WTO Accession and Performance of Chinese Manufacturing Firms*

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Abstract

China's policy-makers argued that WTO accession and the accompanying trade liberalization would have a beneficial impact on the domestic economy. China's import tariffs differed tremendously across industry in the earlier years, but converged to an almost uniform low level after WTO entry. We exploit sectoral variation in the extent of tariff reduction to identify the impact of increased import competition on firm performance and its contribution to the significant productivity growth over the 1995–2007 period. We find evidence of strong downward pressure on prices and mark-ups, but limited evidence that imports took away market share from domestic firms. Furthermore, much of the effects on sectoral productivity come from changes at the extensive margin. Sectors that liberalized most tend to attract especially productive entrants, private firms in particular, which can be rationalized by an increase in the minimum productivity threshold needed to survive in these sectors.

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"The competition arising [from WTO membership] will also promote a more rapid and more healthy development of China's national economy"

Premier Zhu Rongji (Press release, Washington, DC, April 1999)

1. Introduction

China has enjoyed impressive productivity growth in its manufacturing sector for a decade or more (Brandt, Van Biesebroeck and Zhang, 2012). In most narratives, the opening to the international economy and the growth of foreign trade are viewed as key drivers. This process began in earnest in the early 1980s with the establishment of the Special Economic Zones (SEZ) and Economic and Technical Development Zones (EDTZ) in coastal cities. New momentum may have come with China's entry into the WTO. Constrained by domestic political economy considerations in their efforts to restructure major segments of industry, Chinese leaders such as Premier Zhu Rongji believed that reforms mandated as a condition for WTO accession would be a catalyst for change.[1]

Drawing on a firm-level data set that spans the period 1995-2007, our primary purpose is to analyze the effect of several dimensions of policy reforms on firm and sector-level productivity. Over this period, industry-level TFP growth averaged more than 12 percent per annum. The central hypothesis we wish to examine is whether the dispersion in productivity growth we observe within the manufacturing sector, as shown in Figure 1, can be linked to these WTO-related policies; and if so, through what channels. China entered the WTO at the end of 2001, but many policy changes actually predate its entry. Drawing on information we collected on import tariffs, non-tariff barriers and FDI restrictions over the entire period, we investigate the relative importance of alternative mechanisms through which policy changes may have mattered.

We focus on reform efforts that facilitated access to the domestic Chinese market for the rest of the world, not on the effects coming from China's access to overseas markets and exports. Our rationale for doing so is two-fold. First, over the period we examine, eighty percent of China's manufacturing output was consistently sold domestically (Brandt and Thun, 2010). Exports are an important part of the Chinese economy, but even more important is manufacturing activity directed to the domestic market, including intermediate inputs. Moreover, through the processing trade regime, which represents more

[1] The message in the above quote, made after ironing out final details about the WTO accession with President Clinton, is echoed by several researchers. For example, Lardy and Branstetter (2008) also view more competition as an essential source of pressure that forced structural reforms.

than half of China's total trade, exporting firms already benefitted from tariff-free imports of intermediates. Second, even before entry into the WTO, China already enjoyed most-favored nation status in several countries, albeit on an annually-renewable basis in the United States.[2] Elimination of this uncertainty is likely to have had positive effects on Chinese firms, but such a benefit is hard to quantify and we conjecture it is likely to be smaller than the effects coming through increased competition in the domestic market.

To make our argument credible, we need an identification strategy that causally links policy changes to performance changes. Reverse causality due to policy endogeneity is an intuitive and often plausible alternative explanation for a positive correlation (Besley and Case, 2000). Policy makers might have lowered import tariffs selectively after learning which sectors are most likely to enjoy strong productivity growth and thus be able to cope with increased foreign competition. We argue that the striking uniformity of the post-reform import tariff rates makes this reverse causality an unlikely explanation. Policy changes are almost entirely the result of moving all sectors to the same (low) level of tariff protection, making endogeneity a less serious issue.

The sheer size of our data set helps to pin down the effects of liberalization. We observe the universe of state-owned firms and all other firms (collective, private and foreign) with annual sales above 5 million RMB. Limited to the manufacturing sector and the 1998-2007 period, this results in a sample of 2.05 million observations across 536,945 unique firms. As a result, we can include detailed 4-digit industry fixed effects and lagged tariff levels even in a regression in first differences without losing all identifying power.

Entry into the WTO required large reductions 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). We focus primarily on the role of tariff reductions, which are observed most accurately, but also look for links with the other two policy variables. 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: through the effect on prices of imports that compete with locally manufactured goods, and through the prices (as well as quality and variety) of imported intermediate goods (Topalova and Khandelwal 2011). We focus on the combined effect, using the change in effective rate of protection as explanatory variable, but we have also estimated the effects of tariffs on outputs and inputs separately as a sensitivity check.

[2] In the EU, there was no annual renewal process, but a surge of Chinese imports in Europe could very well have led to reinstatement of discriminatory tariffs. This is exactly what happened when the MFA (Multi-Fiber Agreement) for apparel and textile products ended in 2006.

To build confidence in our argument, we carefully examine the mechanism through which the policy change had its effect. We estimate the effects of tariff liberalization on several dependent variables using the same specification for each. The results establish that the cross-sectoral variation in liberalization was only weakly related to the variation in import growth, while the link with reductions in sectoral price indices and price-cost margins is much stronger. In particular, despite a very low import share for most inputs, tariff cuts for inputs are passed-through one-for-one into the sectoral input price indices. In the short run, domestic firms can match price reductions for imports by lowering price-cost margins, but in the long run these cuts must be backed up by productivity increases.

Tariff reduction is found to play an important role there, but the association between productivity growth and tariff reductions is stronger at the sector than at the firm level. We investigate potential explanations by decomposing the sector-level productivity growth into three components and using each one as a separate dependent variable in the same specification as before. The link between tariff liberalization and the contribution of net entry to sector productivity is by far the strongest of the three. The beneficial effect of reallocating resources from exiting to entering firms is strongly associated with the liberalization. This effect is working primarily through the entry of especially productive private firms in more competitive sectors. Private sector entry is large in nearly all sectors over this period, but the "quality" of the entrants is increasing in the degree of competition they will face. Falling tariffs effectively raise the productivity threshold that these firms must achieve in order for entry to be profitable.

The remainder of the paper is organized as following. Section 2 discusses the history of China's relevant policies. Section 3 reviews the literature on trade liberalization effects and motivates the identification strategy of this paper. Section 4 describes the data. Section 5 shows the empirical findings on the impact of the tariff reduction on various variables of interest and pins down the channels through which it affects industry and firm-level productivity growth. Section 6 concludes.

2. Liberalization of China's foreign trade and investment regime

2.1 Evolution of the policy regime

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 Economic and Technical Development Zones in fourteen coastal cities, China encouraged foreign direct investment (FDI) to develop a manufacturing export sector through the importation of much-needed capital, managerial know-how, and technology. Outside of these zones it allowed the importation and licensing of new technologies and capital goods as part of a policy of modernizing existing domestic enterprises. It concurrently started 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. China's renewed openness combined with domestic economic and institutional reform initiatives served as important catalysts for economic growth which has averaged nearly 8 percent per annum in terms of GNP per capita.

2.2 Quantifying the reduction in protectionism

Branstetter and Lardy (2008) observe that even before its accession to WTO at the end of 2001, China's manufacturing sector was already relatively open on several dimensions. First, as part of a policy of encouraging FDI for exporting, China allowed the duty-free importation of raw materials and parts and components involved in export processing, as well as the capital equipment to be used. Exemption of import duties was further expanded in the late-half of the 1990s to certain type of domestic firms and organizations. Branstetter and Lardy (2008) report that in 2000 less than 40 percent of imports were subject to tariffs. Second, beginning in the early 1990s, China started to lower its domestic tariffs. The average tariff at the 8-digit HS level was lowered from an average of 43.2 percent in 1992 to 15.3 in 2001. This was accompanied by a reduction in the share of imports regulated by non-tariff barriers through licenses and quotas (Branstetter and Lardy, p. 635).

In Figure 2 we plot the evolution of the fraction of sectors covered by an average import tariff in excess of fifteen percent, or that contain a product subject to a nontariff barrier or FDI restriction or prohibition. Import tariffs are set at the 8-digit level of the Harmonized System product classification. We map them into China's Industrial Classification (CIC) system at the 4-digit level for the firm and industry-level analysis.[3] To avoid biasing the sectoral average by the low trade volumes in heavily protected product lines, we use an unweighted average. Input tariffs are a weighted average of output tariffs, using industry-input shares from the 2002 Input-Output (IO) table. Reflecting the higher level of aggregation of the Chinese IO table, the input tariffs are effectively at the 3-digit level. 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 1995 to 2007 period.

Drawing on annual circulars of the Ministry of Foreign Trade and Economic Cooperation and the Ministry of Commerce, we also assembled information on the licensing of imports and exports. The measure of non-tariff barriers in Figure 2 is the fraction of sectors, at the 4-digit CIC level, that contains

[3] We extend the HS–CIC concordance table created by the NBS to include all manufactured products (HS) and manufacturing sectors (CIC) and correct several mistakes (about 100). Changes in the HS system in 2002 (affecting nearly ten percent of all product lines) and in the CIC system in 2003 required multiple concordance tables.

at least one 8-digit HS product subject to an import license. It declined from 15.3% in 1997 to 1.2% in 2007 after a brief rise to 22.6% in 2000. The weighted average fraction of products subject to such a license is much smaller, declining from 5.5% to 0.04% over the same period.[4] Information on FDI restrictions comes from the same sources. Sectors can be subject to an FDI restriction or a total prohibition and the indicator in Figure 2 includes either. The total number of sectors subject to some form of FDI restriction declined from a high of 87 (out of 425 sectors) in 1997 to 47 in 2007. The decline is more rapid for the restrictions than the prohibitions, which made up one-fifth of the total in 2007.

The correlation across sectors between the different forms of protection is positive in 1997: We observe a partial correlation of 0.27 between NTB and FDI restrictions, 0.16 between NTBs and tariffs over 15%, but no correlation between FDI restrictions and high tariffs. By 2007, however, the correlations between tariffs and either NTBs or FDI restrictions have become very weak and not statistically significant from zero, while the correlation between NTB and FDI has dropped to 0.1. This behavior reflects the convergence of import tariffs to a fairly uniform level in all sectors and the dwindling importance of recorded NTBs.[5]

Figure 3 provides more information on the evolution of import tariffs over the 1995-2007 sample period. Several patterns stand out. First, output tariffs are on average substantially higher than input tariffs, reflecting the very different treatment of final goods from raw materials, intermediates inputs, and capital imports. As a result, effective rates of protection (ERP) are considerably higher than the stated tariff rates.[6] Second, tariff reduction has proceeded in two spurts, with large and widespread reductions between 1992 and 1997, and then again in 2002, with more heterogeneous and gradual reductions in the other years. Tariff reductions became more predictable as negotiations proceeded, and after WTO entry followed a predetermined pattern. Third, by the end of the period the average difference between input and output tariffs fell to less than four percentage points. Combined with the rising share of value added in total output, this narrowing contributes to a gradual reduction in the effective rate of protection.

The average evolution hides important variation across industries that we use to identify the effects. The dashed lines, denoting the inter-quartile range for ERP, highlight that industries initially differed tremendously in the protection they received. The narrowing of the band, from approximately 20–120% in 1995 to 5–30% in 2007, highlights the important tariff compression. The experience of different sectors must have differed substantially.

[4] Here we use as weight the world trade volume at the 6-digit HS level from the UN Comtrade database.

[5] The reductions in NTBs and output tariffs between 1997 and 2007 are orthogonal however, suggesting that there is some independent information in the two sets of changes.

[6] In the Figure 3, note that that the left and right axis use different scales.

3. Literature, empirical model, and estimation

3.1 Literature

A large literature investigates the potential positive effects of broad-based tariff reductions on domestic industries. One channel featured prominently in the early literature is the impact of foreign competition on price-cost margins.[7] Studies using either accounting measures of the price-cost margin or an adaptation of the Hall methodology to parameterize the average mark-up as a function of trade protectionism systematically find evidence of downward pressure on these margins. Roberts and Tybout (1996) contains studies for four developing countries that use accounting measures, while Levinsohn (1993), Harrison (1994), and Krishna and Mitra (1998) utilize the second methodology in studies for Turkey, Cote d'Ivoire, and India.

The effect of trade liberalization can also work through size rationalization: Smaller firms are forced to exit and production at higher scale is more efficient. Firm-level studies found support for this mechanism following the Canada-U.S. FTA (Head and Ries 1999; Baggs 2005), but not in Mexico (Tybout and Westbrook 1995). In a recent study revisiting the Canadian experience, Baldwin and Gu (2008) find an effect on the size of production runs within plants, pointing to an important within-plant scale effect at the product level.

These effects at the extensive margin are consistent with the heterogeneous firm model of Melitz (2003). Each firm is assumed to operate with a constant level of productivity, but as trade barriers fall and foreign firms start selling in the domestic market, the minimum level of productivity that the marginal firm needs to break even rises. In the context of Columbia's trade liberalization experience, Eslava et al. (2004) show this mechanism is quantitatively important. The reallocation of inputs and outputs is not limited to firm entry and exit however. Hsieh and Klenow (2009) demonstrate that market distortions tend to be larger in developing countries like China or India than in the United States, resulting in a wider dispersion of productivity among active firms. As competition increases following trade liberalization, the scope for productivity improvement through factor reallocation among active firms is likely to be larger in these countries.

In these mechanisms, trade liberalization can improve aggregate productivity even without any change for individual firms. To raise long-run productivity growth, firm-level changes are needed. For example, stronger competition could force firms to improve technical or allocative efficiency. Investment in new technology can achieve the same, but the loss of domestic market share to imports lowers investment

[7] Tybout (2003) reviews the theory and evidence behind this mechanism.

incentives and works in the opposite direction. If trade liberalization is part of a bilateral agreement, increased market access in the trading partner's economy could provide investment incentives, as in the Canada-U.S. FTA that Lileeva and Trefler (2010) study. In a more open economy, firms must also satisfy more demanding clients, either overseas or locally (Javorcik, 2004).

Goldberg et al. (2010) adopt a production structure from endogenous growth models that features a domestic production cost that declines in the number of imported input varieties. When trade is liberalized and the range of imported products expands, the domestic industry endogenously raises its productivity and is able to introduce new products for export as well. The Indian experience provides evidence for the importance of this mechanism. Lower import tariffs on inputs are estimated to account for almost one-third of new product introductions, driven primarily by increased firm access to input varieties.

To identify the effect of trade liberalization on productivity, most studies follow a two-step approach. In the first stage a productivity measure is constructed, which in the second stage is regressed on measures of trade liberalization. The second stage regression can be run in levels, as in Pavcnik (2002) for Chile, but often firm-fixed effects are included or the equation is estimated in first differences.[8] Trefler (2004) even uses double (time) differences to control for heterogeneity in baseline growth rates. Studies differ in the use of tariff rates or trade flows as measures of trade liberalization, in the way productivity is constructed, and 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. from different patterns of changes in protectionism across industries.

Schor (2004) and Amiti and Konings (2007) follow a similar approach, studying the experience of Brazil and Indonesia, but they additionally include in the regression the level of tariff protection on a sector's intermediate inputs. Both studies find that tariff reductions on inputs raise productivity more than tariff reductions on outputs. They do not model the underlying mechanism, but the relative sizes of these effects are consistent with the Indian evidence and the endogenous growth model in Goldberg et al. (2010). Allowing for separate effects by productivity deciles, Schor (2004) further highlights that the positive effect of cuts in input tariffs on productivity are relatively constant across the productivity distribution. Output tariff cuts, however, improve productivity at the bottom of the distribution, but diminish it at the top.

[8] Some 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 (2011) for India.

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). The decision of heterogeneous firms when to adopt productivity-enhancing technological improvements will depend crucially on their expected market share as the fixed costs of adoption need to be recovered. As trade liberalization raises the expected degree of competition and reduces expected market share, some firms will postpone adoption. Firms with characteristics that are related to fast technology adoption, most likely firms with a high productivity level, are likely to suffer most from trade liberalization: "An increase in tariff barriers should result in larger firms, exporting firms and younger firms having higher productivity growth." (Ederington and McCalman, 2009, p. 18) They find support for these predictions in the case of Colombia, but recall that the evidence for Brazil in Schor (2004) pointed in the opposite direction.

3.2 Empirical specification

In light of the previous discussion, we estimate equations of the form:

$$\Delta^k \ln X_{(i)st} = \ln X_{(i)st} - \ln X_{(i)st-k} = \beta_1 T_{st-k} + \beta_2 \Delta^k T_{st} + \alpha_t + \varepsilon_{(i)st} \,. \quad (1)$$

The specification can represent a firm-level (*i*) regression or one at the industry level (*s*), in which case the optional *i* subscript is omitted. We will use several dependent variables, namely, trade flows, price indices, productivity growth, and the individual terms in a linear decomposition of sectoral productivity growth. These regressions can also be estimated in levels with firm or industry-fixed effects included, which lead to very similar results.

The key explanatory variable is the level of trade protectionism (*T*) which is measured using either the import tariff or the effective rate of protection (ERP). The effective rate of protection tends to be higher, as tariffs are generally lower for inputs than for final goods (see Figure 3), and has declined more over the sample period. We include both the lagged level of protectionism and the first difference. The first variable informs us to what extent the variation of the dependent variable across sectors is associated with initial rates of protection, while the second variable captures the association between tariff declines and changes in the dependent variable, controlling for the initial rate of protectionism and an unobserved but constant year effect. The same time lag *k* is used for both variables.

The interpretation of β_2 as the causal effect of, for example, tariff reduction on productivity growth, depends on the exogeneity of the policy change. An unexpected and broad-based implementation, as in the case of the Canada-U.S. FTA, would be helpful in this regard. Trefler (2004) argues that tariff cuts affecting all sectors were announced suddenly and applied quickly thereafter, leaving individual industries little time to lobby for exemptions or preferential treatment. An additional element in his study is the use of double-time differences to control for initial heterogeneity in growth rates and sole focus on a correlation between tariff cuts and the change in productivity growth. The industry or firm-fixed effects already absorb heterogeneous but constant factors that are correlated with the reduction in protectionism. Fernandes (2007) relies on this in her analysis for Colombia. She also uses lagged tariff changes, as these are less likely to be correlated with contemporary productivity shocks.

Several researchers rely on instruments for tariffs that are unlikely to be correlated with productivity changes. Trefler (2004) uses the share of unskilled labor in total employment as a proxy for the likelihood that a sector organizes itself and tries to block tariff liberalization. Amiti and Konings (2007) use the initial tariff level as an instrument for the change in tariffs. The underlying assumption is that policy-makers did not discriminate between sectors and lowered tariff protection to the same level for each sector. Thus, the change in tariff reduction is explained entirely by the initial situation, not by policy discretion. Topalova (2007) makes a similar argument in her study of poverty and inequality in India.

3.3 Endogeneity of tariff reductions

This last argument also fits the Chinese situation rather well. In Figure 4 we plot the change in import tariffs on the vertical axis against the initial level of protection on the horizontal axis. The top panel shows the change between 1992 and 2007, which covers the full period of China's trade liberalization. The dispersion of protection across sectors is extremely wide in 1992, with nine sectors receiving protection of more than 100 percent. By 2007, only a single industry had an import tariff above 40 percent and only nine exceeded the 25 percent threshold. As a result, the relationship between tariff reduction and initial protection is almost one-to-one. Note also the good fit of the dashed line that has a slope of minus one.[9]

The results suggest that over the full period there was very little policy discretion in the extent of trade liberalization in each sector. The average import tariff declined from 43.8 to 9.9 percent between 1992 and 2007, but equally remarkable was the decline in standard deviation across sectors from 28.0 to 7.0 percent over the same period.[10] Moreover, the partial correlation between tariff rates in these two years is extremely high at 0.70. The dispersion in 2007 is well explained by the initial dispersion, suggesting that the decline was almost entirely proportional. The only flexibility left for policy makers was the timing of

[9] The solid line on the graph represents a simple linear regression of the change on the level; it has a slope of -0.84 and R-squared of 0.96.

[10] Another indicator of the lack of dispersion in 2007 is that half of the sectors received an import tariff between 5.3% and 13.5%, for an inter-quartile range of only 8.2%; the corresponding range in 1992 was 40%.

when exactly to reduce a particular sector's tariff rate and the lagged rate of protection is included in the regression to control for the existing degree of protection in a sector when its rates came down.

The bottom panel of Figure 4 indicates that there is more heterogeneity in the extent of tariff reductions in the post-WTO period (2001–2007). For example, the observations above the solid regression line on the right of the graph are sectors with relatively high tariff rates at the eve of WTO accession that experience below average tariff declines. This leaves some scope for policy endogeneity, but only in an expectational sense as tariff cuts after 2001 are already fixed in the accession agreement. Policy makers can only tailor the cuts for specific sectors to satisfactory productivity performance insofar as performance could be predicted when the agreement was being negotiated. It is not the dependency of policy on unobservables that one usually worries about.

Results in Table 1 for regressions of tariff levels on industry characteristics in three separate years are consistent with the above description of the liberalization process. The estimates in column (1) for 1995—the earliest years for which such regressions are possible--indicate that tariffs were significantly lower for sectors producing intermediate and capital goods and for sectors that are more capital or skill intensive in the United States. This is consistent with a desire to force firms in crucial sectors for industrial development to improve by exposing them to more foreign competition.[11] Sectors with high levels employment, especially of less educated workers, and more concentrated sectors also enjoyed higher tariffs. The importance of a these China-specific characteristics before 1995 likely reflects political economy considerations.

The corresponding estimates for tariffs in 2001 and 2007, reported in columns (2) and (3), are by and large consistent with an across-the-board and indiscriminate lowering of all tariff rates. With only a single exception, coefficients all become smaller in absolute value and less statistically significant. By 2007, none of the China-specific industry characteristics (at the bottom) are significant predictors of tariff rates. The only two variables that are still statistically significant are product complexity (positively) and skill intensity (negatively). The fit of the regression also declines markedly.

Finally, we investigate whether the variation in import tariff reductions illustrated in Figure 4 is related to initial productivity levels, as would be the case if policymakers concentrate tariff cuts in sectors they expect to be able to withstand foreign competition. Following Topalova and Khandelwal (2011), we run industry-level regressions of various measures of current protection on lagged levels of productivity. We perform this analysis separately for the pre and post-WTO period and use one or two-year lags. Table

[11] Duty free imports of capital goods and intermediates in the export processing sector may have also required lower tariffs on these goods to prevent their diversion from export processing to the rest of the economy.

2 contains the coefficients on lagged productivity (TFP). In the pre-WTO period, the coefficients are not statistically significant and even positive in the regressions for tariffs and ERPs. As such, any association between tariff reductions and subsequent productivity gains is unlikely to be the result of reverse causality. The relationship between lagged TFP and NTBs or FDI restrictions is negative, however, implying that these measures are more likely to be found in sectors with low productivity and suggesting a more selective use. The regressions for the post-WTO period indicate more broadly that protection is lower for sectors that had higher productivity levels one or two years earlier.

Policy endogeneity can thus not be totally ruled out in the post-WTO period, but as mentioned before this was only possible on an ex-ante basis, i.e. based on the expected performance of the sectors. There is some anecdotal evidence that the policy-setting process over commitments to reduce tariffs and NTBs with entry into the WTO became more politicized and subject to lobbying as negotiations progressed to more contentious sectors. The inclusion of lagged levels of protection in all regressions will absorb some of these effects. In addition, we will be more careful to assign causal interpretations to post-WTO results.

4. Data

We use annual data for 1995 and 1998-2007 for all state-owned industrial firms and non-state owned firms with sales above 5 million RMB. The information is collected through annual surveys by China's National Bureau of Statistics (NBS) and discussed in detail in Brandt et al. (2012). Aggregates for employment, sales, capital, and exports for these firms match almost perfectly the totals reported annually in the China Statistical Yearbook. Compared to the universe of firms observed in the 2004 Economic Census, our sample of "above-scale" industrial firms represents the bulk of industrial activity in China. In 2004, they accounted for 91 percent of the gross 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 with more than eight workers.[12]

A change in the firm IDs in 1998 makes it impossible to link observations in 1995 with the later years, but the data for 1995 are included in the industry-level analysis. For the period between 1998 and 2007, we observe an unbalanced panel that increases from 145,511 firms in 1998 to 311,323 in 2007. As firm identifiers often changed due to restructuring or M&A activity, we supplement the firm IDs with information on the firm's name, sector, and address to establish links over time. Only four percent of the links rely on this additional information, but one-sixth of the firms that are observed for more than one year experience a change in their official ID at some point in the sample period. To account for changes

[12] We drop the few firms with fewer than eight employees as they fall under a different legal regime.

in the Chinese Industry Classification (CIC) codes in 2003, some industries are merged to obtain a consistent classification over the entire sample period.

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

$$\Delta \ln P_{st} \equiv \Delta \ln Y_{st} - \overline{s_L}\, \Delta \ln L_{st} - (1 - \overline{s_L})\, \Delta \ln K_{st}\,. \tag{2}$$

The right hand side represents the difference between output growth and the share-weighted growth in inputs, where $\overline{s_L}$, the industry-specific average wage share in output in the two years over which the growth rate is calculated, used as the weight for labor. One minus this share is used for capital.[13] One and two-year differences are used. Real value-added is constructed by double-deflating gross output and material inputs using the appropriate deflators: the official two-digit output price deflator and an aggregation of the same series using a vector of input shares for each industry from the 2002 Input-Output table as weights. In robustness checks using a gross output production function, material input is added to equation (2) in the same way as labor input and gross output is used instead of value added in the first term. Similar calculations at the firm level produce the index-number productivity measure used in Brandt et al. (2012). The factor shares are now the firm-specific averages over the two years. In robustness checks, we use parametric productivity estimates that rely on the proxy-estimator from Olley and Pakes (1996).

In the empirical analysis, we utilize information on a firm's registered type (*qiye dengji zhuce leixing*) to construct ownership categories. We group firms into four categories: state, hybrid (township & village enterprises, local government owned, etc.), private, and foreign, which includes subsidiaries of firms from Hong Kong, Macao or Taiwan (HMT).[14]

We also use information on import volumes at the industry level. These data are aggregated up from a data set containing the universe of firm-level trade transactions covering the 2000-2006 period—Manova and Zhang (2012) provide extensive details on the data set.[15] In principle, we could use information from UN Comtrade to conduct an analysis over a longer time period, but these data do not enable us to distinguish between export processing and ordinary trade. Given that the large fraction of trade entering

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[13] Labor is measured as total employment and the real capital stock series is constructed using the same algorithm as in Brandt et al. (2012). Employee compensation consists of wages and from 2003 onwards also supplementary benefits. These measures of compensation likely underestimate total payments to labor. Labor's share of value added averages only 32.4 percent in our sample, while the national income accounts suggest an overall share of labor of around 50 percent. The correct share for manufacturing is likely to be intermediate and in Brandt et al. (2012) we experimented with adjustment factors.

[14] When ownership is mixed, we use the following order of priority to categorize firms: foreign, state, hybrid, private.

[15] This uses the same HS-CIC correspondence table discussed in footnote 3.

the country under the trade processing regime is exempt from import duties, it is important to identify imports flows that are actually subject to import tariffs.

The source and construction of the different measures of protection—import tariff rates, non-tariff barriers, and FDI restrictions—was already discussed in Section 2.2.

5. Effects of tariff reductions

5.1 Import volumes

The first place we expect to find evidence for an effect of import tariff reductions on the domestic economy is in the import flows. We use the annual growth in imports for 4-digit CIC industries as the dependent variable in equation (1) and report the estimates over the 2000-2006 period in Table 3. Note that over this period, total imports of manufactured goods increased by a factor of three and a half. The coefficient in column (1) for total imports is –1.53 implying that a one percentage point reduction in (output) tariff is associated with an increase in imports in the same sector of 1.53 percent. If one believes that China is a price taker on world markets, this elasticity is rather small. The low precision of the estimate is especially noteworthy: Despite substantial variation in the explanatory variable and a sample size of 2,442 observations, the coefficient is not even statistically significant at the 10 percent level.[16]

One possible explanation for the small and insignificant estimate is the duty-free entry of a sizable portion of imports, most notably under the processing trade regime. In the next two columns of Table 3, we disaggregate imports and report results separately for ordinary trade and "processing trade" imports. As expected, the elasticity is larger for ordinary trade, 1.95 against 0.45 for processing trade, but both of the estimates are still not statistically significant. A delay in the import response to tariff cuts could be a possible explanation, but the results in column (4) that relate two-year import growth rates to tariff cuts over the same two-year period are virtually identical. Industries with higher initial tariff levels have lower import growth, significant at the 10 percent level, but reductions in tariffs are only weakly related to higher imports, even over a two-year period.[17]

[16] We have run the same regressions using as units of observation the much more detailed 6 or 8-digit HS classification of goods which requires less or no aggregation of tariff rates. The results are qualitatively similar. The point estimates are larger, but still not significantly different from zero. For consistency with the results in the paper using other dependent variables, we report the industry-level results in Table 3.

[17] Looking for different trade responses by Broad Economic Categories (BEC) of goods revealed small, but insignificant differences with the trade response largest for materials and unprocessed intermediate inputs.

To examine import behavior at the firm level, we matched the detailed trade transactions in the customs records to the firm-level sample.[18] We use the BEC system to identify imports that are unprocessed or processed intermediate goods (categories 22, 42, and 53) or materials (categories 21 and 31) to obtain a firm-level estimate of intermediate inputs that are imported (directly). We use this information in two ways: first, to estimate the fraction of manufacturing firms that use imported inputs, and second, to calculate the share of raw materials and intermediate inputs reported in the firm-level data that consist of imports.

Descriptive statistics in Table 4 illustrate that the importance of intermediates that are imported directly by Chinese manufacturing firms remains rather low, despite the huge increase in total imports in the economy. The percentage of firms that directly import any intermediates or materials increased only slightly from 11.2 percent in 2000 to 12.9 percent in 2006. The increase in the share of intermediates that are imported is also modest, increasing from 7.8 percent of total input use in 2000 to 9.4 percent in 2006. Almost the entire increase in the participation rate comes from ordinary trade, consistent with the diminished advantage of duty-free imports under the export processing regime. Still, imported intermediates that enter as ordinary trade remain less than half as important as duty-free imports.

These estimates conceal huge differences across ownership types that stay relatively constant over this period. More than half of all foreign firms in the sample directly import intermediates in 2006, compared to only 3 percent of private firms, and 4 percent of SOEs. On average, almost twenty percent of all inputs used by foreign firms were directly imported; for domestic firms it was less than one percent. Regressions similar to those reported in Table 3 but at the firm level and with imported intermediates as dependent variable (not reported) reveal that private and foreign firms which are only engaged in ordinary trade are the most responsive to import tariff cuts. However, in 2006, the last year for which we observe the detailed information, these imports represented only 0.7 percent of their total input use.

In summary, the significant tariff reductions only have a limited impact on trade flows. Rapid growth in domestic Chinese manufacturing production leads to much higher imports of raw materials, intermediates and capital goods, but the increase is only weakly related to reductions in protection. This is in sharp contrast to the large effects documented for India in Goldberg et al. (2010). Any effect of trade

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[18] In 2006, approximately two-thirds of total imports by value are accounted for. The balance is imports by firms that could not be matched, notably, trading firms that act as agents for firms importing indirectly and by non-manufacturing firms such as retailers. Over time, the role of trading companies declined as more firms obtained direct trading rights. As a result, the statistics in Table 4 are likely to overestimate the increases in either the percentage of firms using imported intermediate goods and their share of inputs.

liberalization on Chinese firms does not seem to run through a loss of market share to importers, which often features prominently in theory models.

5.2 Price levels and price-cost margins

Limit pricing by domestic Chinese firms provides one possible explanation for the muted response of trade flows to tariff reductions. The work of Salvo (2010) on the Brazilian cement industry illustrates this can be an effective competitive response to trade liberalization. Rather than share the domestic market with imported products, domestic firms lower their prices to keep imports at bay. The adjustment to a tariff cut shifts from the quantity to the price dimension.

We again use equation (1), but now with the change in the domestic output deflator as dependent variable. The Chinese National Bureau of Statistics calculates an output deflator at the 2-digit CIC level for the entire sample period (1995-2007). Brandt et al. (2012) calculate a more detailed 4-digit price deflator, but this is only available through 2005 period, and we use the more aggregate series to extend it to the end of the sample period. To facilitate interpretation of the point estimates we express the price changes in the dependent variable in percentage point reductions.

Results in Table 5 suggest that the effect of tariff cuts on domestic prices is both large and estimated very precisely. The two alternatives deflators give similar results: a one percentage point decline in a sector's tariff rate reduces the annual price deflator by 0.23 to 0.30 percentage points. Over a two year period, responses are larger, especially for the more disaggregate series, with an estimate of 0.49. The estimation precision is slightly higher for the more disaggregate series, but in both cases the difference with the results for import volumes in Table 3 is pronounced. The t-statistics are four times higher and all estimates are easily statistically significant at the 1% level.

In the next two columns of Table 5 we regress the change in the input price deflator on the input tariff reductions. These variables are calculated by pre-multiplying the vector of output prices or tariff rates by the Chinese Input-Output matrix. Both input series are thus a weighted average of the corresponding output series using the sectoral input shares as weights. The regressions again produce positive and highly significant point estimates, but they are much higher than for output prices suggesting that the weighing matters greatly. If tariff reductions were passed on completely and prices of domestically produced inputs did not adjust, the point estimate should equal the share of imported intermediates in total inputs, approximately 0.10. However, the point estimates are much higher and for the disaggregate series near unity. Reductions in input tariffs show up one-for-one in the input price deflator that covers both domestically produced and imported intermediates. Price competition for intermediate inputs seems to be very fierce, as domestic producers must have responded strongly to the trade liberalization. For output prices, the point estimates also exceed the import penetration, but the difference is less pronounced. Domestically produced and imported final goods often compete in different market segments which shelters domestic firms somewhat from the import competition.

To investigate how these effects on domestic prices translate into changes in firms' price-cost margins we adopt the framework of De Loecker and Warzynski (2012). They exploit the fact that cost-minimizing firms will equate the output elasticity of each variable input to the revenue share of that input, adjusted for the marginal production cost. This holds locally for any production function and demand system, but for a Cobb-Douglas production function it implies that the optimal price-cost margin for each firm has to equal α_l/s_L, the ratio of the output elasticity with respect to labor and the wage share in revenue. If the production technology is constant over time, the negative of the change in the wage share in revenue ($-\Delta \ln s_L$) is a direct measure of the change in the logarithm of the price-cost margin.

In panel (d) of Table 5 we present estimates using this expression as the dependent variable in regression (1) and the change in trade protection (ERP) as the explanatory variable. The results indicate that price-cost margins decline most appreciably in sectors where trade protection is reduced the most. Year-fixed effects explain some, but not all of the effects. The underlying variation in the data that identifies these effects is that firms increase payments to labor as a percentage of total revenue in sectors where tariffs come down. In the framework of De Loecker and Warzynski (2012) the interpretation is that initially a fraction of the marginal product of labor is appropriated by the firm as profits. With trade liberalization and reduced market power, prices will be lower at each output level and the share of revenue that goes to labor increases. In the limit, for perfect competition, this share should converge to the output elasticity of labor in the production function. The estimates are intuitive and consistent with the direct evidence on price levels, but the effects are not estimated very precisely.

5.3 Productivity growth at the firm level

The previous results suggest that Chinese firms responded to trade liberalization by aggressively lowering domestic prices and conceding only little market share to imports. In the short run, this can be achieved by lowering price-cost margins, but this kind of strategy is only sustainable in the long run if productivity can be increased. Can the increase in TFP documented at the outset of the paper be linked to tariff reductions?

Our starting point is a firm-level version of equation (1) with firm productivity growth as dependent variable. We again add the lagged level of tariff protection as control. In the first four columns of Table 6, we report the effect of changes over one or two years, where changes are annualized and thus directly comparable. We run separate regressions for the full sample of firms, and for a balanced panel of firms that remain in operation throughout the entire period.[19] In columns 5-8, we report the results for corresponding regressions in levels that include both firm and time-fixed effects. Finally, in columns 9-12 and 13-16, we report results for the pre and post-WTO periods separately.

Several patterns are noteworthy. First, over the entire period, tariff reduction is strongly associated with a significant increase in firm-level productivity growth. Second, the effects are appreciably larger for the full sample of firms than for the balance sample. TFP growth of new entrants or exiting firms is apparently more closely related to tariffs than it is for incumbents. Third, estimating the effects in level with firm (and time) fixed effects produces a smaller estimate of the impact of tariff reduction, albeit still highly significant. Fourth, the elasticity of productivity with tariff liberalization appears to be substantially larger in the post-WTO period. As discussed earlier, this could partially be the result of policy endogeneity based on expected future performance.

To put the magnitudes in context, the effective rate of protection fell sixty percentage points over the full period. A coefficient on ΔERP of -0.239 then implies that a total improvement in TFP of nearly 15 percent can be linked to the trade liberalization. This converts to a one percent permanent increase in TFP per year, or one-eighth of firm-level TFP growth. For firms in the balanced panel, the contribution is slightly smaller. As suggested by Figure 3, differences in the reductions in the ERP across sectors are even larger, for example, for industry in the 20th percentile, the ERP rose 5 percent, while for those in the 80th percentile it fell 110 percent. This translates into a permanent annual difference in TFP growth of two percent.

These effects are respectable, but not that large in comparison to the overall TFP growth for manufacturing that we document at the outset of the paper, or the dispersion in rates across sectors. There are other channels though for tariff liberalization to influence productivity growth in China. In addition to TFP improvements for continuing firms, there are two other potentially important margins: Entry and exit or improvements resulting from the reallocation of inputs to more productive firms. We evaluate the importance of these two channels in an analysis at the industry level.

[19] In the "all firms" sample we still omit year-on-year changes that would include the year of entry or the last year of operations prior to exit. This is to avoid inappropriate comparisons where a firm might not have been operating for the entire year and "stock" measures of inputs do not correspond well to "flow" levels of output. We do not omit the first and last year-on-year changes for the balanced panels as there are no comparable concerns. As a result, the sample is the same for the regressions in changes and levels for the “all firms” sample, but not for the “balanced panel” sample.

5.4 Productivity growth at the industry level

We now estimate equation (1) using industry-level productivity growth for the 424 sectors as dependent variable. The interpretation of the results in Table 7 is comparable to those in Table 6.

In the first column of Table 7, we report the effect of one-year changes in tariff protection estimated over the full period. The coefficient of -0.584 implies that a ten percentage point reduction in ERP leads to a permanent six percent improvement in industry-level productivity. On the basis of column (8), a tariff reduction spread over two years is estimated to require a reduction in ERP of fifteen percentage points to have the same effect. The coefficient on lagged productivity in column (1) is also negative and statistically significant, a result that is robust in all specifications in Table 7. Industries that initially enjoy stronger protection tend to experience lower rates of total factor productivity growth. We hesitate to give this a causal interpretation as the earlier results in Table 1 suggest that the initial distribution of protection was not random. Controlling for these effects however, we find that a reduction in tariff rates to the same low levels in all sectors leads to the most pronounced productivity effects in sectors where the decline in ERP is most pronounced.

Results in columns (3) and (5) illustrate that the effects become slightly stronger over time, but the elasticity of -0.505 for the pre-WTO period (1995-2002) is only a quarter below the -0.673 estimate for the period after China joined the WTO (2002-2007). Several factors may help to explain the more pronounced effect including deeper integration with the international economy, elimination of some of the NTBs because of WTO, as well as the development of trade infrastructure, both in terms of hardware and institutions. Tariff declines also became more predictable once China joined the WTO and productivity responses may have become more rapid as a result. Of course, as suggested by Figure 4, we cannot totally rule out some forward-looking policy endogeneity.

In columns (2), (4), and (6), we examine the combined effects on TFP of the use of non-tariff barriers together with tariffs.[20] We include a dummy variable that measures the presence of any NTBs in an industry in the original specification in a way analogous to tariffs, i.e. adding both lags and changes, and also include all interactions between the two policy instruments. The coefficients on the changes in tariff protection are rather robust to this change and increase only slightly in absolute value. The coefficients on the NTBs all tend to be insignificant, with one key exception. The interaction of the change in the effective rate of protection with lagged NTBs is always positive, large, and estimated to be highly

[20] We also examined the effects of restrictions on FDI, but the coefficients were small and insignificant. Most of the changes for FDI occurred in a single year (2002), making the effect difficult to discern from the substantial tariff declines occurring in the same year.

significant. This suggests that the presence of NTBs in a sector neutralizes most of the impact of a tariff reduction: The baseline effect of -0.610 is reduced to one-third of its size (the coefficient on the interaction term is 0.411). This ability to counteract the effects of tariff reduction was especially pronounced in the post-WTO period—the interaction coefficient is 0.890 compared to 0.324 pre-WTO—but of course, NTBs were much less frequently used as time progresses.

In the bottom panel of Table 7 we report the results for various robustness checks. The lower effect for two-year changes in column (8) has already been mentioned. Estimating the equation in levels with industry-fixed effects, as in Amiti and Konings (2007), lowers the elasticity with respect to changes in ERP, as was the case for the firm-level estimates. Using industry-fixed effects in addition to time-differencing—analogous to the double time-differencing of Trefler (2004)—results in slightly larger effects of trade liberalization on productivity growth. Using labor productivity as dependent variable, in column (11), gives nearly identical results, and suggests that differences between sectors in capital accumulation are orthogonal to the trade liberalization. Finally, the elasticity is estimated to be five times smaller using a gross-output based measure of TFP, in column (12), which is lower than the 3:1 ratio of the relative growth rates for the two TFP measures, estimated in Brandt et al. (2012).

One thing that stands out is that the coefficients estimated at the industry level in Table 7 are significantly larger than the estimates at the firm level in Table 6. The increase in absolute magnitude is most pronounced in the pre-WTO period. This relationship suggests that channels other than firm-level changes were important for the full impact of tariff liberalization, which we now investigate.

5.5 Decomposing the industry-level effects

There are several potential explanations for the strong relationship between tariff reductions and productivity growth. The channel envisioned by some Chinese leaders is that it reflects the causal effect of productivity-enhancing restructuring, which would be consistent with the higher estimates at the industry level compared to the firm level. We explore the importance of alternative channels by linearly decomposing sectoral productivity growth and then using each term in the decomposition as the dependent variable in separate regressions of the form of (1).

The decomposition we use is exact for the growth in sectoral productivity if we define the aggregate level ($\ln P_t$) as the weighted aggregate of the firm-level log-productivity levels ($\ln P_{it}$):

$$
\Delta \ln P_t = \sum_{i}^{\text{continuing}} \overline{s_i}\, \Delta \ln P_{it} + \sum_{i}^{\text{continuing}} \Delta s_{it} \left[\overline{\ln P_i} - \ln P_{t-k}\right] + \sum_{n}^{\text{entrants}} s_{nt} \left[\ln P_{nt} - \ln P_{t-k}\right] - \sum_{x}^{\text{exiting firms}} s_{xt-k} \left[\ln P_{xt-k} - \ln P_{t-k}\right]
$$

We end up with four terms, each of which has an intuitive interpretation. The first term captures the contribution of firm-level productivity growth to the industry average, the 'within' term. The second one captures the productivity effects of changes in the firm-weights, the 'between' term, and is associated with the reallocation of resources among firms. This effect can be positive if market shares move to a firm with above-average productivity or negative if the reverse happens. We follow Griliches and Regev (1995) and use the average values over the two periods—for the firm share or productivity—to weight the differences in order to avoid the introduction of an additional term that interacts the changes in shares and productivity.[21] The last two terms contain the effect of net entry on aggregate productivity. We follow Haltiwanger (1997) and normalize all productivity levels by the lagged aggregate productivity level to take into account that unbalanced panels can have different weights for entering and exiting firms. As a result, the contribution of net entry will be positive if entering firms tend to perform better relative to the lagged aggregate than exiting firms.

We are not interested in the contribution of each term to aggregate productivity growth per se—Brandt et al. (2012) already establishes that the extensive margin of firm restructuring through entry and exit was extremely important. Rather, we perform the above decomposition for each sector and then investigate using equation (1) which term has the strongest correlation with the reduction in ERP. As we need to follow individual firms over time, we can only conduct this analysis from 1998 onwards. To identify correctly the extent of tariff reduction that each firm is exposed to, we only include surviving firms that remain in the same sector throughout. In contrast with the previous analyses, only the first and last year of each period are used to construct each term, not the intervening years. The relationship between the

[21] Petrin and Levinsohn (2012) demonstrate that such a term tends to be very volatile and the interpretation is not obvious. Using the average share or productivity level as weight in the within and between terms splits the contribution of the interaction term equally over the first two terms. Petrin and Levinsohn (2012) further argue that the between term only contributes to a welfare-consistent measure of technological change if there are frictions that prevent the efficient allocation of resources. The evidence in Hsieh and Klenow (2009) suggests this is not an unnatural assumption for China.

aggregate productivity growth and the tariff cuts over the entire period is in column (1) of Table 8. The estimate of -0.610 is very similar to the estimate using all annual changes in Table 7 (-0.584).[22]

Because of the linear regression and linear decomposition, the estimates of the four terms in columns (2) to (5) aggregate exactly to the overall effect. In the first panel for the full sample period, the effect from the entry channel is by far the most important and accounts for the entire industry-wide effect. The positive contribution of the within term (negative point estimate) is cancelled out by small, but opposite effects from the between and exit terms. This is not entirely surprising as an enormous share of the aggregate output in 2007 is accounted for by firms that enter in the nine year period between 1998 and 2007. The stark contrast between the strong correlation with the reduction in trade protection for the entry term and the almost total lack of relationship for the other terms is remarkable. Trade liberalization strongly increases the productivity contribution of firm-churning at the extensive margin. Sectors that experience the largest tariff cuts are characterized by far greater productivity differences between entering and exiting firms.

Over the shorter sub-periods before and after WTO entry, the total contribution of net entry to productivity growth will be less important by construction, but the strength of the correlation with tariff cuts could go either way. The estimate in column (14) is almost identical to that in column (4) highlighting that the relationship between the entry-contribution and tariff cuts is equally strong after China joined the WTO and estimated just as precisely. This is especially remarkable given that the variation in the dependent and explanatory variable is far lower in the later period. The fact that tariff reductions have become more predictable and irreversible, and that firms thus could anticipate and prepare for the changes is likely to strengthen the relationship.

In the period prior to WTO entry, the productivity contribution from entry is only weakly associated with tariff reductions, and largely offset by the opposite, and significant, effect through exit. With the overall effect of net entry channel small, the "within" term is responsible for almost the full correlation between industry-level productivity growth and tariff cuts. Note that the estimate of -0.173 in column (7) is far larger than the earlier firm-level estimate, column (9) in Table 6, even though it measures the same effect. The difference is the weights in the within term, suggesting that the larger surviving firms are far

[22] A comparison of the results in Tables 6, 7 and 8 reveals effects similar in magnitude at the firm and industry level for the full period and for the post-WTO period, but much less so than for the pre-WTO period. The pre-WTO coefficients are also typically smaller, but the differences are much less than meets the eye. Note that in Table 6, as we move from the balanced to the full panel the increase in the coefficient on the change in ERP from -.053 to -.093. It more than doubles in Table 8 to -.228 when we calculate the industry level aggregate by output-weighting the micro-level estimates. Finally, in Table 7, it is almost as large at the post-WTO period when we aggregate inputs and outputs before calculating TFP, and extend the pre-WTO period backwards to 1995.

more likely to experience strong productivity growth in sectors that were liberalized. Note that the estimated effects for the within term are remarkably similar in the two periods.[23] This suggests that the pressure on firms to improve their productivity growth when faced with lower tariff protection has been more persistent than the pressure operating through the net entry channel.

The insignificant coefficient estimates for the between terms in all periods indicate that market share changes were not correlated with tariff cuts. Over the full period, see column (3), the weak positive estimate even suggests that the increase in market share of highly productive firms is less likely or at least less important in sectors that liberalized most. The positive coefficients for the (–) exit term are also rather low, but they suggest that exit of highly unproductive firms is a less important contributor to aggregate TFP growth in sectors that liberalized most.

The most important pattern in Table 8 is the strong correlation between tariff cuts and the contribution of new entrants to industry TFP. This contribution is a combination of the entrants' output share and their productivity premium over the previous period's average. More than four-fifths of all firms active in 2007, accounting for approximately two thirds of aggregate output, entered between 1998 and 2007. The breakdown across ownership categories of new entrants differs considerably from the composition of incumbents in 1998. At the end of the sample period, private firms accounted for one-third of aggregate output and half of all active firms. Moreover, 92% of private firms were new entrants, who produced 85% of private firm output. In contrast, the market share of SOEs was comparable in 1998 and 2007, but almost half of SOE output in 2007 was produced by firms already in operation in 1998. Regressions (not reported) show that private firm entry is very high across all sectors, but the sectoral composition is not related to the tariff reductions. We next investigate where new firms enter in the productivity distribution to verify whether the quality of entrants is related to trade liberalization.

5.6 Position of different types of firms in the productivity distribution

To investigate the relationship between trade protection and the relative productivity of new entrants and exiting firms, we estimate the following regression:

$$\ln TFP_{st} = \alpha ERP_{st-k} + \sum_z \beta_z \,\text{type}^z_{st} + ERP_{st-k} * \sum_z \gamma_z \,\text{type}^z_{st} + \alpha_t + \alpha_s + \varepsilon_{st.} \quad (3)$$

[23] The large estimate on the lagged ERP variable in column (12) indicates that sectors that were still heavily protected in 2002 did not enjoy strong productivity growth in the following years. If policy-makers could have anticipated some of this and conditioned future tariff cuts on it, some of the post-WTO effects could be due to reverse causality.

The dependent variable is now the level of productivity and the explanatory variables are a set of firm-type characteristics that are included additively and interacted with the degree of tariff protection in each sector.

We use the contemporaneous ERP variable (*k* = 0) in the first two columns of Table 9 and one-year lagged ERP in the next two columns. In the first and third columns, we use only three dummy variables to define firm-types: entrants, exiting firms, and incumbents. There are three noteworthy findings. First, entrants have higher and exiting firms lower levels of productivity than incumbents, confirming the results in Brandt et al. (2012).[24] Second, each of the three types of firms tends to have relatively lower productivity levels in sectors that receive strong trade protection. Third, the link between productivity and tariffs is a lot less pronounced when lagged protection is used.

Results in the second and fourth column further distinguish between four ownership categories: state-owned firms (SOE), hybrid firms with mixed ownership, private firms, and foreign-owned firms. In total, effects now vary across twelve different firm types (SOE-entrants, etc.). The earlier results survive and become even more pronounced. The non-interacted ownership variables indicate that SOEs (the omitted category) tend to have far lower levels of productivity on average, confirming results from several earlier studies. The triple interactions between ownership, activity status, and degree of protection are even more revealing, and identify similar patterns for hybrid, private, and foreign firms, but very different ones for SOEs.

For the first three ownership types, tariff rates are not systematically related to the productivity level of incumbents. While firms that are about to exit have on average significantly lower productivity, this selection on productivity is significantly dampened in highly protected sectors. When tariff rates are sufficiently high, the negative correlation between exit and productivity disappears entirely. The association between low productivity levels and exit is stronger in unprotected sectors and is particularly pronounced for private firms. Similarly, the superior productivity level of new entrants is a unique feature of open, unprotected sectors. When import tariffs are sufficiently high in a sector, unproductive firms are as likely to enter. Low trade protection heightens the association between productivity and entry or exit, indicative of stronger market selection. In open sectors, entrants are more productive than incumbents, and exiting firms less. In protected sectors, the productivity differences between entrants and exiting firms are less systematic. This mechanism is consistent with the close link between tariff rates

[24] As in the case of the other firm-level regressions in Table 6, we drop the first full year of entry and the last year before exit to make sure we do not use partial years of activity.

and the contribution of the entry-term to aggregate productivity which we illustrated in the previous section.

The patterns are radically different for one type of firms: SOEs have lower productivity levels than the other ownership types on average, but this is especially true for incumbent SOEs in highly protected sectors and for exiting SOEs in the same sectors. In contrast, the few new SOEs that enter the sample do not enter with higher productivity in more open sectors, as was the case for private or foreign firms. Their productivity level is entirely unrelated to the degree of protection. Entry and exit of SOEs does not seem to be the outcome of a selection mechanism based on productivity, as was strongly the case for private firms. The survival of unproductive SOE incumbents in highly protected sectors further differentiates them from other firm types.

6. Conclusions

We have shown that the strong productivity record of China in the time period studied, from 1995 to 2007, is strongly and significantly related to the tariff reductions that accompanied (and preceded) China's entry into the WTO. Since most tariffs are cut to a remarkably uniform and low level, the extent of liberalization in each industry is almost entirely determined by the extent of initial protection. Reverse causality, i.e. tariff reductions being tied to sectors' productivity growth record, is highly unlikely to explain much of the correlation and moreover could only be based on expected performance. We include the lagged level of protection in the regressions to control for the initial competitive environment. The conclusion is that reduced protection of the domestic industry from foreign competition lead to higher domestic productivity growth.

The mechanisms through which tariff reduction has exerted its impact on productivity were unanticipated, and slightly unusual. No strong link could be found between tariffs and import volumes, including the usage of imported inputs. However, input tariff cuts show up one-for-one in the input price index. Accordingly, we find that Chinese firms accommodate such price pressure through downward adjustment of their price-cost margins. Squeezed profit margins are also reflected in the selection of entering and exiting firms across the productivity distribution. By decomposing sectoral productivity growth into contributions by continuing firms, reallocation among continuing firms, and net entry, we show that the association between tariffs cuts and the net entry contribution is by far the strongest link. Firm-level productivity changes are systematically related to tariff cuts, but only in the pre-WTO period does this explain a large fraction of the total relationship at the industry level. A firm-level analysis further indicates that for private and foreign-owned firms, tariff reduction has systematically pushed less efficient firms to exit and replaced them with more productive new entrants; such a pattern does not exist for state-owned firms. Given the importance of newly entering private firms, the competitive selection mechanism dominates and contributes substantially to the productivity growth of the Chinese manufacturing sector in the period under investigation.

These findings highlight the price pressure from potential imports and the associated competitive selection mechanism as an important channel through which trade liberalization affects domestic productivity. This is in contrast with alternative mechanisms found in the context of trade liberalization in other countries, such as easier access to more varieties of and better quality inputs in the case of India by Goldberg et al. (2010). The effectiveness of this mechanism implies that government should try not to intervene in price setting. Secondly, the different response to tariff reduction by state-owned firms from private and foreign-owned firms implies that the former enjoy other forms of protection than trade barriers; further reform is needed to eliminate the remaining inefficiencies among the state-owned firms. Thirdly, our study shows that tariff reduction helps to select better private firms to enter, but it does not affect the size of the entering body of private firms. As a key component of the overall productivity growth, the size of entry itself is worth further investigation which we leave for future research.

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Figure 1: Distribution of sectoral productivity growth, 1998-2007

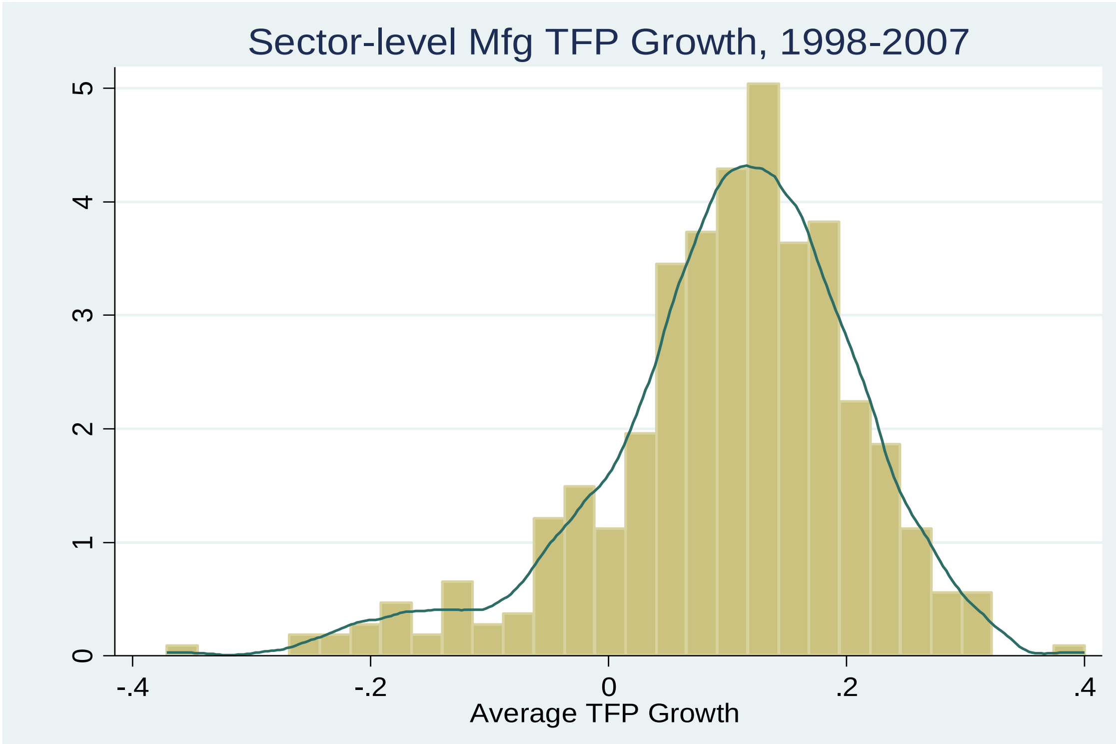


Figure 2: Fraction of sectors covered by various trade or investment restrictions

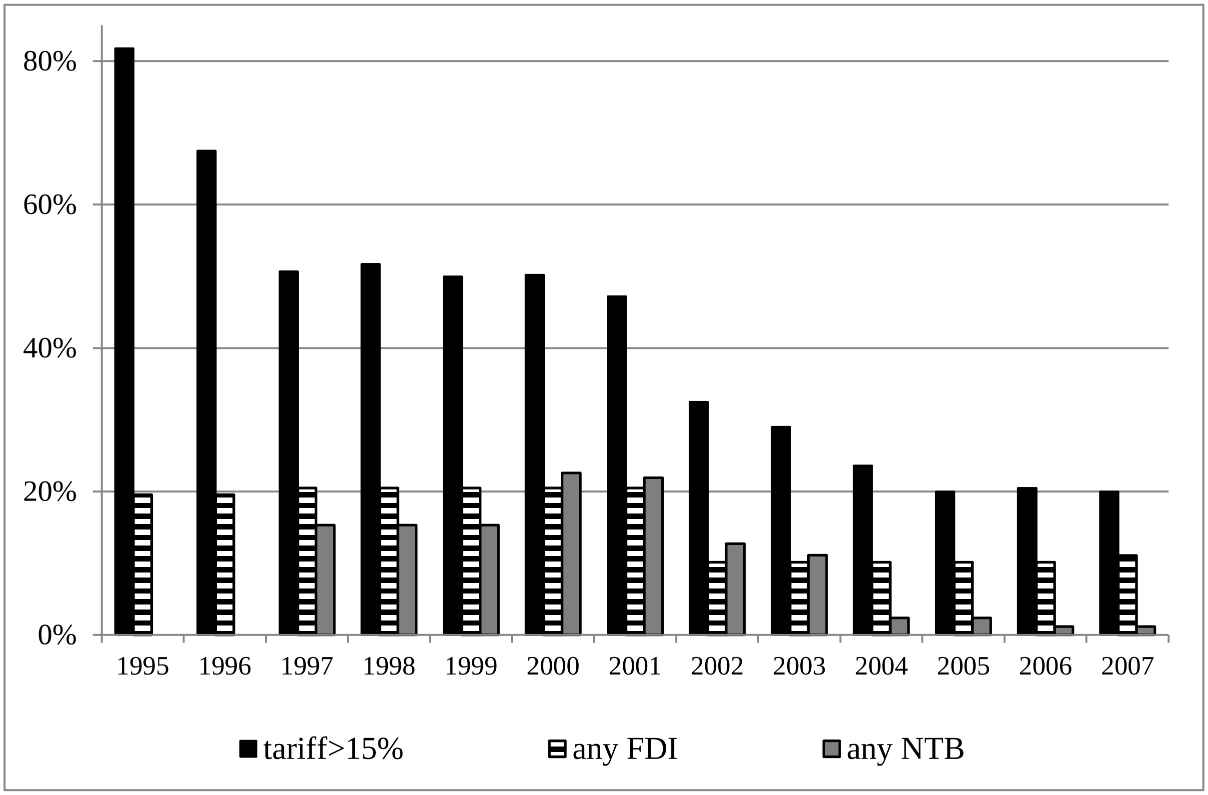


Figure 3: Evolution of tariffs and effective rate of protection

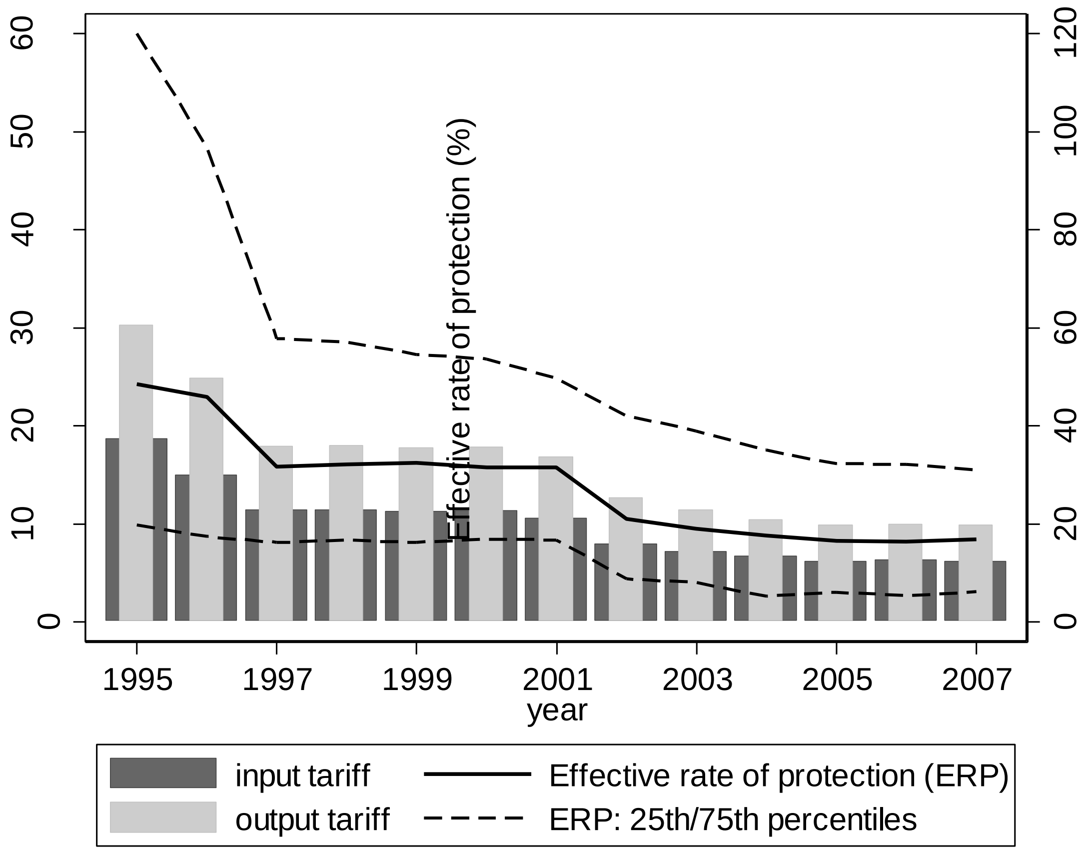
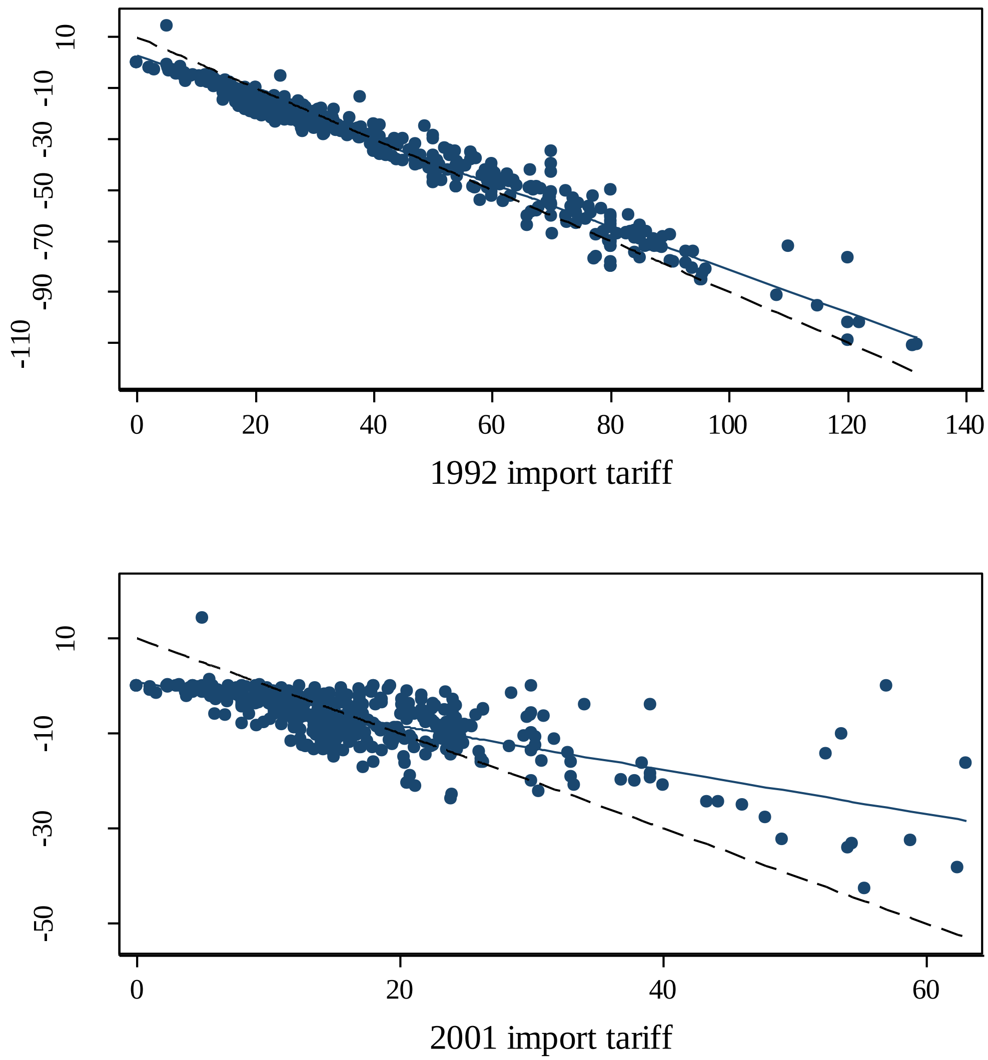


Figure 4: Import tariffs at the sector level (CIC 4-digit)



Notes: Observations are 4-digit manufacturing sectors. Dashed line has slope -1.
Solid line is regression with slope -0.84 above, and -0.46 below.

Table 1: Industry characteristics associated with the level in tariff protection

Dependent variable:	Output Tariff 1995	Output Tariff 2001	Output Tariff 2007
	(1)	(2)	(3)
Trade categories (BEC):			
Intermediates	-0.203***	-0.109***	-0.049
	(-2.9)	(-2.7)	(-1.7)
Capital goods	-0.186***	-0.055	-0.056*
	(-2.6)	(-1.3)	(-1.9)
Consumer Goods	0.117	0.064	0.047
	(1.6)	(1.5)	(1.6)
Differentiated goods (Rauch)	0.023	0.020	0.030***
	(0.9)	(1.4)	(2.9)
U.S. industry characteristics			
Capital intensity	-3.707**	1.413	1.007
	(-2.4)	(1.6)	(1.6)
Skill intensity	-5.418**	-3.770***	-2.816***
	(-2.1)	(-2.5)	(-2.6)
Chinese industry characteristics			
Top 4 market share	0.169***	0.071***	0.013
	(3.3)	(2.4)	(0.6)
Log employment	1.869***	1.123***	0.247
	(2.8)	(2.9)	(0.9)
Log(K/L) ratio	2.033*	0.419	0.488
	(1.7)	(0.6)	(1.0)
SOE sales share	-0.056	0.001	-0.004
	(-1.6)	(0.0)	(-0.3)
Elementary education share	0.461**	0.118	0.096
	(2.3)	(1.0)	(1.2)
R^2	0.490	0.373	0.327
Observations	380	380	380

Note: t-statistics in parentheses. ***,**, and * indicate significance at the 1%, 5%, and 10% level.

Table 2: Effect of lagged productivity on current rates of protection

Dependent variable:	Tariffs (1)	ERP (2)	NTB (3)	FDI (4)
(a) Pre-WTO 1995-2001				
TFP_{t-1}	0.003	0.011	-0.026**	-0.025***
	(1.6)	(1.0)	(-2.0)	(-2.9)
TFP_{t-2}	0.002	-0.004	-0.058***	-0.027***
	(0.9)	(-0.2)	(-3.2)	(-2.6)
(b) Post-WTO 2002-2007				
TFP_{t-1}	-0.003***	-0.009**	-0.025***	-0.004
	(-3.7)	(-2.3)	(-2.9)	(-0.2)
TFP_{t-2}	-0.003***	-0.008*	-0.027***	-0.030*
	(-2.8)	(-1.9)	(-2.6)	(-1.9)

Notes: t-statistics in parentheses. ***,**, and * indicate significance at the 1%, 5%, and 10% level.

Table 3: Effect of import tariffs on trade flows (year-on-year, 2000-2006)

Dependent variable:	Total trade 1-year change (1)	Processing trade 1-year change (2)	Ordinary trade 1-year change (3)	Ordinary trade 2-year change (4)
Lagged tariff change	-0.425	-0.195	-0.517	-0.971*
	(-1.6)	(-0.6)	(-1.5)	(1.9)
Change in tariffs	-1.526	-0.449	-1.947	-2.105
	(-1.3)	(-1.5)	(-1.3)	(-1.6)
Observations	2,442	2,372	2,409	1,998

Notes: Regressions in first differences at the 4-digit industry level. t-statistics in parentheses. ***,**, and * indicate significance at the 1%, 5%, and 10% level.

Table 4: Use of imported intermediates

	Fraction of firms using imported intermediates			Imported intermediates as a share of total intermediates		
	Total trade (1)	Processing trade (2)	Ordinary trade (3)	Total trade (4)	Processing trade (5)	Ordinary trade (6)
2000	11.2%	9.6%	6.2%	7.8%	5.5%	2.4%
2006	12.9%	9.8%	8.7%	9.4%	6.6%	2.9%

Table 5: Effect of import tariffs on price indices

Dependent variable:	Output price change ($\Delta \ln P_O$)		Input price change ($\Delta \ln P_I$)	
	1-year change	2-year change	1-year change	2-year change
	(1)	(2)	(3)	(4)
(a) Price changes based on 2-digit CIC industries (1995-2007)				
Tariff change	0.233***	0.294***	1.702***	1.932***
	(5.4)	(6.3)	(18.5)	(19.1)
(b) Price changes based on 4-digit CIC industries (2000-2007)				
Tariff change	0.297***	0.487***	1.023***	1.261***
	(6.1)	(6.5)	(10.4)	(9.3)
(c) Price changes based on 2-digit CIC industries (2000-2007)				
Tariff change	0.441***	0.524***	2.257***	2.613***
	(7.7)	(6.6)	(25.2)	(21.2)

Dependent variable:	$\Delta \ln PCM$ with PCM = (P-MC)/P			
	Without year fixed effects		With year fixed effects	
	1-year change	2-year change	1-year change	2-year change
(d) Price-cost margin changes (1998-2007)				
ERP change	0.045**	0.058*	0.024*	0.044
	(2.3)	(1.9)	(1.7)	(1.5)

Note: t-statistics in parentheses. ***,**, and * indicate significance at the 1%, 5%, and 10% level.

Table 6: Effect of protectionism on productivity at the firm level

	Balanced panel	All firms	Balanced panel	All firms
	1 year changes		2 year changes	
(a) Full sample period (1998-2007), dependent variable is firm-level productivity change				
	(1)	(2)	(3)	(4)
Lagged ERP level	-0.024	-0.029	-0.023	-0.032
	(1.3)	(1.3)	(1.1)	(1.2)
Change in ERP	-0.166***	-0.239***	-0.189*	-0.303**
	(3.2)	(4.1)	(1.9)	(2.4)
Observations	242,684	897,365	214,914	626,768
(b) Full sample period (1998-2007), regressions in levels with firm-FE				
	(5)	(6)	(7)	(8)
Lagged ERP level	-0.036***	-0.094***		
	(4.2)	(13.0)		
Twice lagged ERP level			-0.048***	-0.031***
			(7.3)	(4.7)
Observations	294,150	897,365	292,766	626,768
(c) Pre-WTO period (1998-2002), firm-level productivity change				
	(9)	(10)	(11)	(12)
Lagged ERP level	-0.003	-0.008	0.008	0.004
	(0.1)	(0.4)	(0.5)	(0.2)
Change in ERP	-0.053	-0.093**	0.032	-0.007
	(1.3)	(2.4)	(0.5)	(0.1)
Observations	241,244	362,303	180,933	626,768
(d) Post-WTO period (2002-2007), firm-level productivity change				
	(13)	(14)	(15)	(16)
Lagged ERP level	-0.072**	-0.060	-0.076***	-0.076*
	(2.5)	(1.2)	(2.7)	(1.9)
Change in ERP	-0.440***	-0.587***	-0.521***	-0.598***
	(4.0)	(4.3)	(3.6)	(3.1)
Observations	371,440	535,062	357,894	410,936

Note: All regressions only include firms that did not change industries in the two years considered (for 1 or 2 year changes). t-statistics in parentheses. ***,**, and * indicate significance at the 1%, 5%, and 10% level.

Table 7: Effect of tariff protection on productivity at the industry level

Dependent variable is ΔTFP	Full period (1995-2007)		pre-WTO (1995-2002)		post-WTO (2002-2007)	
	(1)	(2)	(3)	(4)	(5)	(6)
lagged ERP	-0.082*** (-5.8)	-0.096*** (-5.2)	-0.070*** (-4.6)	-0.085*** (-3.8)	-0.087*** (-3.3)	-0.099*** (-3.4)
ΔERP	-0.584*** (-10.5)	-0.610*** (-10.4)	-0.505*** (-7.9)	-0.493*** (-7.7)	-0.673*** (-7.5)	-0.807*** (-7.8)
ΔERP * lagged NTB		0.411*** (3.4)		0.324*** (2.8)		0.890*** (2.8)
ΔERP * Δ NTB		0.030 (0.1)		-2.463* (1.8)		0.293 (0.8)
lagged ERP *ΔNTB		-0.014 (-0.2)		0.096 (0.3)		0.074 (0.5)
lagged ERP*lag NTB		0.066* (1.9)		0.065* (1.8)		0.183* (1.8)
lagged NTB		0.027 (1.3)		-0.001 (-0.1)		0.061* (1.7)
ΔNTB		-0.021 (-0.5)		0.024 (0.2)		0.000 (0.0)

	Full period (1995-2007)					
Dependent variable:	ΔTFP	ΔTFP 2-year change	TFP with sector FE	ΔTFP with sector FE	ΔLP	ΔTFP Gross output
	(7)	(8)	(9)	(10)	(11)	(12)
lagged ERP	-0.082*** (-5.8)	-0.060*** (-5.4)	-0.148*** (-4.8)	-0.113*** (-4.4)	-0.081*** (-5.6)	-0.019*** (-5.9)
ΔERP	-0.584*** (-10.5)	-0.388*** (-7.6)	-0.363*** (-4.7)	-0.646*** (-10.0)	-0.577*** (-10.1)	-0.110*** (-8.7)

Notes: NTB stands for non-tariff barriers and it measures import license requirements in a sector. t-statistics in parentheses. ***,**, and * indicate significance at the 1%, 5%, and 10% level.

Table 8: Decomposition of the industry-level effect (following Haltiwanger, 1997)

	Total effect	Within	Between	Entry	–Exit
(a) Full period (1998-2007)					
	(1)	(2)	(3)	(4)	(5)
Lagged ERP level	-0.457***	-0.085	0.033	-0.446***	0.041**
	(2.8)	(1.4)	(1.2)	(3.2)	(2.1)
Change in ERP	-0.610***	-0.098	0.058	-0.613***	0.042
	(2.7)	(1.2)	(1.6)	(3.2)	(1.5)
(b) Pre-WTO period (1998-2002)					
	(6)	(7)	(8)	(9)	(10)
Lagged ERP level	-0.087	-0.074*	-0.008	-0.071	0.067**
	(1.0)	(1.7)	(0.4)	(1.1)	(3.5)
Change in ERP	-0.228	-0.173**	0.000	-0.128	0.072**
	(1.4)	(2.1)	(0.0)	(1.1)	(2.0)
(c) Post-WTO period (2002-2007)					
	(11)	(12)	(13)	(14)	(15)
Lagged ERP level	-0.390***	-0.182***	0.059**	-0.315***	0.048**
	(2.9)	(2.8)	(2.4)	(3.2)	(2.2)
Change in ERP	-0.745***	-0.178	-0.010	-0.597***	0.039
	(2.6)	(1.3)	(0.2)	(2.9)	(0.9)

Notes: The different terms of a linear decomposition of sectoral productivity growth, combining the methods of Griliches and Regev (1995) and Haltiwanger (1997), are each used as dependent variable in separate regressions. Number of observations is 424 in each regression. t-statistics in parentheses. ***,**, and * indicate significance at the 1%, 5%, and 10% level.

Table 9: Position of different types of firms in the productivity distribution

	Dependent variable: TFP level			
	Concurrent ERP		1-year lagged ERP	
	(1)	(2)	(3)	(4)
Entrant	0.187	1.167	0.178	1.163
	(17.5)***	(18.5)***	(15.2)***	(18.7)***
Exiting firm	-0.218	-0.257	-0.217	-0.253
	(10.1)***	(17.8)***	(10.5)***	(17.5)***
Hybrid		0.522		0.519
		(13.4)***		(13.3)***
Private		0.476		0.464
		(16.4)***		(16.4)***
Foreign		0.257		0.242
		(9.3)***		(8.5)***
Incumbent * ERP(t-x)	-0.218		-0.116	
	(2.2)**		(1.3)	
* SOE		-0.337		-0.263
		(3.1)***		(2.6)***
* Hybrid		-0.048		0.015
		(0.5)		(0.2)
* Private		-0.124		-0.026
		(1.1)		(0.3)
* Foreign		-0.114		-0.011
		(1.1)		(0.1)
Entrant * ERP(t-x)	-0.222		-0.099	
	(2.5)***		(1.1)	
* SOE		-0.015		0.053
		(0.1)		(0.5)
* Hybrid		-0.098		-0.037
		(1.0)		(0.4)
* Private		-0.318		-0.192
		(2.8)***		(1.8)*
* Foreign		-0.364		-0.242
		(3.3)***		(2.2)**
Exiting firm * ERP(t-x)	-0.211		-0.127	
	(1.8)*		(1.2)	
* SOE		-0.616		-0.520
		(5.1)***		(4.7)***
* Hybrid		0.243		0.247
		(2.3)**		(2.5)**
* Private		0.452		0.446
		(5.0)***		(5.5)***
* Foreign		0.178		0.218
		(1.6)		(2.1)**

Note: t-statistics in parentheses, standard errors are clustered at industry level. ***,**, and * indicate significance at the 1%, 5%, and 10% level.