productivity record. The unweighted average annual productivity growth is 5.24% for firms that switch versus an average of 5.81% for surviving firms that remain in the same sectors over the entire period. In the post-WTO period, the difference is even smaller, with a 0.4% advantage for firms that do not switch. Weighting the firm-level productivity growth rates by output shares eliminates the differences entirely.

The same is apparent if we decompose the aggregate productivity growth, separati. 0 0 W nBT0 0 0 rg/T

absolute importance for sectoral productivity growth of the association between trade liberalization and firms that switch sector is only one sixth of the effect estimated from the entry-exit channel.

A final thing we look at is the reallocation of market share between active firms. For this purpose we look at the evolution of the correlation term in the decomposition from Olley and Pakes (1996). If we define the aggregate productivity level for sector *s* as the share weighted average of the (exponentiated) firm-level productivity estimates, it can be decomposed linearly into an unweighted average productivity and a second term consisting of the interaction between deviations in the share and the productivity level from the mean.

$$\overline{} \tag{3}$$

To calculate the different terms in equation (3), we restrict the sample to continuing firms, construct output shares within each sector, and use deviations from the (unweighted) industry means for both variables. The last term in equation (3) is sometimes called the ‘correlation term’ and it captures to what extent firms with above average productivity levels are able to grab an above average market share.

In previous work using a different methodology, we have already shown that the reallocation of inputs towards more productive firms is not a strong channel of productivity growth in China, in strong contrast with the United States (Brandt, *et al.* 2009). It is informative to mention a few statistics upfront. The ratio of the correlation term to aggregate productivity is on average zero across all sectors in 1998. There are a number of very negative outliers, and at least the median is positive at 6.6%. The ratio grows noticeably over time, averaging 12.1% in 2007 with a median of 24.2%. Omitting the 1st and 99th percentiles, the average even grows from 3.8% to 19.3%. We now verify whether the stronger correlation between share and productivity level is related to the extent of trade liberalization.

In the regressions in Table 10, we use the change in the last term between 2007 and 1998 as the dependent variable in the usual regression using lagged and first-differences ERP as explanatory variables. The robustness checks in panel (b) uses tariff levels instead, and in panel (c) we divide the correlation term by the aggregate productivity level before taking the time difference.

[Table 10 approximately here]

To avoid biasing the results by extreme outliers, we have omitted sectors with fewer than 5 surviving firms over the 1998-2007 interval and sectors with the 1^{st} and 99^{th} outliers for the dependent variable. One finding that appears very robust is the increase in the dependent variable over time, already mentioned earlier. All constant terms are positive and significantly different from zero, most even at the 1% level. The interpretation is most straightforward in panel (c): on average, the contribution of the correlation term to aggregate productivity increases by 3.7% to 39.1%, depending on the measure of productivity.

With only a few insignificant exceptions, declines in trade protection are associated with an increase in the correlation term, in absolute or relative terms. Of the 12 different point estimates for this effect, two are positive and insignificant, three are negative and insignificant, and seven are negative and significantly different from zero. Especially if we enforce the same technology on all firms in a sector—using the Olley-Pakes productivity estimates—all effects are estimated negative. With the index number estimates, the general pattern is the same, but it tends to be weaker.

Trade liberalization does seem to be accompanied with a reallocation of market share towards the more productive of the surviving firms. The average point estimate on the ERP difference in panel (c) of 0.102 has the interpretation that a one standard deviation reduction in ERP increases the contribution of the correlation term in aggregate productivity by 3.3%, holding the initial rate of protection constant. The average coefficient on the lagged ERP level (0.12) indicates further that sectors with an initial rate of protection one standard deviation above the average had a 5.2% lower contribution of the correlation term than the average sector. Both of these effects should be compared to an average contribution of 36.7% in 1998.

7. Conclusions

[To add]

References

Amiti, M. and J. Konings (2007). “Trade Liberalization, Intermediate Inputs and Productivity: Evidence from Indonesia,” *American Economic Review*, 97(5), December, 1611-1638.

Baldwin, J.R. and W. Gu (2008), “The Impact of Trade on Plant Scale, Production-Run Length and Diversification,” in T. Dunne, J.B. Jensen, and M.J. Roberts (Eds.), *Producer Dynamics: New Evidence from Micro Data*, Chicago: University of Chicago Press.

Bernard, A.B., J.B. Jensen, and Peter K. Schott (2006). “Survival of the Best Fit: Exposure to Low-wage Countries and the (Uneven) Growth of U.S. Manufacturing Plants,” *Journal of International Economics*, 68(1), January, 219-237.

Brandt, L. and J. Van Biesebroeck (2005). “Capability Building in China's Auto Supply Chains,” Chapter 3 in Conference Proceedings: *Offshore Outsourcing: Capitalizing on Lessons Learned*, Industry Canada and Rotman School of Management.

Brandt, L., J. Van Biesebroeck, Y. Zhang (2009). “Creative Accounting or Creative Destruction? Firm-level Productivity Growth in Chinese Manufacturing,” NBER Working Paper No. 15152, July.

Branstetter, L. and N.R. Lardy (2008). “China's Embrace of Globalization,” in L. Brandt and T.G. Rawski (Eds.), *China's Economic Transition: Origins, Mechanisms, and Consequences*. Cambridge University Press.

Caves, D. W., L. R. Christensen, and E. W. Diewert (1982) “Multilateral Comparisons of Output, Input, and Productivity using Superlative Index Numbers.” *Economic Journal*, 92(365), March, 73-86.

Ederington, J. and P. McCalman (2008). “Endogenous Firm Heterogeneity and the Dynamics of Trade Liberalization,” *Journal of International Economics*, 74(2), 422-440.

Ederington, J. and P. McCalman (2009). “The Impact of Trade Liberalization on Productivity Within and Across Industries: Theory and Evidence,” Working Paper, University of California at Santa Cruz, July.

Eslava, M., J. Haltiwanger, A. Kugler, and M. Kugler (2004). "The Effects of Structural Reforms on Productivity and Profitability Enhancing Reallocation: Evidence from Colombia," *Journal of Development Economics,* 75, 333-71.

Fernandes, A.M. (2007). "Trade Policy, Trade Volumes and Plant-level Productivity in Colombian Manufacturing Industries," *Journal of International Economics*, 71(1), March, 52 – 71.

Goldberg, P.K., A. Khandelwal, N. Pavcnik, and P. Topalova (2010). "Imported Intermediate Inputs and Domestic Product Growth: Evidence from India," *Quarterly Journal of Economics,* forthcoming.

Haltiwanger, J. C. (1997). "Measuring and Analyzing Aggregate Fluctuations: The Importance of Building from Microeconomic Evidence." *Federal Reserve Bank St. Louis Review,* 79(3), May-June, 55-77.

Hsieh, C.-T. and P.J. Klenow (2009). "Misallocation and Manufacturing TFP in China and India," *Quarterly Journal of Economics*, 124(4), November, 1403-1448.

Javorcik, B.S. (2004). "Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages," *American Economic Review*, *94*(3), June, 605 – 627.

Lileeva, A. and D. Trefler (2010). "Improved Access to Foreign Markets Raises Plant-Level Productivity ... for Some Plants," *Quarterly Journal of Economics*, 125(3), August, xx-xx.

Olley, G. S. and A. Pakes (1996). "The Dynamics of Productivity in the Telecommunications Equipment Industry," *Econometrica* 64(6), 1263-97.

Pavcnik, N. (2002). "Trade Liberalization, Exit, and Productivity Improvement: Evidence from Chilean Plants," *Review of Economic Studies,* 69(1), January, 245 – 276.

Rodrik, D. (1992). "Closing the Productivity Gap: Does Trade Liberalization Really Help," in G. Helleiner (Ed.), *Trade Policy, Industrialization, and Development: New Perspectives*, Wider studies in development economics, Oxford: Clarendon Press, 155-175.

Salvo, A. (2010). "Inferring Market Power under the Threat of Entry: The Case of the Brazilian Cement Industry," *RAND Journal of Economics,* 41(2), 326-350.

Schor, A. (2004). “Heterogeneous Productivity Response to Tariff Reduction. Evidence from Brazilian Manufacturing Firms,” *Journal of Development Economics*, 75(2), December, 373 – 396.

Sivadasan, J. (2009). “Barriers to Competition and Productivity: Evidence from India,” *B.E. Journal of Economic Analysis & Policy*, 9(1), article 42.

Topalova, P. and A. Khandelwal (2010). “Trade Liberalization and Firm Productivity: The Case of India,” *Review of Economics and Statistics*, forthcoming.

Trefler, D. (2004). “The Long and Short of the Canada-U.S. Free Trade Agreement,” *American Economic Review*, 94(4), September, 870 – 895.

Tybout, J.R. (2003). “Plant- and Firm-Level Evidence on ‘New’ Trade Theories,” in E.K. Choi and J. Harrigan (Eds.), *Handbook of International Trade*, Oxford: Blackwell Publishing, 388-415.

Van Biesebroeck, J. (2007). “Robustness of Productivity Estimates,” *Journal of Industrial Economics*, 55(3), September, 529-569.

Figure 1: China's merchandise trade and FDI inflows

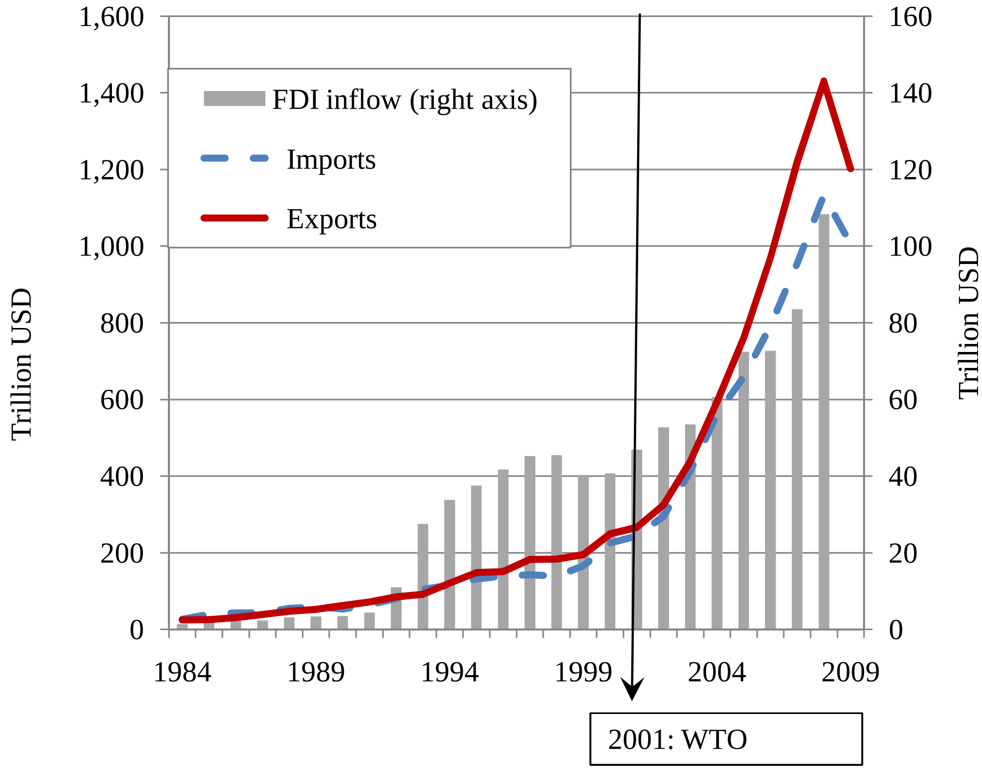

Figure 2: Evolution of trade protection over time

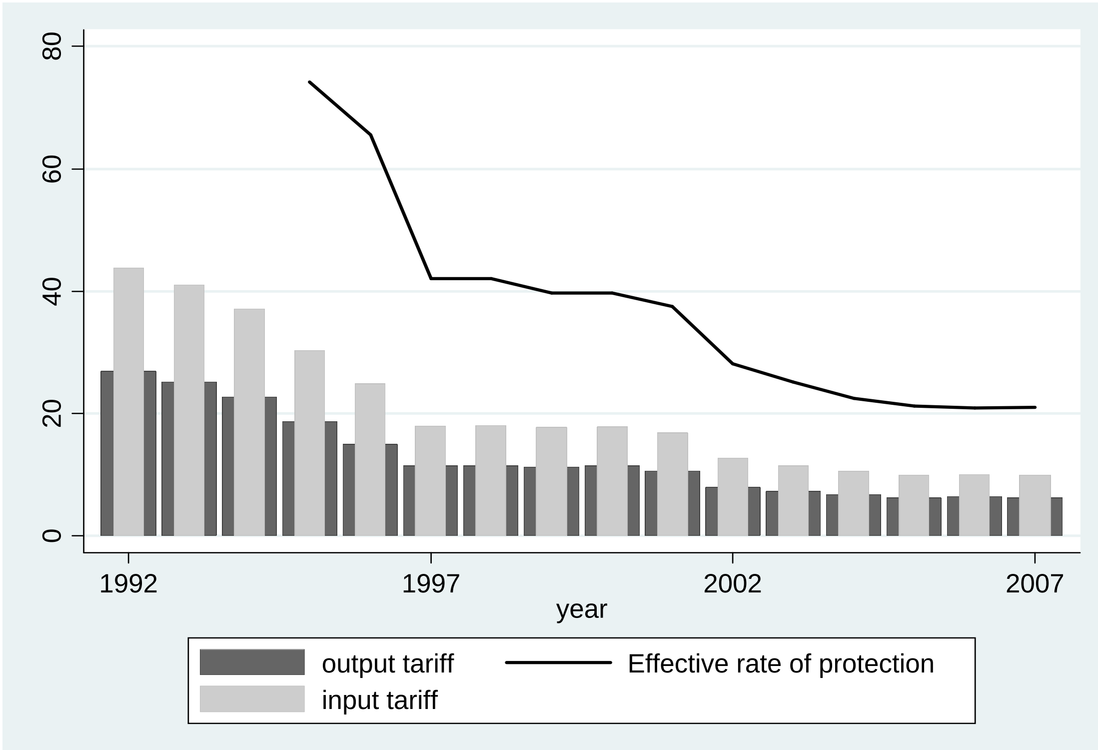

Figure 3: Distribution of trade protection

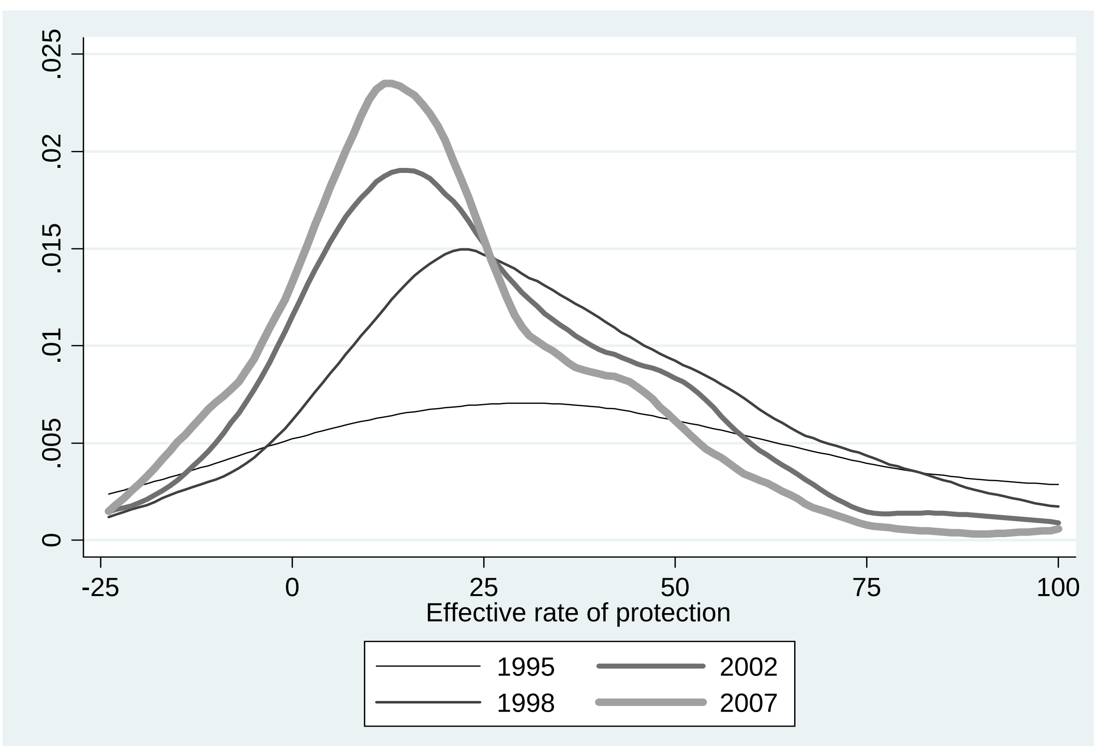

Figure 4: Ownership breakdown of firms, output, and exports

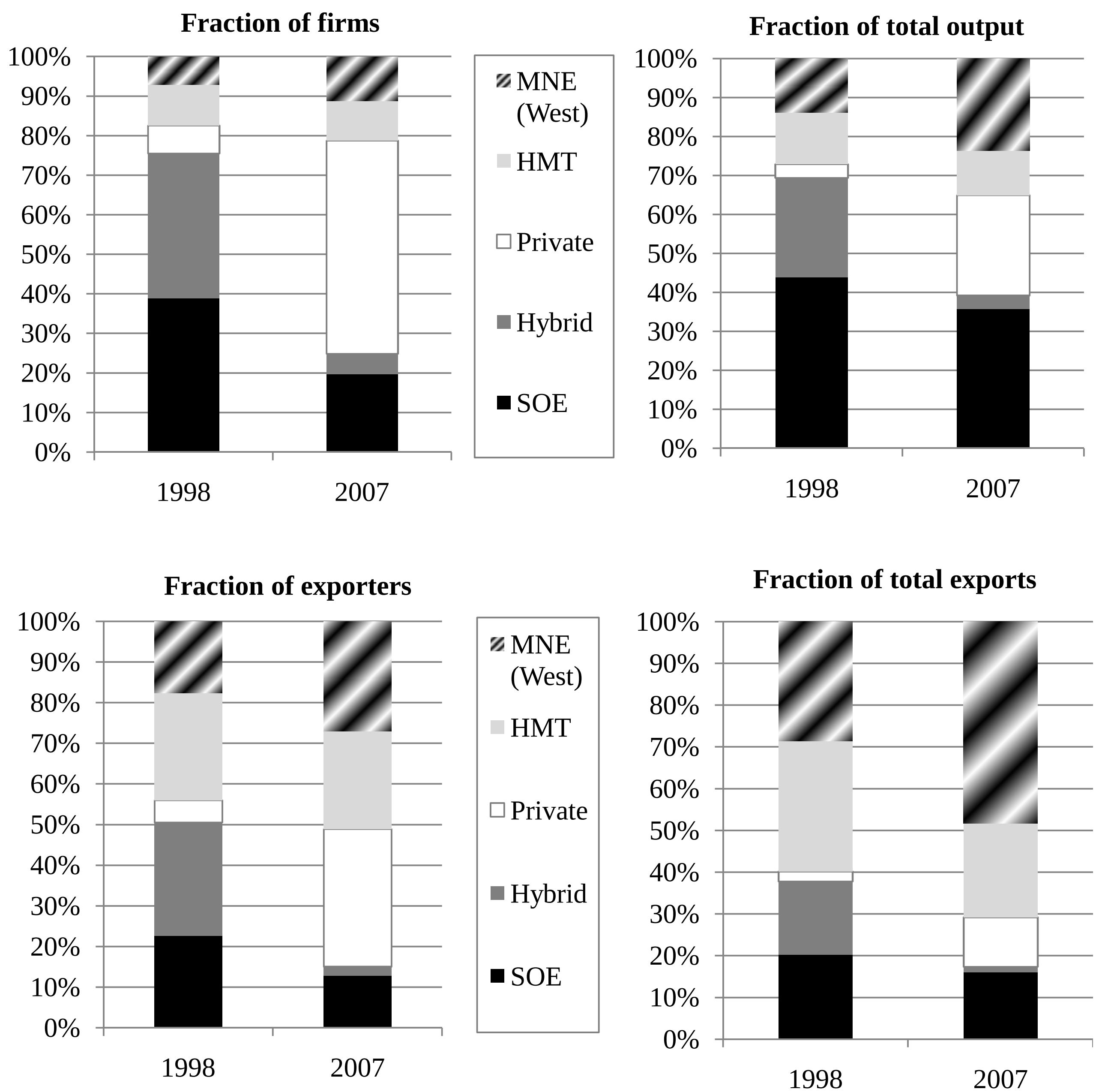

Figure 5: Productivity level and effective rate of protection (lagged-levels & changes)

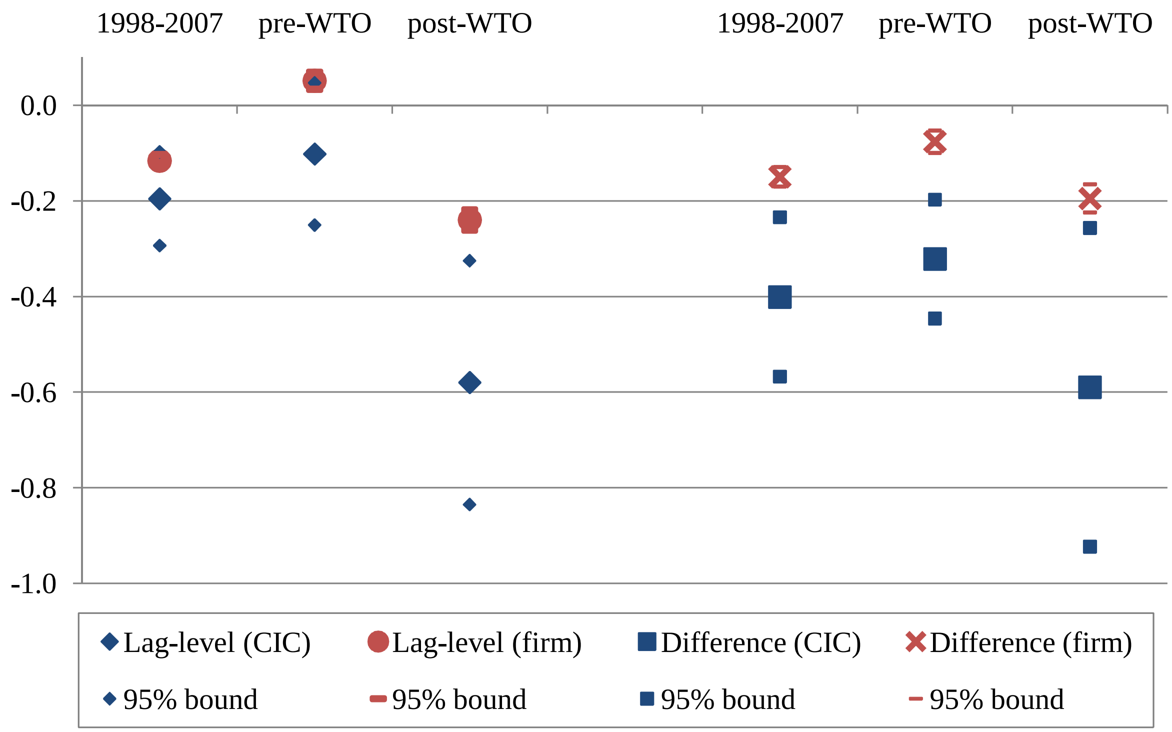

Table 1: Patterns in tariff protection across industries (1992)

	Dependent variable: output tariff at 4-digit CIC level	
	Effect	R^2
BEC categories		0.45
capital goods	−	
materials	−	
intermediates	−	
durable consumer goods	+	
Rauch index		low
differentiated products	+	
Industry attributes (Chinese census)		low
number of workers	+	
capital intensity	0	
SOE revenue share (1993)	−	(robust & significant)
Industry attributes (U.S. FTC)		0.25
R&D intensity	−	
Sales intensity	−	
Advertising intensity	+	

Table 2: Correlation between tariffs and productivity growth at the industry level (1998-2007)

(a) Final good (output) tariffs

Dep. variable:	Value added productivity growth			Gross output productivity growth		
	1998-2007	pre-WTO	post-WTO	1998-2007	pre-WTO	post-WTO
Tariff level (t-1)	-0.05	-0.03	-0.11**	-0.04***	-0.01	-0.07***
	(1.0)	(0.5)	(1.9)	(2.8)	(0.3)	(4.4)
Δtariff (t - t-1)	0.22	1.18***	-0.13	0.07	0.37***	-0.05
	(0.9)	(2.6)	(0.4)	(1.1)	(2.6)	(0.7)

(b) Effective rate of protection

Dep. variable:	Value added productivity growth			Gross output productivity growth		
	1998-2007	pre-WTO	post-WTO	1998-2007	pre-WTO	post-WTO
ERP level (t-1)	-0.03***	-0.03*	-0.05***	-0.02***	-0.01*	-0.03***
	(2.6)	(1.8)	(3.2)	(4.4)	(1.6)	(5.8)
ΔERP (t - t-1)	-0.40***	-0.55***	-0.33***	-0.11***	-0.11***	-0.11***
	(8.5)	(8.0)	(5.7)	(8.1)	(5.1)	(6.8)

Note: Seperate regressions with year fixed effects. Significant at the * 10% level, ** 5% level, *** 1% level.

Table 3: Robustness checks for the correlation between industry-level productivity growth and effective rates of protection

(a) 3-year intervals 1995-2007

Dep. variable:	Value added productivity growth					Gross output productivity growth				
	1995-07	1998	2001	2004	2007	1995-07	1998	2001	2004	2007
ERP level (t-3)	-0.05***	-0.08***	-0.04***	-0.04	-0.04	-0.02***	-0.02***	-0.01**	-0.02**	-0.02***
	(5.3)	(4.9)	(2.7)	(1.4)	(1.4)	(5.6)	(4.1)	(2.1)	(2.4)	(3.4)
ΔERP (t - t-3)	-0.12***	-0.15***	-0.17***	-0.09**	-0.18**	-0.03***	-0.03***	-0.04***	-0.03***	-0.07***
	(7.4)	(6.3)	(3.9)	(2.0)	(2.1)	(5.3)	(4.8)	(2.9)	(2.6)	(3.0)

Note: Seperate regressions with year fixed effects in the full-period and for separate 3-year periods in subsequent columns (year indicated is the end period).

(b) Productivity level as dependent variable with industry fixed effects

Dep. variable:	Value added productivity growth				Gross output productivity growth			
	1998-2007	post - WTO	1995-2007	post - WTO	1998-2007	post - WTO	1995-2007	post - WTO
	1 year intervals		3 year intervals		1 year intervals		3 year intervals	
ERP level (t-k)	-0.20***	-0.34***	-0.20***	-0.23***	-0.34***	-0.03**	-0.03*	-0.04*
	(4.9)	(4.0)	(3.4)	(2.6)	(3.0)	(2.1)	(1.6)	(1.7)
ΔERP (t - t-k)	-0.19***	-0.12***	-0.27***	-0.28***	0.02	0.05**	-0.04**	-0.04
	(3.0)	(1.1)	(4.1)	(2.9)	(1.0)	(2.3)	(2.4)	(1.6)

Note: interpretion of the coefficient is as in Table 2 or panel (a) above.

(c) Productivity growth as depedent variable with industry fixed effects

Dep. variable:	Value added productivity growth				Gross output productivity growth			
	1998-2007	post - WTO	1995-2007	post - WTO	1998-2007	post - WTO	1995-2007	post - WTO
	1 year intervals		3 year intervals		1 year intervals		3 year intervals	
ERP level (t-k)	0.01	-0.20***	-0.03	-0.14	-0.01	-0.07***	-0.01	-0.04
	(0.4)	(2.7)	(1.5)	(1.4)	(1.0)	(3.4)	(1.3)	(1.5)
ΔERP (t - t-k)	-0.40***	-0.45***	-0.11***	-0.18*	-0.10***	-0.16***	-0.02***	-0.06**
	(7.7)	(4.5)	(4.6)	(1.7)	(6.5)	(6.0)	(3.7)	(2.0)

Note: specification as in Trefler (2004) and amounts to double time differencing (dif-in-dif, with both differences in the time dimension). Interpretation of the coefficients are accelerations in productivity growth.

Table 4: Correlation between protectionism and imports at the industry level (2000-2006)

(a) Imports and tariff levels for two types of trade and two periods

Dep. variable:	Log of imports (2000-06)			Log of imports (Ordinary Trade)		
	Total Trade	Duty Free	Ordinary Trade	2000-06	pre-WTO (2000-02)	post-WTO (2002-06)
Tariff level (t-1)	-1.60**	0.22	-3.52***	-3.52***	-2.82**	- 3.90***
	(0.7)	(0.8)	(0.7)	(0.7)	(1.1)	(0.8)
Δtariff (t - t-1)	-4.90*	-3.48	-6.09**	-6.09**	-7.79*	-6.26**
	(2.8)	(3.2)	(3.0)	(3.0)	(4.1)	(3.1)

(b) Imports and protectionism: final good (output) tariffs and effective rates of protection

Dep. variable:	Log of imports (2000-06, OT)		Log of imports (2000-06, OT)	
Explanatory variable	tariff level		Effective rate of protection	
	1y lag	3y lag	1y lag	3y lag
Level of protection (t-k)	-3.52***	-4.41***	-0.38**	-0.61**
	(0.7)	(0.9)	(0.2)	(0.2)
Δprotection (t - t-k)	-6.09**	-5.31***	-0.48	-0.87**
	(3.0)	(1.9)	(0.6)	(0.4)

Note: similar regressions as in panel (a), but limited to ordinary trade (OT) and the entire 2000-06 period

(c) Imports and tariffs using different estimation methods and dependent variables

Dep. variable:	Log of imports (2000-06, OT)			Log of imports (2000-06, OT)			
	OLS	year FE	year & CIC FE	Capital	Inter-mediates	Materials	Other
Tariff level (t-1)	-4.49***	-3.52***	0.34	-4.13***	-5.43***	-4.78***	6.56***
	(0.7)	(0.7)	(0.9)	(0.8)	(1.8)	(1.3)	(0.9)
Δtariff (t - t-1)	0.41	-6.09**	-0.52	-9.09***	-6.15**	4.50	-6.59*
	(2.5)	(3.0)	(1.6)	(3.4)	(4.4)	(5.4)	(3.7)

Note: Seperate regressions with year fixed effects (except for columns (1) and (3) in panel (c). Significant at the * 10% level, ** 5% level, *** 1% level.

Table 5: Imported Intermediates

(a) Use of imported intermediates

Year	Percentage of firms using imported intermediates			Imports as a fraction of intermediate inputs		
	Total	Duty free	Ordinary trade	Total	Duty free	Ordinary trade
2000	11.2%	9.6%	6.2%	7.8%	5.5%	2.4%
2001	11.7%	9.7%	6.5%	7.3%	4.9%	2.5%
2002	12.1%	9.9%	7.5%	7.9%	5.5%	2.4%
2003	12.2%	9.7%	8.0%	8.3%	5.5%	2.8%
2004	12.7%	10.1%	8.2%	9.9%	6.8%	3.2%
2005	13.3%	10.3%	8.6%	8.9%	6.3%	2.7%
2006	12.9%	9.8%	8.7%	9.4%	6.6%	2.9%

(b) Fraction of inputs imported by ownership category

	Fraction of firms		Total trade	Duty free	Ordinary trade	Total trade	Duty free	Ordinary trade
	2000	2006	2006	2006	2006	Change 2000 to 2006		
Foreign	7.9%	11.2%	26.0%	19.5%	6.8%	-2.1%	-0.4%	-1.5%
HMT	11.0%	10.3%	16.5%	13.0%	3.8%	-0.5%	-0.3%	0.0%
Hybrid/Collective	43.3%	24.1%	2.3%	0.8%	1.6%	1.2%	0.3%	1.0%
Private	14.5%	50.9%	0.9%	0.4%	0.5%	0.4%	0.1%	0.3%
State	23.3%	3.5%	2.8%	0.7%	2.1%	1.4%	0.2%	1.3%

Note: sample is the universe of above scale manufacturing firms. Trade informaton is obtained by matching firms to customs records.

Table 6: Correlation between price changes and tariff changes

	One-year changes: $(p_t\text{-}p_{t-1})/p_{t-1}$			Two-year changes: $(p_t\text{-}p_{t-2})/p_{t-2}$		
Deflator used:	2-digit	2-digit	4-digit	2-digit	2-digit	4-digit
	1995-2007	post-WTO (2001-07)	post-WTO (2001-04)	1995-2007	post-WTO (2001-07)	post-WTO (2001-05)
(a) Output (final good) prices and tariffs						
$\Delta tariff_{output}$	0.147***	0.460***	0.322***	0.310***	0.621***	0.403***
(b) Input (IO weighted) prices and tariffs						
$\Delta tariff_{input}$	0.873***	1.979***	1.115***	1.574***	2.703***	1.190***

Note: All coefficients are estimated to be significantly different from zero at the 1% significance level, using standard errors clustered at the 4-digit CIC level.

Table 7: Correlation between tariffs and productivity growth at the firm level (2002-2007)

(a) Benchmark: ERP (changed in (b)), VA (c), 1 year lag (d), firm FE (e)

Dep. variable:	Industry-level TFP (to compare)	Firm-level TFP (index)	Firm-level TFP (OP)
ERP level (t-1)	-0.581***	-0.240***	-0.098***
	(0.13)	(0.01)	(0.01)
ΔERP (t - t-1)	-0.586***	-0.195***	-0.035**
	(0.17)	(0.01)	(0.01)

Note: Benchmark regressions use ERP as measure of trade protection (b), a value added productivity concept (c), 1 year lags (d), firm fixed effects (e). These four assumptions are subsequently modified in the panels indicated. All regressions are for the post-WTO period and productivity in levels.

(b) Final good (output) tariffs (instead of ERP)

Dep. variable:	Industry	Firm (index)	Firm (OP)
tariff level (t-1)	-1.147*	-1.066***	-0.591***
	(0.61)	(0.04)	(0.04)
Δtariff (t - t-1)	0.937	-0.272***	-0.286***
	(0.91)	(0.06)	(0.06)

(c) Gross output production function (instead of value added)

Dep. variable:	Industry	Firm (index)	Firm (OP)
ERP level (t-1)	-0.377**	-0.175***	-0.112***
	(0.17)	(0.01)	(0.00)
ΔERP (t - t-1)	-0.290	-0.114***	-0.055***
	(0.21)	(0.02)	(0.01)

(d) Two year lag and difference (instead of one year)

Dep. variable:	Industry	Firm (index)	Firm (OP)
ERP level (t-1)	-0.465***	-0.267***	-0.145***
	(0.18)	(0.01)	(0.01)
ΔERP (t - t-1)	-0.439**	-0.193***	-0.031***
	(0.19)	(0.01)	(0.01)

(e) Industry FE in (2)-(3) (instead of firm FE)

Dep. variable:	Industry	Firm (index)	Firm (OP)
ERP level (t-1)	-0.581***	-0.656***	-0.712***
	(0.13)	(0.02)	(0.02)
ΔERP (t - t-1)	-0.586***	-0.466**	-0.542***
	(0.17)	(0.03)	(0.02)

Note: Seperate regressions with year fixed effects; Significant at the * 10% level, ** 5% level, *** 1% level.

Table 8: Correlation between tariffs and the contribution of net entry to productivity growth

(a) Benchmark: Value added productivity (b), ERP (c), B-H-C decomp. (d), absolute growth (e)

	1998-2007	pre-WTO	post-WTO	1998-2007 with FE
ERP level (t-k)	-0.336**	-0.013	-0.260***	-0.116
	(0.14)	(0.07)	(0.10)	(0.22)
ΔERP (t - t-k)	-0.463**	-0.071	-0.500**	-0.195
	(0.19)	(0.12)	(0.21)	(0.23)

Note: The dependent variable is the absolute contribution of net entry to sectoral productivity growth, always comparing productivity of entering and exiting firms to the initial aggregate productivity level of the sector. The benchmark regressions in panel (a) use a value added productivity concept (b), ERP as measure of trade protection (c), the decomposition based on Haltiwanger (1997) (d), and the absolute productivity growth generated through net entry (e). These four assumptions are subsequently modified in the panels indicated. The regressions in the first three columns are for a single cross-section of sectors; the results in the last column pool the pre- and post-WTO periods and include industry FE.

(b) Gross output productivity

	1998-2007	pre-WTO	post-WTO	1998-2007 with FE
ERP level (t-k)	0.420*	0.212*	0.042	-0.367
	(0.22)	(0.12)	(0.17)	(0.38)
ΔERP (t - t-k)	0.230	0.063	-0.588*	-0.817**
	(0.30)	(0.22)	(0.36)	(0.41)

Note: Turns negative (and significant) in (e) for 1998-2007

(c) Output (final good) tariff

	1998-2007	pre-WTO	post-WTO	1998-2007 with FE
tariff level (t-k)	-1.268***	-0.201***	-0.790**	-0.746
	(0.51)	(0.01)	(0.36)	(0.89)
Δtariff (t - t-k)	-2.148***	-0.375***	-2.005**	-0.348
	(0.77)	(0.02)	(0.86)	(1.07)

(d) Petrin-Levinsohn (2009) decomposition

	1998-2007	pre-WTO	post-WTO	1998-2007 with FE
ERP level (t-k)	-0.166**	-0.007	-0.113**	-0.083
	(0.07)	(0.03)	(0.05)	(0.11)
ΔERP (t - t-k)	-0.239**	-0.046	-0.241**	-0.125
	(0.10)	(0.06)	(0.10)	(0.12)

(e) Fraction of aggregate growth

	1998-2007	pre-WTO	post-WTO	1998-2007 with FE
ERP level (t-k)	-0.050	-0.110	-0.043	0.093
	(0.06)	(0.08)	(0.07)	(0.20)
ΔERP (t - t-k)	-0.038	-0.102	-0.041	0.168
	(0.08)	(0.14)	(0.14)	(0.21)

Note: Seperate regressions in each column of each panel. Significant at the * 10% level, ** 5% level, *** 1% level.

Table 9: Correlation between tariffs and the contribution of firms that switch industry to sectoral productivity growth

	1998-2007	post-WTO		1998-2007	post-WTO
ERP level (t-k)	-0.053*	-0.049	Tariff level (t-k)	-0.196*	-0.131
	(0.03)	(0.03)		(0.10)	(0.13)
ΔERP (t - t-k)	-0.074**	-0.064	Δtariff (t - t-k)	-0.321**	-0.050
	(0.04)	(0.07)		(0.16)	(0.30)

Note: The dependent variable is the absolute contribution to sectoral productivity growth of one group of firms, those that survive the period but switch industries. The regressions are for a single cross-section of sectors. Significant at the * 10% level, ** 5% level, *** 1% level.

Table 10: Correlation between tariffs and the output share-productivity link (1998-2007)

(a) Dependent variable is the change in the absolute importance of the correlation term

	Value added productivity		Gross output productivity	
	(index)	(OP)	(index)	(OP)
Constant	0.351***	0.786***	0.014***	0.163***
	(0.04)	(0.12)	(0.01)	(0.02)
ERP level (t-k)	-0.097	-0.281	0.020	-0.215***
	(0.14)	(0.36)	(0.02)	(0.05)
ΔERP (t - t-k)	-0.346**	-0.047	0.024	-0.268***
	(0.18)	(0.47)	(0.02)	(0.07)

(b) Robustness check using final good (output) tariffs

	Value added productivity		Gross output productivity	
	(index)	(OP)	(index)	(OP)
Constant	0.332***	0.827***	0.015*	0.183***
	(0.06)	(0.17)	(0.01)	(0.03)
Tariff level (t-k)	-0.238	-0.984	0.046	-0.761***
	(0.47)	(1.33)	(0.06)	(0.19)
ΔTariff (t - t-k)	-1.156*	-0.495	0.063	-1.020***
	(0.68)	(1.84)		