Trade Liberalization, Intermediate Inputs and Productivity: Evidence from Indonesia*

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Abstract

This paper estimates the effects of trade liberalization on plant productivity. In contrast to previous studies, we distinguish between productivity gains arising from lower tariffs on final goods relative to those on intermediate inputs. Lower output tariffs can produce productivity gains by inducing tougher import competition whereas cheaper imported inputs can raise productivity via learning, variety or quality effects. We use Indonesian manufacturing census data from 1991 to 2001, which includes plant level information on imported inputs. The results show that the largest gains arise from reducing input tariffs. A 10 percentage point fall in output tariffs increases productivity by about 1 percent, whereas an equivalent fall in input tariffs leads to a 3 percent productivity gain for all firms and an 11 percent productivity gain for importing firms.

Key Words: tariffs, inputs, productivity.
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1. Introduction

The effects of trade reform on productivity have been widely studied, but there remains a gap in this literature. Theoretical models consider both the effects of reducing final goods tariffs and input tariffs on productivity. Lower output tariffs can produce productivity gains by inducing tougher import competition whereas cheaper imported inputs can raise productivity via learning, variety or quality effects. Empirical studies, however, have primarily focused on the effects of reducing output tariffs. Although a fall in a tariff on inputs such as compressors may force the domestic compressor industry to become more competitive, it has quite different effects on users of these inputs such as producers of refrigerators. Their productivity can increase due to the foreign technology embodied in those inputs.[1]

This paper disentangles the productivity gains arising from tariff reductions on final goods and on intermediate inputs, using Indonesian data. An essential feature of the Indonesia data set for this study is that it provides information on imported inputs at the plant level. This allows us to identify the differential effects of a fall in tariffs on firms that import these inputs to those that compete with them.

The main data source is manufacturing census from 1991 to 2001, for all plants with 20 or more employees.[2] This comprises information on output, employment, ownership, exports and imports. The input tariffs are constructed as a weighted average of output tariffs, where the weights are based on cost shares for over three hundred industries. For example, if an industry uses 70 percent steel and 30 percent rubber, then the input tariff for that industry is equal to 70 percent of the steel tariff plus 30 percent of the rubber tariff.

[1] One of the principal opponents to NAFTA was a Mexican refrigerator manufacturer who was concerned that he would be driven out of business by US competition. The refrigerators were of such poor quality that they did not last very long due to the use of flawed domestically produced compressors. Following NAFTA, this manufacturer was able to obtain much better-made American compressors and became one of the largest suppliers of refrigerators to the US market. See Krueger (2004).

[2] There may be some skeptism about the reliability of micro level data from a developing country with a high level of corruption. Alatas and Cameron (2003) found that this data produced a wage distribution similar to that for formal sector workers in the most commonly used source of Indonesian wage data, the Labor Force Survey (*Sakernas*). Furthermore, the data are consistent across the whole sample period, thus increasing the condfidence in its reliability.

Rather than relying on aggregate input/output tables for these weights, we use plant level details of every single input used in the production process for 1998 (the only year this data was available), and assume constant technology over the sample period. The data show there are wide disparities along the production chain, generally exhibiting an escalating structure with lower tariffs on inputs and higher tariffs on final goods. For example, tariffs are zero percent on motor vehicle bodies, 11 percent on motor vehicle components and 31.6 percent on motor vehicles.[3] The largest tariff reductions in Indonesia began in 1995 with the WTO commitment to reduce all bound tariffs to 40 percent or less.[4] Final goods tariffs have fallen from an average of 21 percent in 1991 to 8 percent in 2001 with large variations across and within industries - some tariffs are still as high as 170 percent.[5] Given the large variation in tariffs along the production chain and between industries, it is essential to have a high level of disaggregation for this kind of study.

We estimate production functions at the three digit level (29 industries) using the Olley-Pakes (1996) methodology to correct for simultaneity in the choice of inputs, and firm exit. We modify the Olley-Pakes approach to also control for the simultaneity between the decision to import intermediate inputs and productivity shocks as in Kasahara and Rodrigue (2004), and we take account of the Asian crisis in 1997 and 1998. Then we regress productivity at the plant level on final goods tariffs and input tariffs at the 5-digit ISIC level. To see whether trade liberalization has a larger effect on importing firms, we interact the input tariffs with importing firms.

The results show that the largest productivity gains arise from reducing input tariffs. A

[3] These rates are for 2001 for ISIC codes 38432, 38433, 38431 respectively. This escalating tariff structure is typical in many countries. Using data for 1994 to 2000, the World Bank found that 48 out of 86 countries exhibited an escalating tariff structure. Production process are divided into three stages: first-stage, semi-processed and fully processed. The rest of the countries are either classified as having de-escalating, uniform or mixed tariff structures. See www.worldbank.org/trade.

[4] A bound tariff provides an upper bound for tariffs that can be imposed on a member of the WTO - it is a commitment given by a country under GATT/WTO negotiations not to increase tariffs on products originating in WTO member countries beyond the bound tariff.

[5] Given the high level of corruption in Indonesia, there might be concern that the tariff reform process has been driven by politically connected firms. However, Mobarak and Purbasari (2005) find that political connections in Indonesia did not affect tariff rates.

10 percentage point fall in input tariffs leads to a 3 percent productivity gain on average, and an 11 percent productivity gain for importing firms. In contrast, a 10 percentage point fall in output tariffs is associated with a much smaller productivity gain of about 1 percent, most likely due to tougher import competition. These results are robust to including separate effects for the Asian crisis period. Interestingly, when we regress productivity only on final goods tariffs, as is common in the literature, the effect is more than doubled. This suggests that excluding input tariffs could lead to an omitted variable problem, overestimating the 'import-competition' effect, and perhaps under-estimating the total effect.

Many studies have found that lower output tariffs have boosted productivity due to 'import competition' effects. For example, Trefler (2004) shows that labor productivity increased by 14 percent in Canada and US in the industries that experienced the largest tariff cuts.[6] Pavcnik (2002) shows that import competing industries in Chile enjoyed productivity gains up to 10 percent higher than gains in the non-traded goods sector due to liberalized trade.[7] Note that industries are classified as import-competing based on the total imports of those categories. However, firms within these categories may actually be importing firms rather than import-competing. The import data at the plant level enables us to take account of this. Other studies on output tariffs and productivity include Topalova (2004), Head and Ries (1999), Krishna and Mitra (1998), Gaston and Trefler (1997), Tybout and Westbrook (1995), Harrison (1994), Levinsohn (1993) and Tybout et al. (1991). This evidence is consistent with cross-country regression studies on output tariffs and growth (see Romalis, 2005).

None of these studies take account of input tariffs. They draw on theoretical models that only comprise final goods, such as Krugman (1979), and Helpman and Krugman (1985) where productivity gains arise due to scale effects. In those models exposure to foreign competition increases the elasticity of demand faced by domestic producers, reducing market

[6] This is the only other study that uses highly disaggregated tariff data comprable to our study.

[7] This is the first study to carefully take account of the endogeneity of input choices in the first stage estimation of total factor productivity, and to control for exit.

power and forcing firms down their average cost curves. However Rodrik (1988) shows that this is not necessarily so, for example if there are barriers to exit, industries that contract will experience a fall in their average size.[8] Gains could also arise due to reallocation effects, with more efficient plants gaining market share, and hence increasing average industry productivity (see Roberts and Tybout, 1991). Other gains can be grouped under the heading of externalities, due to technical innovation (Grossman and Helpman, 1991); managerial effort (Corden, 1974, and Rodrik, 1992); or domestic knowledge spillovers and learning by doing (Krugman, 1987; Lucas 1988, 1993; Young, 1991). However, as Tybout (2003) points out, "if learning externalities are generated by experience producing a good, then ...whether trade liberalization helps or hurts...depends upon which productive processes generate the most positive externalities, and whether they expand or contract as protection is dismantled."

There are fewer theoretical models analyzing the effects of reducing input tariffs. In Corden (1971), lower input tariffs increase effective protection,[9] reducing import competition, and hence could result in lower productivity. In contrast, models by Ethier (1982), Markusen (1989), and Grossman and Helpman (1991) show that firms can enjoy productivity gains from lower input tariffs due to access to more varieties of intermediate inputs, and possibly higher quality inputs, or learning effects. Ours is the first study to provide empirical evidence that lower input tariffs directly benefit importing firms. A related study by Schor (2004) on Brazil shows that the effect of reducing input tariffs and output tariffs on productivity are of similar magnitude. This similarity could be due to the high level of aggregation (27 industries) of the tariffs, where some important variation is lost. Furthermore, unlike our study, she is unable to separately estimate the effect on importing firms. Using tariff data on 300 industries, we show that it is the importing firms that enjoy the highest productivity gains from reducing input tariffs. Fernandes (2003) indirectly accounts for the effect of input

[8] Bolaky and Freund (2004) show that trade does not stimulate growth in economies with excessive business and labor regulations.

[9] Effective rate of protection is the percentage by which a country's trade barriers increase the value added per unit of output, taking into account that both input and output tariffs affect an industry's value added.

tariffs in a study on Columbia via a 3-digit effective protection measure calculated by the national authorities, thus she is unable to separately identify the effect from input tariffs.

Other studies that consider the effect of imported inputs on productivity are Feenstra, Markusen and Zeile (1992), Muendler (2004), and Kasahara and Rodrigue (2004) but none of these relate the effects to trade liberalization.[10] Feenstra, Markusen and Zeile (1992) show that productivity, estimated at the industry level, is positively correlated with the introduction of new inputs in Korea. Muendler (2004) includes the foreign inputs in the first stage productivity estimations for Brazil and finds this is a relatively unimportant channel of productivity. Kasahara and Rodrigue (2004) find that foreign inputs increase plant productivity in Chile by 2.3 percent. Our study is also consistent with cross-country studies in the growth and trade literature, such as Sala-i-Martin, Doppelhofer and Miller (2004), which finds that one of the most robust variables in cross country regressions is the relative price of investment goods. They show that a low price of investment goods at the beginning of the period is positively related to subsequent income growth. Lowering input tariffs is a direct way of reducing the price of investment goods.[11]

The rest of the paper is organized as follows. Section 2 outlines the estimation strategy. Section 3 provides background on Indonesia's trade policy. Section 4 describes the data. Section 5 presents the results. Section 6 concludes.

2. Model and Estimation Strategy

To determine the effect of trade liberalization on productivity, we consider a plant with a Cobb-Douglas production function,

[10] Blalock and Veloso (2004) focus on productivity benefits to domestic suppliers of inputs in Indonesia as a result of import competition. They ignore the direct benefits to importing firms and do not consider the effects of trade liberalization. Blalock and Gertler (2005) and Javorcik (2004) find evidence of vertical spillovers from domestic suppliers to foreign firms in Indonesia and Lithuania, respectively.

[11] Lower input tariffs can also be interpreted as lowering the price of international 'outsourcing' of material inputs, thus our results would suggest that international outsourcing is associated with higher total factor productivity.

$$Y_{it} = A_{it}(\tau) L_{it}^{\beta_l} K_{it}^{\beta_k} M_{it}^{\beta_m}, \tag{2.1}$$

where output in firm i at time t, Y_{it}, is a function of labor, L_{it}, capital, K_{it}, and materials, M_{it}. We are interested in assessing whether the productivity of plant i is a function of trade policy, denoted by τ. So the first step is to estimate plant level productivity, and in the second stage we specify how productivity can be affected by trade policy.

2.1. Productivity

We use the semi-parametric estimator from Olley and Pakes (1996) to estimate total factor productivity (TFP) at the plant level for each group of plants that operate in the same sector, defined at the three digit level of disaggregation. A key issue in the estimation of production functions is the correlation between unobservable productivity shocks and input levels, which yields inconsistent estimates under OLS. The reason is that the variable input factors and thus their choice can be affected by the current value of the unobservable productivity shock. In other words, the variable input factors are likely to be correlated positively with the error term. This results in an upward bias of the coefficients on the variable input factors, like labor and material, under OLS. One way to deal with this endogeneity problem is to use instrumental variables as in Arellano and Bond (1991). However, this estimator requires a large number of cross-section observations to obtain reliable estimators. Pooling all sectors together to estimate the production function would be one option, but this has the disadvantage of imposing the same technological coefficients across all sectors. An additional problem is that it is not straightforward to find good instruments. Lagged values of the endogenous input factors are sometimes used, however, the validity of such instruments relies on the absence of serial correlation in production.

As an alternative, Olley and Pakes (1996) developed a semi-parametric estimator that uses investment as a proxy for these unobservable productivity shocks. An advantage of this approach is that it also controls for endogenous exit from the sample, which is assumed to occur when productivity falls below a threshold.[12] In particular, plants with more capital, such as importers, are likely to allow for greater reductions in productivity, making the exit threshold a decreasing function of capital. Following Olley and Pakes (1996), we estimate a Cobb-Douglas production function, taking the logs of equation 2.1, which we denote by small letters,

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + e_{it} \tag{2.2}$$

$$e_{it} = \omega_{it} + \eta_{it}.$$

The error term, e_{it}, has two components, a white noise component, η_{it}, and a time varying productivity shock, ω_{it}, which is known to the firm, but not to the econometrician. It is a state variable that can have an impact on the choices of inputs, which leads to a simultaneity problem. Pakes (1994) shows that the investment function, $I_{it} = i_{it}(k_{it}, \omega_{it})$, which is a function of two state variables, capital and productivity, is monotonically increasing in productivity. Inverting the investment function gives an expression for productivity as a function of capital and investment,

$$\omega_{it} = g(k_{it}, I_{it}). \tag{2.3}$$

Substituting equation 2.3 into 2.2 allows estimation of the variable input coefficients using nonparametric techniques. In a second step, the survival probability of a plant is predicted from a nonparametric probit regression and, finally, the coefficient on the state variable, capital, is recovered using semiparametric nonlinear least squares.

We modify the Olley-Pakes approach to take account that productivity in 2.3 not only depends on the state variable capital, but also on the decision to import inputs, d_{it}.[13] If there exist sunk start-up costs of importing materials then the current import choice is

[12] Levinsohn-Petrin (2003) build on the Olley-Pakes approach, but use intermediate inputs instead of investment as a proxy for unobserved productivity shocks. One drawback of their approach is that exit is not explicitly modelled, while in Olley-Pakes it is. We have experimented with this alternative approach and our results remain robust.

[13] See Kasahara and Rodrigue (2004). Similar extensions have been developed in more detail by Van Biesebroeck (2005) in the context of firms that export.

going to have an impact on future usage of input factors and on the investment decisions because plants that import inputs face different factor markets and different market prospects than those that only use domestic materials. Adjusting equation 2.3 and substituting the unobserved productivity term out in equation 2.2 gives a partial linear model:

$$y_{it} = \beta_l l_{it} + \beta_m m_{it} + \phi_{it}(I_{it}, k_{it}, d_{it}) + \eta_{it}. \tag{2.4}$$

In the first stage we obtain consistent estimates of β_l and β_m . We use a series estimator using a fourth order polynomial in investment, capital and the import decision.[14] To identify the coefficient on capital we model survival as a function of capital, investment and in addition the import decision. The estimation algorithm is the same as in Olley-Pakes (1996).

We estimate the production functions for plants in each three digit sector separately. All our variables are deflated using three digit price deflators. For gross output we use producer prices. Capital was deflated using a three digit capital deflator (see appendix for details of deflators). Materials include domestic materials and imported materials. A three digit domestic material price deflator was constructed using the producer price deflator weighted by the cost proportion of each input. Imported inputs were deflated with an import price deflator to ensure that differentials in total factor productivity between importing and non-importing firms are not driven by differences in domestic and import prices. But note that this does not turn out to be an important adjustment because domestic and imported input prices move together as seen in Figure 1.

The estimated input coefficients obtained from estimating equation 2.2 with OLS, and with Olley-Pakes are reported in Table 1. Typically the labor and material coefficients are over-estimated with OLS, which is what can be expected if labor, material usage and productivity shocks are positively correlated. In order to verify that our results are not just driven by the methodology of estimating TFP we also report a number of robustness checks using TFP estimates from OLS, as well as labor productivity.

[14] We also make the function time dependent to allow for interactions with the Asian crisis years in Indonesia.

Using the estimates of the input coefficients from the Olley-Pakes methodology, we compute the log of TFP of plant i at time t, denoted by tfp_{it}, as

$$tfp_{it} = y_{it} - \widehat{\beta}_0 - \widehat{\beta}_l l_{it} - \widehat{\beta}_k k_{it} - \widehat{\beta}_m m_{it}. \tag{2.5}$$

In Figure 2 we plot the average plant level evolution of TFP based on estimates using OLS and Olley-Pakes, with 1991 normalized to 1. First, note that the evolution of average TFP is similar using both estimation techniques,[15] but the increase in average TFP is typically higher with OLS, especially after 1997. The OLS estimation does not take into account the exit of plants nor the effect of the financial crisis on investment decisions, while in the Olley-Pakes approach these factors are explicitly modelled. This might explain why there is a divergence in TFP growth using OLS and Olley-Pakes, especially after 1997. Second, note that average TFP has increased from 1991, and peaks first in 1998 and later in 2001, with average TFP 18.7 percentage points higher relative to 1991 (using the Olley-Pakes TFP measure).

2.2. Trade Liberalization

In the second stage, we specify the possible links between trade liberalization and plant level productivity. Using the plant level measures of TFP from equation 2.5, we estimate the following equation:

$$\begin{aligned} tfp_{it}^{k} &= \gamma_0 + \alpha_i + \alpha_t + \gamma_1 \text{tariff}_t^k \\ &+ \gamma_2 \text{inputtariff}_t^k + \gamma_3 \text{inputtariff}_t^k * FM_{it} + \gamma_4 FM_{it} + \varepsilon_{it}, \end{aligned} \tag{2.6}$$

where tariff_t^k is the tariff on final goods for industry k, at the 5-digit ISIC level. A fall in final goods tariffs increases import competition and thus can lead to an improvement in efficiency of plants, due to trimming of fat, for example. We hypothesize that γ_1 is negative.

Reducing input tariffs could offset some of the import competition effects that arise from lower output tariffs, as many firms are affected by both output and input tariffs. This

[15] The sample correlation between the OLS estimates and the Olley-Pakes is 0.78.

was the idea behind the effective protection literature (see Corden, 1971). For example, a lower input tariff could reduce the incentives for firms to pursue more efficient techniques. However, more recent literature emphasizes the benefits that accrue from lower input tariffs, by making foreign inputs more accessible. A higher usage of foreign inputs can increase firm productivity due to learning effects from foreign technology embodied in the imported inputs, or from higher quality inputs or more input varieties. In this case the importing firms should reap highest benefits from this direct effect.

There may also be indirect positive effects spreading from importing to non-importing firms. As importing firms become more productive they can pass on benefits to other firms through sales of their goods along the vertical production chain, for example. A fall in the price of imported inputs can force domestic substitute producers to become more competitive by becoming more innovative, and passing on benefits to users of domestic inputs; or by trimming fat they could lower domestic prices.[16] We expect these indirect effects to be of lower magnitude than the direct effects.

To capture these effects, we construct an input tariff for each industry k as a weighted average of all tariffs, where the weights are based on the cost shares of each input used in the industry at the 5-digit level. This input tariff is then interacted with a firm level indicator of importing firms, denoted by FM, which equals 1 if imports account for more than 10 percent of total intermediate inputs; and in some specifications it is interacted with the actual share of imported inputs to total inputs. We hypothesize that γ_2, and γ_3 are negative. A negative and significant coefficient on the interaction term, γ_3, would imply that importing firms do reap higher benefits than non-importing firms from lower input tariffs. We hypothesize that γ_4 is positive, indicating that imported inputs generate some kind of technological externality.

[16] It should be noted that lower prices could also lead to increases in 'measured productivity' since deflators are at the 3-digit industry level rather than the firm level. We attempted to minimize this effect by using separate import deflators. Recall that this does not turn out to be an important modification given that imported and domestic input prices moved together, as shown in Figure 1.

In some of our robustness checks, we also include an effective protection measure developed by Corden (1971), which takes account of the net effect of tariffs on inputs and final goods, defined as

$$erp_{it}^{k} = \frac{(\text{tariff}_t^k - a_{i,t}^k \text{inputttariff}_t^k)}{\left(1 - a_{i,t}^k\right)},$$

where $a_{i,t}^k$ is the ratio of inputs to outputs for firm i in industry k at time t. The idea is that a lower output tariff decreases the protection that industry k receives whereas a lower input tariff increases the protection industry k receives, since low input tariffs make it less costly to produce final goods. We hypothesize that lower effective protection increases productivity. However, we expect that productivity gains from lower input tariffs will dominate any potential negative competition effect.

Equation 2.6 is estimated using ordinary least squares, with firm fixed effects, α_i, to control for unobserved firm level heterogeneity, and time fixed effects, α_t, to control for shocks over time that affect productivity across all sectors.

3. Trade Policy in Indonesia

Indonesia became a WTO member on January 1, 1995, at which time it gave a commitment to reduce all bound tariffs to 40 percent or less over a ten year period, starting in 1995, subject to an exclusion list of products for which this commitment did not apply.[17] There were 73 five-digit ISIC codes that included at least one excluded HS code, and only 9 ISIC codes which contained 10 or more excluded HS codes. The industries with the highest number of exclusions were motor vehicles and components, and iron and steel basic industries. Plotting the change in tariffs over the sample period, 1991 to 2001, as a function of tariffs at the beginning of the sample, we see from Figure 3 that there is a clear trend, with the industries with the highest initial tariffs experiencing the largest tariff reductions. Note there were 4 product groups in the sample for which tariffs actually increased over the period (not

[17] The tariff lines are at the HS 9-digit level, compirisng thousands of product codes. For the exclusion list see http://www.wto.org/english/tratop_e/schedules_e/goods_schedules_e.htm

included in the figure). These were liquors and wine (ISIC code 31310 and 31320), and rice milling (ISIC code 31161 and 31169).

In order to identify the effects of tariff reductions on productivity, an important question is whether the trade reform process is endogeneous as this would lead to biased estimates. There is a large political economy literature that argues that certain industries have more political power to lobby governments for protection (see Grossman and Helpman, 1994). However, for Indonesia, Mobarak and Purbasari (2005) find that political connections do not affect tariff rates. They regress tariffs at the industry level on a political connection indicator and find this is insignificant. They explain their result by arguing that in developing countries it is difficult for governments to provide favors in the form of high output tariffs because they are under the close scrutiny of international organizations such as the International Monetary Fund. So instead, political favors are given at the firm level in a less transparent way. The authors show that politically connected firms in Indonesia receive benefits by way of the right to import. But note that only about 1% of the firms fall within this category since in most product groups any firm is allowed to import. Hence, their study seems to imply that the endogeneity of tariffs may not be so serious in the case of Indonesia.

The potential bias due to endogeneity is also reduced due to our estimates all including fixed effects, so if political economy factors are time invariant then this is already accounted for (see Goldberg and Pavcnik, 2001). However, time varying industry characteristics could simultaneously influence productivity and tariffs. For these reasons, Trefler (2004) proposes the share of unskilled labor in total employment as an indicator of industries' propensity to get organized.

As a robustness check, we estimate equation 2.6 using two-stage least squares with a number of different instruments. In addition to the share of unskilled labor in total employment, we use the 1991 levels of tariffs as instruments for changes in tariffs, as in Goldberg and Pavcnik (2005) in their Columbia study. Regressing the tariff change between 1991 and 2001 on initial tariffs in 1991 gives a coefficient of -0.58 (t-stat=8.26, R-squared=0.2).

When we exclude the four product groups for which tariffs increase, the size of the coefficient increases to -0.69 (t-stat=42.7, R-squared=0.88). This suggests that the level of tariffs in 1991 is indeed a good predictor of changes in tariffs over the sample period.

Another important form of protection provided to industries is through non-tariff barriers (NTBs), which are generally very difficult to measure. We experimented with an NTB measure equal to one post 1995 for 5-digit product codes where at least one HS 9-digit product was listed as having a non-tariff barrier that the Indonesian government agreed to remove over a 10 year period from 1995. There were 17 such 5-digit product codes. However, we found that this had an insignificant effect on productivity. Most of the NTBs (43 HS codes) to be removed fell within the product code 37101 (iron and steel basic industries). We also experimented with an NTB post-1995 only for this product code. Again, we found that this had an insignificant effect on productivity. The insignificance of these coefficients might be due to the imprecise measure of the NTBs or perhaps the NTBs had not yet been removed since the Indonesian government has until 2004 to meet these obligations. Unfortunately, we were unable to find any further information on NTBs, hence the rest of the analysis focuses on the effects of tariff reform.

4. Data

Our main data source is the Manufacturing Survey of Large and Medium-sized firms (Survei Industri, SI) for 1991 to 2001. This is an annual census of all manufacturing firms in Indonesia with 20 or more employees. The SI data capture the formal manufacturing sector with plant level data on output, intermediate inputs, labor, capital, imports, exports, and foreign ownership. We use data on outputs and inputs, deflated by wholesale price indices, to obtain productivity estimates. We construct domestic input deflators by weighting the final goods wholesale prices with their cost shares as intermediate inputs; and use officially published import price deflators for the imported inputs.

The input data provided in this data set is unusually rich. The SI questionnaire asks each firm to list all of its individual intermediate inputs and the amount spent on each in rupiah. Although this information is not routinely prepared, it was coded up by the Indonesian Statistical Agency (Badan Pusat Statistic, BPS) and made available to us for the year 1998. For all other years, we have total expenditure on domestic inputs and imported inputs, but not by individual type of input. So, we aggregate the 1998 data up within 5 digit industry categories to provide a 277 manufacturing input/output table,[18] and assume that the mix of inputs used by industries does not change over our sample period. This input data is of particular importance for this study as it enables us to construct an input tariff for each industry.

The input tariff is calculated using HS 9-digit tariffs from the Indonesia Industry and Trade department. With the help of an unpublished concordance between this HS 9-digit classification and the 5-digit ISIC from BPS we were able to match the international and production data.[19] For each 5-digit industry, we computed the input tariff based on the cost share of that input. For example, if an industry uses 90 percent steel and 10 percent rubber, we give a 90 percent weight to the steel tariff and only a 10 percent weight to the rubber tariff. And we use a simple average of the HS 9-digit codes to construct a final goods tariff for each 5 digit industry. The variation in average tariffs by 2-digit industry is shown in Table 3 for 1991, 1995 and 2001. We see that in general input tariffs are lower than final goods tariffs, and all have been on a downward trend over the sample period, although the largest reductions take place from 1995. The correlation between the final goods tariffs and input tariff is 0.66.[20]

We begin our analysis in 1991 to avoid the reclassification of industry codes between 1990

[18] Note that there are actually 307 5-digit ISIC industry codes but only 277 are in our sample.

[19] This concordance was incomplete so a large portion was manually concorded by the authors, based on product descriptions. Some of the 5-digit industries had to be grouped together, for example it was difficult to separate rice milling from other grain milling products so these two industries were grouped together. This left us with a total of 221 output tariff codes. But note that we have a larger number of input tariffs (277) since different industries use inputs in different proportions.

[20] Note that this is the correlation after the tariff data has been merged with the firm data. The correlation at the industry level is much lower, at 0.46.

and 1991, and prior to this the capital stock data was less complete. The data needed to be cleaned due to missing variables for some observations and large unrealistic numbers. The cleaning process is described in the data appendix. In the end, we have an unbalanced panel of around 10,000 firms per year with a total of 116,121 observations. The summary statistics are provided in Table 3.

5. Results

We estimate equation 2.6 as an unbalanced panel with fixed effects for the period 1991 to 2001. The errors have been corrected for heteroskedasticity at the plant level.[21]

5.1. Productivity and Tariffs

The results from estimating equation 2.6 with plant fixed effects and year fixed effects are presented in Table 4. First, we regress *tfp* only on final goods tariffs, as is common in the literature, as a benchmark. Column 1 of Table 4 shows that a fall in output tariffs of 10 percentage points increases productivity by 2.1 percent. This significant negative coefficient is consistent with the literature, for example in Pavcnik (2002) the effect is 2.8 percent in a similar specification. In column 2, we add input tariffs - the coefficient on output tariffs is more than halved and its statistical significance is reduced. The point estimate suggests that a 10 percentage point fall in tariffs only increases productivity by 0.8 percent. In contrast, the coefficient on input tariffs is much higher, indicating a 10 percentage point fall in input tariffs increases productivity by 4 percent. The results clearly show that the gains from reducing input tariffs are much higher than those from reducing output tariffs. And comparison of columns 1 and 2 suggests there is an omitted variable bias in column 1.

If productivity gains from reducing input tariffs are really due to the technology embodied in foreign inputs then we would expect that importing firms would enjoy the largest gain from this direct effect. To check this we interact input tariffs with an indicator of importing

[21] The footnotes of the tables also provide information on clustering at the industry/year level. Our main conclusions are unaffected by the clustering groupings.

firms. Firms are classified as importing if they import more than 10 percent of their total inputs. In column 3 we see that the coefficient on this interactive term is negative and significant, equal to -0.83. This shows that firms that import inputs do indeed enjoy a larger productivity gain than non-importing firms, which is what we would expect if there are benefits arising from higher quality inputs, more varieties of inputs or learning effects. Adding this coefficient to the overall input tariff effect indicates that a fall in input tariffs of 10 percentage points improves productivity for importing firms by 11 percent, whereas non-importing firms only benefit by 3 percent. And the coefficient on importing firms, FM, is positive and significant as expected, showing that importing firms are 8.6 percent more productive on average than non-importing firms.

There may be concern that the productivity estimates are just capturing differences in mark-ups and not actual productivity. To address this, we added a Herfindahl concentration index, defined as the sum of the squared market shares in each 4-digit sector, in column 4. We see that including this variable does not affect any of the other coefficients, and has a negative, but insignificant coefficient. In column 5, we control for the exit of firms. This is a dummy variable equal to one if the firm exits in the following period. The negative and significant coefficient indicates that it is the least productive plants that exit, as one would expect. Firms that exit are on average 2.5% less productive. Again, the other coefficients are hardly affected.

In column 6, we include the actual share of imported inputs rather than a dummy variable and interact this with input tariffs. This gives almost identical results. The coefficient on the interaction term between input tariffs and import share is equal to -1.5. Multiplying this by the mean import share for importing firms (equal to 0.46) gives an effect equal to 0.71, a little lower than the coefficient of 0.83 on input tariffs interacted with an importing dummy in columns 3 to 5. Adding this to the coefficient on input tariffs gives the overall productivity gain for importing firms of 1.1, indicating that a 10 percentage point fall in input tariffs leads to an average productivity gain of 11 percent for importing firms. The coefficients on input tariffs and output tariffs are the same as in column 5 where input tariffs are interacted with the importing firm dummy. In column 7 we control for potential first order serial correlation in the error term and implement a correction derived in Baltagi and Wu (1999), which essentially applies a Cochrane-Orcutt transformation. Note that the estimates on the coefficients on the output and input tariffs are very similar to those in column 6.

5.2. Effective Protection Rates

In Table 5, column 1, we include the effective rate of protection and find that the coefficient is negative and significant.[22] A fall in effective protection, which could come about due to lower output tariffs, higher input tariffs, or a change in input intensity, leads to an increase in productivity. This effect persists even after we control for output tariffs or input tariffs. In column 2, to determine the total effect of reducing output tariffs now, we need to add the coefficient on output tariffs to the indirect effect through the effective rate of protection (i.e. $\beta_{tariff} + \frac{\beta_{erp}}{1-a^k_{i,t}}$). Using the coefficients in column 2, and evaluated at the mean input share, equal to 0.52, this equals -0.17, which is very close to our coefficient of -0.21 in Table 4. In columns 3 and 4 we add input tariffs instead of output tariffs, and again there is a negative and significant coefficient on *erp*. The total effect of reducing input tariffs on importing firms can be calculated by adding the indirect effect via the effective rate of protection $\frac{-\beta_{erp}a^k_{i,t}}{1-a^k_{i,t}}$ to the direct effects, which equals -1.1, close to the total effect in Table 4, as can be seen by comparing columns 3 and 4 of Table 5, with Table 4. These results suggest that the benefits of reducing input tariffs outweigh any potential negative effect on competition.

The advantage of including an effective protection measure is that it calculates a net competition effect, since many firms would be affected by both input and output tariffs. However, with *erp* alone it is not possible to disentangle the differential effects of input and output tariffs. Moreover, the input tariff applies to total inputs irrespective of whether

[22] The *erp* was constructed only for firms with input shares less than or equal to 99%. Some firms reported input shares higher than this, which may be due to production lags.

it is a domestic input or imported input. We include it here for completeness but our preferred specification is to include output and input tariffs separately as in Table 4, where interpretation of coefficients is more straightforward.

5.3. Additional controls

Table 6 adds additional controls to ensure the robustness of the key results in Table 4. We begin by adding the share of output exported and the share of foreign ownership in columns 1 and 2 since exporters and foreign firms are generally expected to have higher productivity on average. The foreign share is insignificant in all specifications, and the export share is negative and significant, only at the 10 percent level, in some specifications. It should be noted that since all of these estimations include firm fixed effects, the additional firm characteristic indicators only pick up changes over time. If we define an exporting firm as being one that exports at least 10% of its output, we can see from the summary statistics in Table 3 that there are very few firms in our sample that switched their export status. Similarly, there were very few firms that had a major switch in their share of foreign ownership. Hence, it is not surprising that these coefficients are insignificant.

Most importantly for this study, we check that the results are not driven by the Asian crisis that started in August 1997. The crisis dummy is equal to one for the years 1997 and 1998. We interact the final goods tariff and the input tariff variables with the crisis dummy in columns 3 and 4 of Table 6. We see that the key results are robust - the size of the coefficients on the final goods and input tariffs remain unchanged. So our results are not driven by the Asian crisis. Looking at the crisis interaction terms, we note that the interaction term on output tariffs is insignificant but there is an additional effect from input tariffs. Non-importing firms perform relatively better than importing firms during the Asian crisis. This may not be surprising given the large depreciation during that period.[23]

[23] Recall that deflators are at the industry level rather than the firm level, so measured productivity can change due to price effects.

5.4. Alternative specifications

In Table 7, we check whether the results are sensitive to the way we measure productivity. In the first two columns we present results with TFP estimated using ordinary least squares and domestic prices are used to deflate domestic and imported inputs. We want to ensure that the adjustments we made for importing firms using the Olley-Pakes methodology are not driving the results. Using OLS *tfp* measures, we find that the effect from output tariffs becomes insignificant once we control for input tariffs, whereas the magnitude of the effect of input tariffs is close to the previous results.

We also check whether our results apply to labor productivity to ensure that results are not being driven by imprecisely measured capital stock. Labor productivity is defined as the difference between real output and real intermediate inputs divided by total employment. In column 3, we regress log value added per worker on final goods tariffs, and in column 4 we control for capital per worker. We see that reducing output tariffs also increases labor productivity and the effect is much higher than it was for *tfp*. Furthermore, these results are not sensitive to the inclusion of capital per worker. The estimated coefficient on output tariffs in columns 3 and 4 are very close. In column 5, we add input tariffs and interact this with importing firms. The pattern is consistent with the *tfp* results in Table 4, that is by including input tariffs the coefficient on output tariffs is once again more than halved (from -0.52 to -0.21) and the coefficient on input tariffs is much higher. Furthermore, the coefficient on the interactive term between input tariffs and importing firms is large and significant, indicating that importing firms also enjoy higher labor productivity. The same general pattern persists irrespective of the measure of productivity.

So far, all the estimations have been on levels with firm and year fixed effects. In Table 8, we go back to using log TFP from the Olley-Pakes methodology as the dependent variable and experiment with alternative econometric specifications. In columns 1 and 2, the dependent variable is log TFP and the specifications include 5-digit industry fixed effects instead of firm fixed effects. The input tariff is interacted with import share. We see that the results are generally consistent with the firm fixed effect model. In columns 3 and 4, we include all variables in first differences. This first differences wipes out unobserved firm heterogeneity. We also add year fixed effects to allow for the possibility that unobserved time effects could effect productivity growth, as well as levels. The coefficients are smaller now. In column 3 with only the output tariff as a regressor the coefficient is negative and significant at the 5 percent level but once we add input tariffs this becomes insignificant. The effect of reducing input tariffs is negative and significant for both importing and non-importing firms but the effect for importing firms is now even smaller than in the previous specifications. These smaller and less significant coefficients may be due to measurement error that can be induced by taking first differences.

In columns 5, 6 and 7 of Table 8 we experiment with longer time differences in order to help wash out measurement error. In columns 5 and 6, all variables are in five period time differences. In column 5, we only include final goods tariffs and the coefficient is equal to -0.18, which is close to our original estimate in the fixed effects model. In column 6 we add the input tariffs and the Herfindahl index, and once again the coefficient on output tariffs is more than halved and becomes insignificant. Importing firms receive the largest gains from tariff reform. The five period difference model produces very similar results to the fixed effects model (see column 6 in Table 4). In column 7 we include all variables in 10 period differences (2001 less 1991). As well as reducing measurement error, this has the advantage of avoiding serial correlation since there is now only one observation per firm. The size of the output tariff is now much higher than in previous specifications, indicating that a 10 percentage point fall in output tariffs increases productivity by 4 percent. The magnitude on the input tariff coefficients are only slightly higher than previous specifications. A 10 percentage point fall in input tariffs is associated with a 4.7 percent increase in productivity on average for all firms, and a 13 percent increase for importing firms. The same general pattern persists with importing firms enjoying the largest productivity gains.

5.5. Endogeneity

Finally, we address the issue of the potential endogeneity of tariffs. It may be that firms in low productivity industries lobby for protection leading to reverse causality or it might be that governments pick 'winners' to protect, so it is unclear which way the bias, if any, would go. It is generally difficult to find valid instruments for tariffs, and in the case of Indonesia in a firm fixed effects model it is unclear whether there is in fact a serious endogeneity issue. However, for the sake of completeness in Table 9 we address this potential concern by instrumenting for output tariffs, input tariffs and the input tariff interacted with input shares. All specifications are for the 5 period difference model as it is easier to find instruments for changes in tariffs rather than for levels, since our levels equations all include fixed effects, and the five period differences are less likely to induce measurement error than one year differences. Furthermore, we showed that the five period difference model produced almost identical results to the levels with firm fixed effects.

The instruments in column 1 comprise the 1991 level of output tariff, 1991 level of input tariff, 1991 level of input tariff interacted with a dummy indicator of firms that import more than 10 percent of their output, and a dummy indicator for product levels where at least one HS code was excluded from the commitment to reduce bound tariffs to 40 percent. The second column includes the level of input and output tariffs lagged 5 years instead of 1991 tariffs as instruments; and finally in column 3 we add the proportion of low skilled workers by industry in 1991 and the Herfindahl index by industry in 1991. In all of the specifications, the instruments provide a good fit in the first stage regressions as indicated by the Shea partial R-squared;[24] and they all comfortably pass the overidentification tests with p-values ranging from 0.58 to 0.69.

The two-stage least squares results suggest that the OLS coefficients are underestimated. In all cases the coefficient on output tariff is much higher, ranging from 0.49 to 0.55; the effect for importing firms is also higher ranging between 1.4 and 1.5 (compared with the

[24] This takes account of the collinearity between endogenous variables. For further details, see Shea (1996).

OLS estimate of 1.1), and the effect of input tariffs on non-importing firms is now either lower at 0.20 (compared with an OLS estimate of 0.34) and in some cases it is insignificant. So although the magnitudes are somewhat different now, the key message remains. That is, reducing output tariffs increases productivity but the largest gains are enjoyed by importing firms as a result of lower input tariffs.

5.6. Interpretation of Results

For the firms in our sample, output tariffs fell on average by 16.6 percentage points between 1991 and 2001. Based on the results in column (6) of Table 4, this translates into a productivity gain of only 1.5 percent over the sample period. In contrast, input tariffs only fell by 8.3 percentage points over the sample period. However, this translates into a larger gain of 2.9 percent for all firms, and an increase in productivity of 8.8 percent for importing firms. Of course these are only averages. Some output tariffs fell by as much as 46 percentage points, which is associated with a total productivity gain of 4.1 percent. Some input tariffs fell by as much as 29 percentage points, leading to a gain of 10 percent for all firms, and 31 percent for importing firms over the sample period, or annual average increase of 3.1 percent.

The finding that importing firms enjoy the largest productivity gains as a result of trade reform is robust across all specifications. However, this result should not be misinterpreted as support for the existing escalating tariff structure we have seen many countries adopt. Although the gains from lower input tariffs seem much higher than those from lowering output tariffs, it must be remembered that most of these gains are enjoyed only by those firms that are importing inputs, and these constitute only 19 percent of the sample. Furthermore, we have only focused on the effects of reducing tariffs on productivity. Although productivity growth is a key determinant of economic well-being, it is not in itself a welfare measure. Changes in tariffs can induce many other effects, including a change in incentives on where firms locate (see Krugman and Venables, 1995;Amiti 2005a). A different tariff structure, such as a lower final goods tariffs to match the level of input tariffs, could in principle have led to the entry of more firms in Indonesia. Amiti (2005b) shows that an escalating tariff structure may produce lower welfare than uniform tariffs, for example, because it works against agglomeration of vertically linked upstream and downstream industries and hence countries forego the benefits, such as lower prices, that arise from these agglomerations.

6. Conclusions

This study is one of the first to empirically analyze the effects of reducing input tariffs on firm productivity, and the only one to isolate the effect on importing firms from other firms. Our analysis has produced important new findings. First, we showed that the effect of reducing input tariffs significantly increases productivity, and this effect is much higher than reducing output tariffs. A 10 percentage point fall in input tariffs increases productivity by 3 percent whereas an equivalent fall in output tariffs increases productivity by a little less than 1 percent. Second, the effect of reducing input tariffs is much higher for firms that import inputs than non-importing firms, which is what we would expect if the productivity gains are due to direct benefits, arising from higher quality foreign inputs, more differentiated varieties of inputs and/or learning effects. A 10 percentage point fall in input tariffs leads to a productivity gain of 11 percent for importing firms. Third, our analysis suggest that excluding input tariffs could result in an omitted variable bias problem, over-estimating the competition effect arising from lower output tariffs. Once we included input tariffs the coefficient on output tariffs was more than halved, and the largest productivity gains came from reducing input tariffs.

Our results are robust across different specifications. Estimates of total factor productivity were obtained using the Olley-Pakes (1996) methodology, which corrects for the simultaneity of input choices and exit. In addition, we corrected for the simultaneity between the decision to import intermediate inputs and productivity shocks, we deflated the share of imported inputs by import price deflators and took account of the Asian crisis in the first stage estimates of TFP. We found that the results were not sensitive to the way we measured productivity, including TFP measures using OLS and labor productivity. The results were also robust to five period differencing, 10 period differencing, instrumental variables estimation, as well as additional controls such as a concentration measure, firm characteristics such as exporters, and foreign ownership, and allowing for differential effects during the Asian crisis.

These results raise the question as to why the benefits from import competition due to lower output tariffs are not as high as we would expect. The most likely explanation is that in regulated economies such as Indonesia, resources cannot move freely between sectors, which is an essential ingredient in achieving productivity gains from import competition. Hence, there are likely to be further potential gains from trade reform that could be exploited.

Data Appendix

1. Plant Level Data and cleaning operations

We cleaned the data to minimize noise due to non-reporting, misreporting and obvious typing mistakes of data input. We made three key adjustments. First, we used interpolation to fill in the gaps if a plant reported for a particular variable no value in a given year, while values were reported in the year prior and the year after the missing one. This applies to less than 1% of the sample. Second, we dropped plants with unrealistically large spikes in the data (e.g. employment growth of more than 200%, growth in output of more than 500%, etc.). Third, the capital stock is measured by the replacement value of fixed assets, however, for the year 1996 this information was missing. We therefore interpolated the capital stock for the year 1996 using the 1997 and 1995 values. After having estimated TFP a small number of plants had unrealistically high or unrealistically low TFP levels, we dropped those from the analysis. Note that the results were not sensitive to dropping these observations.

2. Deflators

Output deflators: The wholesale price indices (WPI) are published monthly in the Buletin Statistik Bulanan Indikator Ekonomi of the Indonesian Statistical Agency (Badan Pusat Statistic, BPS), the Monthly Statistical Bulletin of Economic Indicators. We used an unpublished concordance from the BPS to map the 192 WPI commodity codes into the 5-digit ISIC product codes. Some ISIC codes mapped into more than one commodity code, so we took the average price of those to obtain a price index at the 5-digit ISIC product code.

Material Input deflators: The domestic input deflators are constructed by weighting the final goods wholesale prices with their cost shares as intermediate inputs. These costs shares were obtained from the list of firm self-reported inputs (only available in 1998) which we aggregate up within 5 digit ISIC industry categories to provide a 277 manufacturing input/output table, and assumed that the mix of inputs used by industries does not change over our sample period, 1991 to 2001. The imported input deflators are the officially published import price deflators for imported inputs.

Capital deflator: We constructed the capital price deflator by making use of the aggregate price index of imported electrical and non-electrical machinery and equipment, imported transport goods and the wholesale price index of manufactured construction materials. We then used the information from the SI to compute the shares of vehicles, buildings and equipment at the 4-digit ISIC level. Those shares are used to weight each of the individual aggregate deflator to obtain a capital deflator at the sector level.

References

[1] Alatas, Vivi and Lisa Cameron (2003). "The Impact of Minimum wages on Employment in a Low Income Country: An Evaluation Using the Difference-in-Difference Approach." World Bank Policy Research Working Paper 2985, 1-31.

[2] Amiti, Mary (2005a). "Location of Vertically Linked Industries: Agglomeration versus Comparative Advantage", *European Economic Review*, May vol. 49(4), 809-832.

[3] Amiti, Mary (2005b). "How the Sequence of Trade Liberalization affects Industrial Location", International Monetary Fund, unpublished manuscript.

[4] Arellano, M. and Bond, S. (1991). "Some Tests of Specification for Panel Data: Monte Carlo Evidence and Application to Employment Equation", *Review of Economic Studies*, 58, pp. 277-297

[5] Baltagi, B.H. and Wu, P.X. (1999). "Unequally Spaced Panel Data Regressions with AR(1) Disturbances",.*Econometric Theory,*15, pp. 814-823.

[6] Bolaky, Bineswaree and Caroline Freund (2004). "Trade, Regulations, and Growth", World Bank Policy Research Working Paper No. 3255

[7] Blalock, Garrick and Francisco Veloso (2004). "Trade, Technology Transfer and Productivity Growth: The Neglected Role of Imports", Cornell University, unpublished manuscript.

[8] Blalock, Garrick and Paul Gertler (2005). "Welfare Gains from Foreign Direct Investment through Technology Transfer to Local Suppliers" Cornell University, unpublished manuscript.

[9] Corden, Max W. (1974). *Trade Policy and Economic Welfare* (Oxford, England: Clarendon Press).

[10] Corden, Max W. (1971). *The Theory of Protection* (Oxford, England: University Press).

[11] Ethier, Wilfred (1982). "National and International Returns to Scale in the Modern Theory of International Trade", *American Economic Review* 72, 389-405.

[12] Feenstra, Robert C., James R. Markusen, and William Zeile (1992). "Accounting for Growth with New Inputs: Theory and Evidence", *American Economic Association Papers and Proceedings*, 415-421.

[13] Gaston, Noel and Daniel Trefler (1997). "The Labour Market Consequences of the Canada-U.S. Free Trade Agreement", *Canadian Journal of Economics* 30(1), 18-41.

[14] Grossman, Gene and Elhanan Helpman (1994). "Protection for Sale", *American Economic Review* 84, 833-850.

[15] Feenstra, Robert C., James R. Markusen and William Zeile (1992). "Accounting for Growth with New Inputs: Theory and Evidence", *American Economic Review* 82, 415-21.

[16] Fernandes, Ana M. (2003). "Trade Policy, Trade Volumes and Plant Level Productivity in Colombian Manufacturing Industries", *World Bank Working Paper 3006.*

[17] Goldberg, Pinelopi Koujianou and Nina Pavcnik (2005). "Trade, Wages, and the Political Economy of Trade Protection: Evidence From the Columbian Trade Reforms", *Journal of International Economics*, forthcoming.

[18] Grossman, Gene and Elhanan Helpman (1991). *Innovation and Growth in The Global Economy*, Cambridge, MA: MIT Press.

[19] Harrison, Ann E. (1994). "Productivity, Imperfect Competition and Trade Reform: Theory and Evidence", *Journal of International Economics* 36(1-1), 53-73.

[20] Head Keith and John Ries (1999). "Rationalization Effects on Tariff Reductions", *Journal of International Economics* 47, 295-320.

[21] Helpman Elhanan and Paul R. Krugman (1985). *Market Structure and Foreign Trade,* Cambridge, MA: MIT Press.

[22] Javorcik, Beata S. (2004). Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages, *American Economic Review,* 94, 605-627.

[23] Kasahara, Hiroyuki and Joel Rodrigue (2004). "Does the Use of Imported Intermediates Increase Productivity?", unpublished manuscript.

[24] Krueger, Anne O. (2004). "Expanding Trade and Unleashing Growth: The Prospects for Lasting Poverty Reduction", IMF Seminr on Trade and Rgional Integration, Dakar, Senegal.

[25] Krugman, Paul R. (1987). "The Narrow Moving Band, the Dutch Disease, and the Consequences of Mrs Thatcher: Notes on Trade in the Presence of Scale Economies", *Journal of Development Economics* 27, 41-55.

[26] Krugman, Paul R., (1979). "Increasing Returns, Monopolistic Competition and International Trade", *Journal of International Economics* 9, 469-479.

[27] Krugman, Paul R. and Anthony J. Venables, 1995, "Globalization and the Inequality of Nations," *Quarterly Journal of Economics*, Vol. 110, pp. 857-880.

[28] Krishna, Pravin and Devashish Mitra (1998). "Trade Liberalization, Market Discipline and Productivity Growth: New Evidence from India", *Journal of Development Economics* 56(2), 447-462.

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

[30] Levinsohn, J and Petrin, A. (2003). "Estimating Production Functions using Inputs to Control for Unobservables", *Review of Economic Studies*, Vol. 70, pp. 317-342

[31] Markusen, James R., (1989) "Trade in Producer Services and in Other Specialized Intermediate Inputs", *American Economic Review* 79, 85-95.

[32] Mobarak, Ahmed Mushfiq and Denni Puspa Purbasari (2005), "Corrupt Trade Protection in Developing Countries: Firm Level Evidence on Political Connections and Import Licenses in Indonesia", University of Colorado, unpublished manuscript.

[33] Muendler, Marc-Andreas (2004). "Trade, Technology, and Productivity: A Study of Brazilian Manufactures, 1986-1998.

[34] Olley, S. and Pakes, A. (1996). "The Dynamics of Productivity in the Telecommunications Equipment Industry", *Econometrica*, Vol 64 (6), 1263-98.

[35] Pakes, A. (1994). *The Estimation of Dynamic Structural Models: Problems and Prospects*, Part II. Mixed Continuous-Discrete Control Models and Market Interactions, J.J. Laffont and C. Sims eds,

[36] Advances in Econometrics: Proceedings of the 6th World Congress of the Econometric Society, Chapter 5.

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

[38] Roberts, Mark and James Tybout (1991). "Size Rationalization and Trade Exposure in Developing Countries," in *Empirical Studies of Commercial Policy.* Robert Baldwin, ed. Chicago: U. Chicago Press for NBER.

[39] Rodrik, Dani (1988). "Imperfect Compeition, Scale Economies, and Trade Policy in Developing countries", in R. Baldwin (ed.) *Trade Policy Isues and Empirical Analysis* (Chicago: The University of Chicago Press).

[40] Rodrik, Dani (1991). "Closing the Technology Gap: Does Trade Liberalization Really Help?" in G. Helleiner (ed.) *Trade Policy, Industrialization and Development: A Reconsideration* (Oxford: Clarendon Press).

[41] Romalis, John (2005). "Market Access, Openness and Growth", University of Chicago.

[42] Sala-i-Martin, Xavier, Gernot Doppelhofer and Ronald I. Miller (2004). "Determinants of Long-Term Growth: A Baysian Averaging of Classical Estimates (BACE) Approach", *American Economic Review* 94(4), 813-835

[43] Schor, Adriana (2004). "Heterogeneous Productivity Response to Tariff Reduction: Evidence from Brazilian Manufacturing Firms", NBER Working Paper 10544.

[44] Shea, J. (1996). "Instrument Relevance in Mulitvariate Linear Models: A Simple Measure", Technical Working Paper, NBER.

[45] Topalova, Petia (2004). "Trade Liberalization and Firm Productivity: The Case of India" IMF Working Paper.

[46] Trefler, Daniel (2004). "The Long and the Short of the Canada-U.S. Free Trade Agreement", *American Economic Review* 94(4), *870-895.*

[47] Tybout, James, Jamie de Melo and Vittorio Corbo (1991). "The Effects of Trade Reforms on Scale and Technical Efficiency", *Journal of International Economics* 31(3-4), 231-50.

[48] Tybout, James and M. Daniel Westbrook (1995). "Trade Liberalization and the Dimensions of Efficiency Change in Mexican Manufacturing Industries", *Journal of International Economics* 39(1-2), 53-78.

[49] Tybout, James (2000). "Manufacturing Firms in Developing Countries: How Well Do They Do, and Why?", *Journal of Economic Literature* XXXVIII, 11-44.

[50] Tybout, James (2003). "Plant and Firm-Level Evidence on "New" Trade Theories" in James Harrigan and Kwan Choi, eds., *Handbook of International Trade*, New York: Blackwell Publishing Ltd, 388-415.

[51] Van Biesebroeck, J. (2005). "Exporting Raises Productivity in Sub-Saharan African Manufacturing Firms", *Journal of International Economics*, forthcoming.

[52] Young, Allwyn, (1991). "Learning By Doing and the Dynamic Effects of International Trade", *Quarterly Journal of Economics* 106, 369-405.

Figure 1: Input price indices

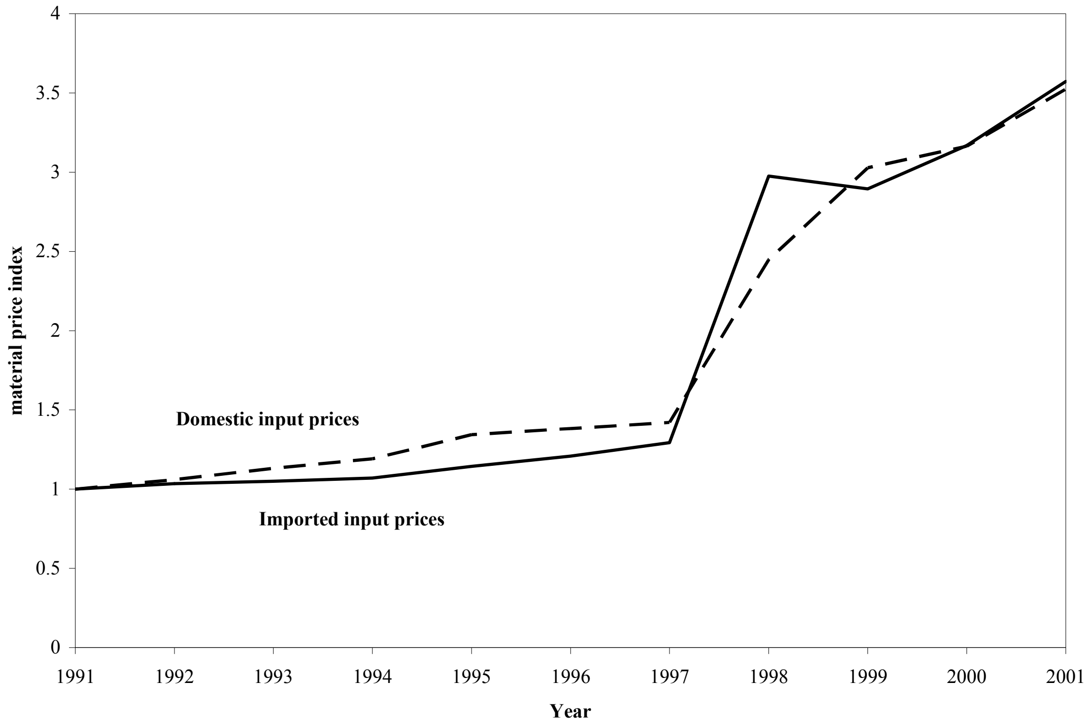
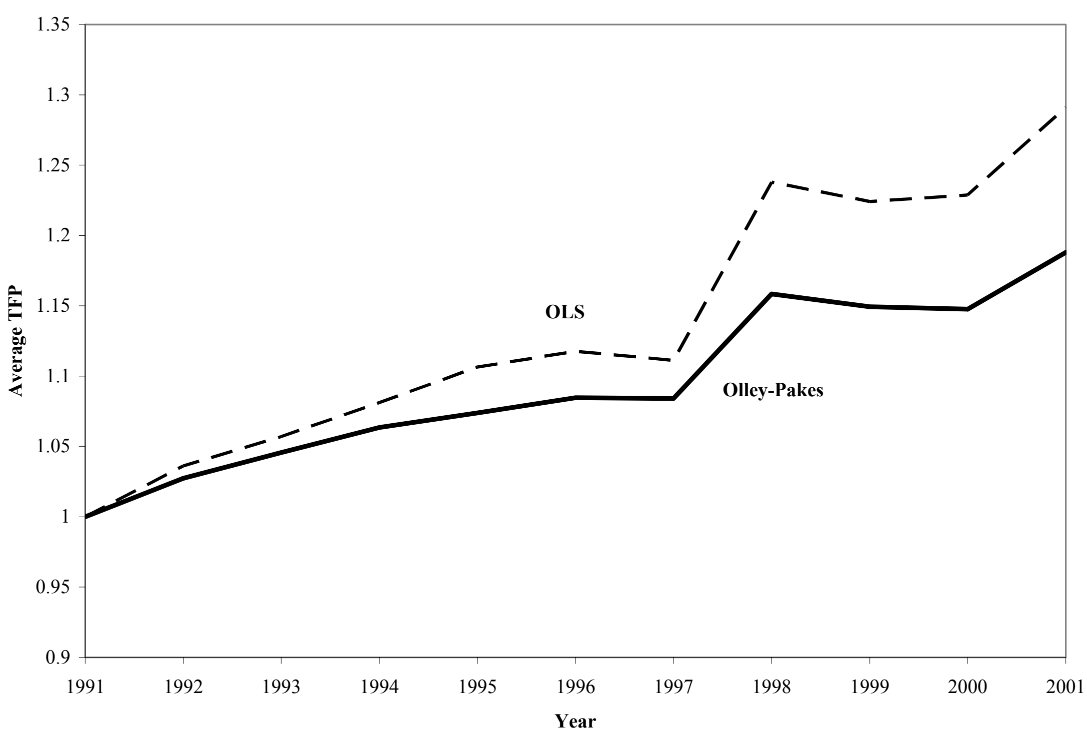
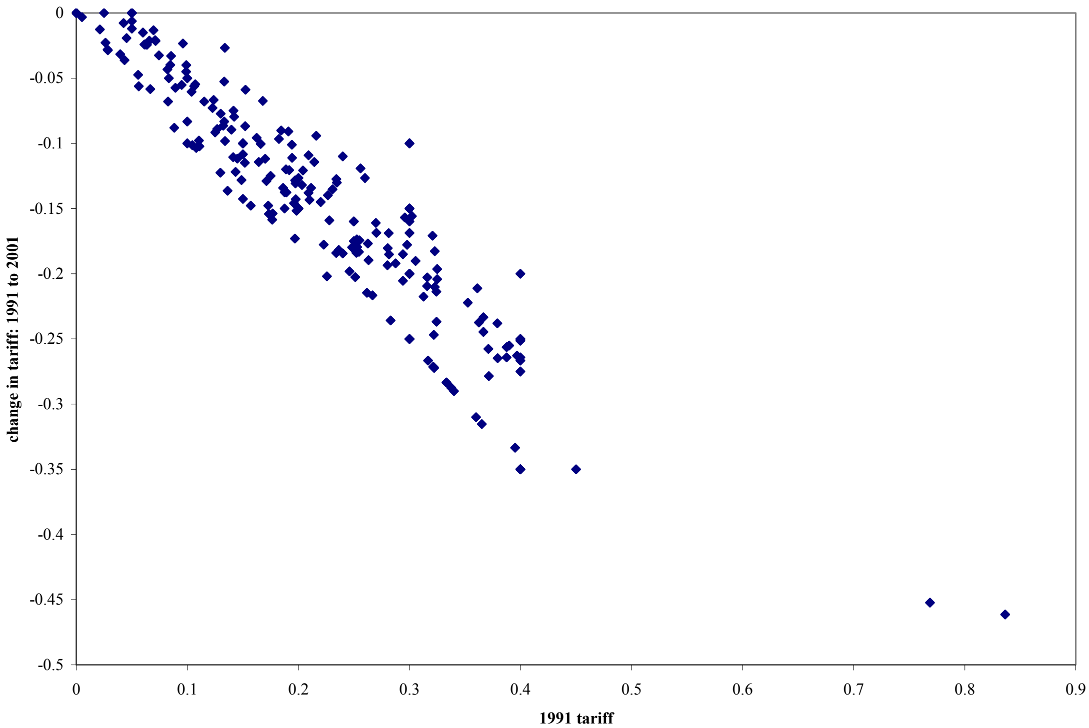


Figure 2: Average TFP



Notes: 1991=1; Simple average of firm level log(TFP).

Figure 3: Change in tariffs relative to initial levels



Note: A regression of change in tariffs on initial levels gives a coefficient of -0.69 (t-stat=42.7, R-squared=0.88). Industries that experienced an increase in their tariff over the sample period are excluded from the Figure. These are industries 31161, 31169, 31320, 31310.

Table 1: Coefficients of the Production Function

Industry	Labor		Materials		Capital	
	OLS	OP	OLS	OP	OLS	OP
Food Products (311)	0.33	0.30	0.69	0.68	0.13	0.12
Food Products, nes (312)	0.44	0.37	0.47	0.44	0.25	0.12
Beverages (313)	0.89	0.85	0.33	0.33	0.25	0.18
Tobacco (314)	0.16	0.13	0.89	0.87	0.05	0.03
Textiles (321)	0.31	0.26	0.65	0.66	0.12	0.12
Clothing (322)	0.32	0.27	0.71	0.71	0.09	0.10
Leather Goods, nes (323)	0.40	0.35	0.69	0.67	0.07	0.01
Leather Footwear (324)	0.41	0.41	0.60	0.58	0.09	0.06
Wood and Cork, except Furniture (331)	0.30	0.30	0.68	0.65	0.08	0.07
Furniture (332)	0.30	0.28	0.68	0.67	0.07	0.07
Paper and Paper Products (341)	0.32	0.29	0.69	0.71	0.11	0.06
Printing, Publishing and Allied Industries (342)	0.40	0.27	0.62	0.65	0.11	0.07
Industrial Chemicals (351)	0.26	0.25	0.53	0.47	0.28	0.22
Other Chemical Products (352)	0.39	0.36	0.62	0.60	0.18	0.09
Rubber Products (355)	0.29	0.31	0.67	0.66	0.09	0.01
Plastic Products nes (356)	0.28	0.25	0.69	0.68	0.10	0.07
Pottery, China and Earthware (361)	0.43	0.31	0.51	0.54	0.24	0.02
Glass and Glass Products (362)	0.44	0.29	0.63	0.57	0.16	0.05
Cement (363)	0.41	0.29	0.68	0.69	0.09	0.11
Clay Products (364)	0.57	0.56	0.38	0.36	0.19	0.14
Other Non-Metallic Mineral Products (369)	0.45	0.37	0.56	0.56	0.19	0.08
Iron and Steel Industries (371)	0.34	0.34	0.71	0.65	0.13	0.11
Non Ferrous Metal Basic Industries (372)	0.30	0.16	0.66	0.59	0.26	0.14
Fabricated metal products, except machinery (381)	0.37	0.32	0.68	0.67	0.11	0.12
Non Electrical Machinery (382)	0.36	0.34	0.68	0.65	0.14	0.01
Electrical Marchinery (383)	0.31	0.26	0.70	0.70	0.12	0.09
Transport Equipment (384)	0.43	0.35	0.63	0.59	0.11	0.05
Professional, Scientific and Controlling Equipment (385)	0.43	0.35	0.63	0.59	0.11	0.05
Miscellaneous Manufacturing (390)	0.47	0.41	0.58	0.57	0.11	0.10

Table 2: Tariffs

		1991		1995		2001	
	Industry	output tariffs	input tariffs	output tariffs	input tariffs	output tariffs	input tariffs
31	food	21.00	13.88	20.99	9.82	16.21	6.87
32	textile clothing	27.28	17.59	20.10	13.25	9.39	6.27
33	wood	24.20	10.24	17.95	6.51	6.91	2.90
34	paper	21.21	17.56	10.09	9.43	4.03	4.18
35	chemicals	15.60	11.14	12.05	9.00	6.92	5.17
36	metal	23.04	14.81	10.62	9.52	5.65	5.64
37	machinery	11.50	9.80	8.08	7.82	5.77	6.15
38	electrical	18.90	13.88	14.75	10.29	6.72	6.28
39	other	32.48	15.94	22.11	11.25	10.97	6.17
	all	20.88	13.68	15.60	9.90	8.44	5.92

Table 3: Summary Statistics

Variable	**Obs**	**Mean**	**std dev**
Output tariff	116,121	0.165	0.111
Input tariff	116,121	0.103	0.063
Effective rate of protection	115,219	0.283	0.367
ln(TFP) - Olley-Pakes	116,121	1.574	0.690
ln(TFP) - OLS	116,121	1.087	0.546
ln(Value added per worker)	113,592	3.130	1.227
ln(L)	116,120	4.098	1.165
ln(K)	115,604	7.013	2.103
ln(K/L)	115,603	2.916	1.487
ln(inputs)	116,015	12.689	2.309
Share of imported inputs	116,021	0.087	0.237
Share of imported inputs if >0	22,016	0.458	0.354
FM=1 if imported inputs>0.1	116,121	0.145	0.353
FM(t)-FM(t-1)	96,975	-0.002	0.193
Share of output exported	115,356	0.110	0.288
Share of output exported if >0	17,826	0.712	0.329
FX=1if export share>0.1	115,356	0.144	0.351
FX(t)-FX(t-1)	96,978	0.0007	0.295
Share of foreign ownership	116,121	0.038	0.169
Share of foreign ownership if >0	6,184	0.714	0.237
FF=1 if foreign share>0.5	116,121	0.044	0.204
FF(t)-FF(t-1)	96,978	0.0004	0.097
Herfindhal index (4 digit level)	116,121	0.088	0.120
Exit=1 if firm exits next year	116,121	0.079	0.270

Table 4: Basic Results

Dependent Variable: ln(TFP_{it})							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Output Tariff	-0.212***	-0.078	-0.093*	-0.090*	-0.092*	-0.092*	-0.076**
	(0.040)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.030)
Input tariff		-0.420***	-0.349***	-0.351***	-0.350***	-0.348***	-0.317***
		(0.075)	(0.075)	(0.075)	(0.075)	(0.075)	(0.053)
Input tariff * FM			-0.831***	-0.834***	-0.825***		
			(0.127)	(0.127)	(0.127)		
FM= 1 if import share>0.1			0.086***	0.086***	0.085***		
			(0.018)	(0.018)	(0.018)		
Input tariff * import share						-1.548***	-1.491***
						(0.223)	(0.132)
Import share						0.170***	0.153***
						(0.033)	(0.018)
Herfindahl index				-0.020	-0.019	-0.019	-0.012
				(0.019)	(0.019)	(0.019)	(0.016)
Exit=1 if firm exits in t+1					-0.025***	-0.025***	-0.029***
					(0.005)	(0.005)	(0.005)
Year fixed effects	yes	yes	yes	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes	yes	yes	yes
Observations	116,121	116,121	116,121	116,121	116,121	116,121	93,270
R-squared	0.82	0.82	0.82	0.82	0.82	0.82	

Notes: Notes: Robust standard errors corrected for clustering at the firm level in parentheses. If instead error terms were corrected for clustering at the industry/year level, all significant variables remain significant with *p*-values <0.05, except output tariff in columns (3) to (6) becomes insignificant. Note that the input tariff interacted with FM and import share is significant at the 1% level irrespective of the clustering group. * significant at 10%; ** significant at 5%; *** significant at 1%.In column (7) no R-squared is reported because the within and between transformation was applied.

Table5: Effective Protection Rate

Dependent Variable: ln(TFP_{it})				
	(1)	(2)	(3)	(4)
erp	-0.150***	-0.165***	-0.147***	-0.157***
	(0.011)	(0.014)	(0.011)	(0.011)
Output tariff		0.169***		
		(0.050)		
Input tariff			-0.125***	-0.125***
			(0.057)	(0.074)
Input tariff*FM			-0.864***	
			(0.124)	
FM=1 if import share>0.1			0.087***	
			(0.018)	
Input tariff*import share				-1.567***
				(0.215)
Import share				0.169***
				(0.033)
Herfindahl index			-0.001	-0.001
			(0.019)	(0.019)
Exit=1 if firm exited in t+1			-0.025***	-0.025***
			(0.005)	(0.005)
Year fixed effects	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes
Observations	115,219	115,219	115,219	115,219
R-squared	0.82	0.82	0.82	0.82

Notes: Robust standard errors corrected for clustering at the firm level in parentheses; If instead error terms were corrected for clustering at the industry/year level, all significant variables remain significant with *p*-values<0.05. Note that the input tariff interacted with FM and import share is significant at the 1% level irrespective of the clustering group. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6: Additional Controls

Dependent Variable: ln(TFP_{it})				
	(1)	(2)	(3)	(4)
Output tariff	-0.093*	-0.092*	-0.095*	-0.094*
	(0.053)	(0.053)	(0.052)	(0.052)
Input tariff	-0.350***	-0.349***	-0.357***	-0.356***
	(0.075)	(0.075)	(0.075)	(0.074)
Input tariff*FM	-0.821***		-0.757***	
	(0.127)		(0.128)	
FM=1 if import share>0.1	0.085***		0.071***	
	(0.018)		(0.019)	
Input tariff*import share		-1.541***		-1.434***
		(0.222)		(0.225)
Import share		0.170***		0.146***
		(0.033)		(0.034)
Herfindahl index	-0.019	-0.019	-0.020	-0.020
	(0.019)	(0.019)	(0.019)	(0.019)
Exit=1 if firm exits in t+1	-0.025***	-0.025***	-0.025***	-0.024***
	(0.005)	(0.005)	(0.005)	(0.005)
Share of exports	-0.015*	-0.014*	-0.013*	-0.013
	(0.008)	(0.008)	(0.008)	(0.008)
Share of foreign ownership	0.006	0.005	0.006	0.005
	(0.025)	(0.025)	(0.025)	(0.025)
Output tariff*crisis dummy(1)			0.038	0.038
			(0.062)	(0.062)
Input tariff*crisis dummy(1)			-0.171*	-0.173*
			(0.105)	(0.105)
Input tariff*crisis dummy *importing firms(2)			0.392***	0.632***
			(0.097)	(0.134)
Year fixed effects	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes
Observations	115,356	115,356	115,356	115,356
R-squared	0.81	0.81	0.81	0.81

Notes: Robust standard errors in parentheses. If instead error terms were corrected for clustering at the industry/year level, all variables with at least 5% significance remain so, except output tariff becomes insignificant and the input tariff interacted with the crisis dummy becomes insignficant.* significant at 10%; ** significant at 5%; *** significant at 1%; (1) crisis dummy=1 in 1997 and 1998; (2)in column 3 importing firms is FM, the import dummy, and in column 4 the interaction is with the import share.

Table 7: Alternative productivity measures

Dependent variable	$\ln(TFP_{it})$ using OLS		ln(value added per worker)		
	(1)	(2)	(3)	(4)	(5)
Output tariff	-0.193***	-0.044	-0.561***	-0.522***	-0.217**
	(0.041)	(0.054)	(0.079)	(0.078)	(0.086)
Input tariff		-0.441***			-0.900***
		(0.077)			(0.144)
Inputtarif*import share		-1.508***			-1.923***
		(0.225)			(0.350)
Import share		0.153***			0.377***
		(0.033)			(0.052)
Herfindahl index		-0.016			-0.058*
		(0.019)			(0.034)
Share of exports		-0.017**			-0.012
		(0.008)			(0.014)
Share of foreign ownership		-0.000			0.062
		(0.026)			(0.042)
Exit=1 if firm exits in t+1		-0.017***			-0.085***
		(0.005)			(0.009)
ln(K/L)				0.097***	0.988***
				(0.005)	(0.005)
Year fixed effects	yes	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes	yes
Observations	116,121	115,356	113,592	113,085	112,332
R-squared	0.69	0.69	0.80	0.80	0.80

Notes: Robust standard errors corrected for clustering at the firm level in parentheses. If instead error terms were corrected for clustering at the industry/year level, all significance levels remain unchanged except in column 5 the output tariff becomes insignficant and foreign share becomes significant at the 10 % level. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 8: Alternative econometric specifications

Dependent variable: ln(TFP_{it})							
	Levels		1st period difference		5 period difference		10 period difference
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
output tariff	-0.243***	-0.170***	-0.110***	-0.030	-0.180***	-0.046	-0.412***
	(0.035)	(0.047)	(0.038)	(0.055)	(0.049)	(0.063)	(0.096)
Input tariff		-0.190***		-0.251***		-0.389***	-0.467***
		(0.071)		(0.079)		(0.081)	(0.162)
Input tariff*import share		-1.866***		-0.567**		-1.781***	-1.872***
		(0.181)		(0.256)		(0.254)	(0.547)
Import share		0.436***		0.077**		0.187***	0.139
		(0.027)		(0.038)		(0.038)	(0.086)
Herfindahl index		-0.050**		0.038***		-0.104***	0.306***
		(0.020)		(0.013)		(0.025)	(0.076)
Exit=1 if firm exits in t+1		-0.063***		-0.023***			
		(0.005)		(0.004)			
Year fixed effects	yes	yes	yes	yes	yes	yes	no
Industry fixed effects	yes	yes	no	no	no	no	no
Firm fixed effects	no	no	no	no	no	no	no
Observations	116,121	116,121	92,626	92,626	34,500	345,00	3,076
R-squared	0.62	0.63	0.01	0.01	0.01	0.01	0.03

Notes: Robust standard errors in parentheses. If instead the error terms were corrected for clustering at the industry/year level, all significance variables remain significant except the output tariff in the first difference model in columns 3 and 4 becomes insignificant, the input tariff in the levels and first difference becomes insignificant but remains significant in the 5 period differenced model, and the Herfindahl index is insignficant in all of the specifications. Note that the input tariff interacted with import share remains significant in all specifications. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 9: Endogeneity

Dependent variable: $\ln(TFP_{i,t})$-$\ln(TFP_{i,t-5})$ All variables in 5 period difference			
	(1)	(2)	(3)
Output tariff	-0.545***	-0.511***	-0.495***
	(0.078)	(0.084)	(0.084)
Input tariff	-0.156	-0.205*	-0.212*
	(0.122)	(0.110)	(0.111)
Input tariff*import share	-2.903***	-2.784***	-2.771***
	(0.298)	(0.294)	(0.294)
Import share	0.316***	0.303***	0.301***
	(0.041)	(0.041)	(0.041)
Herfindahl index	-0.076***	-0.077***	-0.078***
	(0.026)	(0.026)	(0.026)
Year fixed effects	yes	yes	yes
Shea Partial R^2			
Output tariff	0.43	0.41	0.43
Input tariff	0.44	0.50	0.51
Input tariff*import share	0.46	0.46	0.47
Overidentification	0.15	0.16	1.95
Hansen J statistic	$\chi^2(1)$=0.70	$\chi^2(1)$=0.68	$\chi^2(3)$=0.58
Observations	34,851	34,512	34,467

Notes: Robust standard errors in parentheses ; * significant at 10%; ** significant at 5%; *** significant at 1%; Instruments (1) output tariff (1991), input tariff (1991), input tariff (1991)*FM, exclusion dummy=1 if product excluded from commitment to reduce bound tariffs to 40%, (2) output $tariff_{t-5}$, input $tariff_{t-5}$*FM, exclusion dummy; (3) as in column 2, plus proportion of low skilled workers by industry in 1991, and Herfindhal index in 1991.