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Heterogeneous Productivity Response to Tariff Reduction: Evidence from Brazilian Manufacturing Firms
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ABSTRACT

This paper studies the effects of trade liberalization on the evolution of firm productivity. The productivity of each firm was estimated using an unbalanced panel data of 4,484 Brazilian manufacturing firms from 1986 to 1998, following the procedure first proposed by Olley and Pakes (1996) and further developed by Levinsohn and Petrin (2003). First, the effect of nominal tariffs on firms' productivity levels is identified. After controlling for the endogeneity of nominal tariffs, the estimated coefficient for tariffs in the productivity equation turns out to be negative. Second, a measure of tariffs on inputs is added in the productivity equation. The coefficient associated with tariffs on inputs is also negative, and the inclusion of this new variable reduces the size of the estimated coefficient of nominal tariffs. Thus, it seems that, along with the increased competition, the new access to inputs that embody better foreign technology also contributes to productivity gains after trade liberalization. Third, it is shown that there is a huge degree of heterogeneity of responses to trade liberalization. The effect of the tariff reductions depends heavily on observed and unobserved characteristics of the firm.

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1. Introduction

There is plenty of evidence that tariff reduction increases the efficiency of manufacturing firms. Tybout, de Melo and Corbo (1991) studied the impact of trade liberalization on the performance of Chilean firms in the 70's. They concluded that industries that experienced higher tariff reductions were the same as those that experienced higher efficiency gains. Similar results were found by Harrison (1994) for the Ivory Coast, by Iscan (1998) for Mexico and by Hay (2001) for Brazil. More recently, several papers sharing similar methodology, which solves some econometric problems regarding productivity estimation, also tried to answer whether trade liberalization enhances firm productivity gains. Pavcnik (2002) found that the in-plant productivity improvements in Chile can be attributed to trade liberalization. Fernandes (2003) and Muendler (2002) using data from Colombia and Brazil, respectively, found a negative relationship between nominal tariffs and productivity, reinforcing the perception that trade liberalization has a positive impact on productivity. Tybout (2000 and 2001) surveys several papers on productivity and trade, based on firm-level databases.

However, little has been said about the channels through which tariff reduction affects productivity. Usually, trade liberalization is seen as a sharp reduction in nominal tariffs that leads to a much higher degree of competition in domestic markets, which in turn pushes firms to reduce inefficiencies. The other – less examined – side of trade liberalization and nominal tariff reduction is the reduction of tariffs on inputs, which reduces the costs and increases the access to foreign intermediate and capital goods by domestic firms. The overall reduction of nominal tariffs leads not only to a reduction of tariffs on inputs but also creates an incentive for firms to adopt outsourcing strategies. From a theoretical point of view, both embodied technology in imported inputs and outsourcing can explain productivity gains when trade increases.

Muendler (2002) seems to be the first attempt to deal with this issue. Besides testing the effect of nominal tariffs on productivity, he explicitly includes foreign capital and intermediate inputs in the production function, to test whether firms with higher usage of foreign inputs have higher productivity.

Here a very similar hypothesis is tested: whether increased availability of foreign inputs (intermediate and capital goods) affects the firm's productivity. The approach, however, is different. Here, instead of considering the impact of trade liberalization on the observed volume of imported inputs, the impact of tariff reduction on the intermediate and capital good markets is considered. The first reason to do so is because imported inputs may be used by firms indirectly, since most of manufacturing inputs undergo local remanufacturing. Secondly, it tests the impact of trade policy more directly.

Another point discussed in this paper is the heterogeneous response to tariff reduction. It is a stylized fact that there is a substantial difference between and within-industry heterogeneity in output, input and productivity in the manufacturing sector. Thus, it is relevant to ask whether the average impact of tariff reduction is representative for most of the firms, or if there is substantial cross-firm variation in the productivity response to reduced tariffs. To sort out the effect of trade liberalization on different firms, these firms were classified according to observed and unobserved characteristics, and the estimation of the impact of decreased tariffs is conditioned on such characteristics.

To address these questions, I use a data set of Brazilian manufacturing firms, which has information on production and inputs used by those firms between 1986 and 1998. Brazil, as many Latin-American countries, relied heavily on import-substitution industrialization programs for decades. Although a very diversified industrial sector flourished in the country, the firms faced a very protected environment with very limited competition from abroad and reduced access to imported inputs and capital goods.

In less than a decade, Brazilian trade policy suffered a significant change. Average nominal tariffs decreased from 77% in 1987 to 13.6% in 1994. The tariff dispersion was also sharply reduced. The standard deviation fell to 8.4% in 1994 from 53.8% in 1987. Despite the fact that there was a relative setback in the last half of the 90's, the decade ended with nominal tariffs 20 percentage points below their initial value. Brazilian manufacturing firms were undoubtedly much less protected than before. The impact on the volume of imports was also very significant. During the 90's, imports grew 170%, almost 10.5% per year. Imports of capital goods increased 196% and of intermediate goods, 259%. Import penetration, according to Moreira (2000) rose from 4.5% in 1989 to 19.3% in 1998.

This paper yields important findings. First, it shows that both nominal tariffs and tariffs on inputs have a negative impact on firm productivity. Thus, it seems that along with higher competition, new access to better inputs also contributes to enhance productivity after trade liberalization. Second, it argues that the effect of trade liberalization upon a representative firm is not the best way to evaluate the impact of tariff reduction on the productivity of a given firm. There is much heterogeneity in the response to trade liberalization, and this heterogeneity is far from random. Observed and unobserved characteristics of firms can explain why firms react differently when tariffs are reduced.

The remainder of this paper is organized as follows. The next two sections describe the Brazilian trade liberalization process and the data. Section 4 presents the structural model and how it is implemented to yield a measure of firm productivity. Section 5 relates to productivity and tariffs, while section 6 shows the heterogeneity of such relationships among different firms. The last section presents a summary and conclusions.

2. Brazilian Trade Liberalization[1]

Until the end of the 80's, Brazilian trade policy meant extremely high nominal tariffs and a huge amount of non-tariff barriers. Nominal tariffs were in general redundant. The price difference between domestic and international prices was much lower than the tariffs suggested. Imports were restricted not because of high nominal tariffs, but mainly by innumerous non-tariff restrictions like lists of prohibited imported goods, difficult access to government import authorization and limits on imports for each firm. On the other hand, there were several exception rules that reduced both the tariff and the non-tariff barriers for the import of some specific goods.

In 1988 there was the first attempt to rationalize trade policy. Some of the non-tariff barriers were extinguished (elimination of some taxes on imported goods and some of the special regimes faced by several industries) and nominal tariffs had a small reduction.

In 1990, the newly elected government announced a new trade policy that would change substantially the old regime. At first, all but a few non-tariff barriers were eliminated. Trade policy thereafter would rely mostly on tariffs and on exchange rate management (although the exchange rate regime was much more flexible than before). Secondly, a four-year schedule of tariff reductions was announced. After these four years, the tariff range would be between 0% and 40%. The average tariff would decrease from slightly lower than 50% in 1989 to 14% in 1994. According to Kume, Piani and Souza

[1] This section relies heavily on Kume, Piani and Souza (2000).

(2000), at first there was no discrimination among industries except for a higher protection for the production of goods with high technological requirements such as computers, some chemical sectors and biotechnology. The tariff structure was designed according to the comparative advantage, the initial tariff level and tariff on inputs. There were some exceptions, but the result was a much more rational tariff structure.

The schedule of tariff reduction was constructed so as to have first a reduction of tariffs on inputs and only then a more aggressive reduction of tariffs on consumer goods. The program was fully implemented in the second semester of 1993 – several months before schedule.

After the stabilization plan was launched in July of 1994, there was a further push to reduce tariffs, mainly on those goods that had a significant impact on inflation indices. In order to increase the supply of imported goods to discipline domestic prices, there was also an anticipation of the adoption of the Mercosur common external tariff, which in several cases implied a reduction in current tariffs. If the Mercosur tariff was higher than the current one, the lower tariff was maintained. Trade policy during this period had an important role in helping to stabilize inflation in Brazil.

However, the Mexican crisis in December of 1994, the currency overvaluation due to the huge capital inflows observed after the introduction of the Real and the huge increase in imports led to a revision of the recent trade policy changes, since the external imbalance became a major concern. Tariffs were increased as the government asked for the inclusion of several goods in the exception list, since by this time Mercosur imposed some restrictions on tariff rises. As a result, from 1995 to 1998 the nominal average tariff went up almost 3 percentage points, from 12.8% to 15.5%.

3. Data: Pesquisa Industrial Anual

The data source used to construct measures of productivity is the Pesquisa Industrial Anual (PIA) carried out by Instituto Brasileiro de Geografia e Estatistica (IBGE), the Brazilian census bureau. PIA collects firm-level economic data annually since 1986 – excluding 1991.

Firms are qualified to enter in the PIA sample if they have at least half of their income related to industrial activity. The initial sample was based on the 1985 industrial census and includes all of the biggest industrial firms and a random sample of medium-sized firms. All newly founded firms were supposed to be included yearly, although it seems that the surveying method was not rigorously applied[2]. After cleaning the dataset[3], the sample of firms utilized in this study is of 4,844 firms, compared to a total of 9,130 firms identified with at least one year of positive sales. Table 1 displays the number of firms in each industry for different periods of time. The reduction of the number of firms in the sample is due to several factors. The most direct one is the fact that new entries were not fully incorporated in the survey sample before 1996. The change in the questionnaire after 1996 in which the balance sheet data are no longer reported implied that only firms sampled in 1995 were kept in the sample for the following years, since the construction of a capital series was then changed to the perpetual inventory method. There are certainly other factors that may have contributed to the reduction of the number of firms, probably related to trade liberalization, such as mergers and acquisitions and the exit of firms that did not adapt to the new liberalized economic environment.

PIA contains information on the number of production and non-production workers, sales, inventories of inputs and of produced goods and other inputs (materials). There is also balance sheet data, which allows us to construct a capital stock series. In table 1 some information is displayed regarding these variables.

Unfortunately, information on sales, inventories and materials are given at nominal levels at the end of each calendar year. Due to extremely high inflation during most of the period covered by the survey, each series was first inflated so that it best represented the sum of the monthly values at the end of the year, and only then converted to a common currency – reais as of August of 1994. Although this procedure is necessary, one should bear in mind that these variables may suffer from measurement errors. The higher the inflation and price dispersion, the higher the error.

The capital stock was the only item in the balance sheet that was indexed to the official inflation rate until 1995. However, the official correction was systematically below the observed inflation rate, calculated by several organizations (even by the government).

[2] Muendler (2001) offers a complete and detailed description of PIA's sample procedure and the survey's contents.

[3] The outliers were discarded (1% of the highest and lowest values for labor-production, capital-production and materials-production ratios) as well as firms with less than two consecutive observations. The dataset was carefully screened and clearly misreported values were also discarded.

The series was then corrected for this and real August 1994 values used. One possible setback of this series is the fact that the government, recognizing that official correction systematically reduced the real value of capital stock, allowed firms to make a once-and-for-all optional correction in their capital stock in 1991, by the amount they judged it was undervalued. Since the survey was not carried out this year, it is impossible to say which firms made the correction and by what amount. I thus utilized here the uncorrected series. After 1995, PIA stopped collecting information on capital stock. Since only investment values were available, only firms that were in the sample before this year were included, and the capital stock was calculated adding the investment net of depreciation to the previous year's capital stock.

In order to estimate the production functions that will allow me to measure firms' productivity, firms were grouped in 27 manufacturing industries (close to two-digit SIC classification – or nível 50 in the Brazilian industrial classification). As table 1 shows, there is a significant difference in firms' characteristics across industries and, especially, within industries, represented by the standard deviation higher than the average.

Data on nominal tariffs is available from 1986 to 1998 for industries classified according to nível 100 in the Brazilian industrial classification (close to three-digit SIC classification) from Kume, Piani and Souza (2000). Tariffs on inputs were constructed using input-output tables, available for 1985 and annually from 1990 to 1996. For each industry a vector of inputs is associated with nominal tariffs to give tariffs on inputs.

Average nominal tariffs and average tariffs on inputs are displayed for the 27 manufacturing industries in table 1. There is significant variation of tariffs over time and across industries.

4. Productivity Measure

Productivity is usually calculated as the difference between the observed output and the output predicted by an estimated production function. Thus, the main empirical concern is how to estimate an unbiased production function. Let us suppose that the technology of firm *i* is well described by a Cobb-Douglas production function:

$$y_{it} = \beta_0 + \beta_{lw} lw_{it} + \beta_{lb} lb_{it} + \beta_m m_{it} + \beta_k k_{it} + \mu_{it}$$

where y_{it} is the gross output, lw_{it} and lb_{it} are the amount of labor on administrative tasks and on production, respectively, m_{it} is the quantity of other inputs (materials) and k_{it} is the stock of capital used by firm *i* in time *t*. The firm *i* specific residual term μ_{it} can be decomposed as $\mu_{it} = \omega_{it} + \varepsilon_{it}$, where ω_{it} is an efficiency term (or productivity level) that is known by the firm but not by the econometrician and ε_{it} is an unexpected productivity shock (unobserved both by the firm and the econometrician and with zero mean).

The fact that ω_{it} is known by the firm when it takes the decision as to whether to stay in the market and produce and, if deciding to produce, which input combination to use, makes the OLS estimate of the production function biased. The error term is not uncorrelated with the explanatory variables, the key assumption for OLS to produce unbiased estimates. There is not only a simultaneity bias, that arises due to the fact that the unobserved efficiency level is taken into account when the firm decides what input combination and quantities it will use to produce, but also a selection bias, which comes from the fact that the firm chooses whether to stay in the market or exit after it knows its productivity level ω_{it}, which is not observed by the econometrician.

The alternative is to use fixed-effects to correct for this bias, assuming that ω_{it} is firm-specific but constant over time. However, during periods of substantial changes in the economic environment, it is not a reasonable assumption to let a firm's productivity be fixed over time. In fact, I am interested in measuring the change occurred in productivity due to trade liberalization.

So far, the standard alternative to solve the bias introduced by acknowledging that ω_{it} is known by the firm but not by the econometrician is given by Olley and Pakes (1996). Starting from the same production function described above, they propose an econometric method based on a structural model that is able to solve both the simultaneity and the selection bias.

Those authors developed a model where the firm maximizes its expected current and future profit values. In each period the firm decides whether to exit the market or to continue to produce, by comparing the net profit cash flow and the exit value. If it decides to produce, it chooses the inputs. The firm-specific efficiency factor is known at the beginning of time *t* and determines the firm's choices.

To overcome the fact that ω_{it} is not observed by the econometrician, they write down an investment function that depends on the unobserved efficiency variable and the capital stock. Assuming that investment is always positive if the firm decides to continue in the market, it is possible to invert this function and write ω_{it} as a function of the observed capital stock and investment made by the firm in time *t*.

I follow quite closely the Olley and Pakes (1996) methodology (O-P hereafter). However, a few changes need to be made to make sure that the proposed method is suitable for the Brazilian data set I work with.

First, I cannot use investment as a proxy for the unobserved efficiency variable because in my data set most of the firms, most of the years, do not have positive investment. Pavcnik (2002) shows that there is a significant change in the estimated coefficients when you include the zero-investment observations. Levinsohn and Petrin (2003) recognize that observing lots of zero-investment observations is a common feature of developing country data sets. They propose to use other inputs as a proxy for the unobserved efficiency variable.

Second, it is not a reasonable assumption to set labor as a free mobile factor as it is assumed in O-P algorithm. In Brazil, due to the high cost of dismissing workers, firms at first adjust the labor requirement by adjusting the working hours. Only when significant changes in production or in technology take place is there a change in the number of workers. Since the information on firms' labor usage is on the number of workers, labor seems to be better treated as a state variable.

Third, O-P addresses the selection bias by explicitly modeling the firm’s probability of continuing in the market as a function of the observed variables. Although PIA provides the information as to whether a firm is active or exited, there are several observations in which a firm is not producing but did not choose to exit definitively (it is said to be paralyzed). Moreover, some firms cease appearing in my sample without any information as to whether they exited or if it is a missing observation. As a consequence, I do not explicitly correct for the selection bias. Levinsohn and Petrin (2003), however, argue that by using an unbalanced panel of firms, the selection bias is significantly minimized.

4.1 Structural Model and Implementation

As before, firm *i*'s technology can be described as a Cobb-Douglas production function such as

$$y_{it} = \beta_0 + \beta_{lw} lw_{it} + \beta_{lb} lb_{it} + \beta_m m_{it} + \beta_k k_{it} + \mu_{it}$$

$$\mu_{it} = \omega_{it} + \varepsilon_{it}$$

The unobserved productivity level variable ω_{it} is assumed to follow a 1st order Markov process. The expected value of ω_{it} is a function of an unexpected shock with zero mean and of its value at time *t*-1.

$$\omega_{it} = \omega_{it-1} + \zeta_{it} \Rightarrow \omega_{it} = E(\omega_{it}/\omega_{it-1}) + \zeta_{it}$$

Besides labor and capital, the firm needs other inputs (materials) to produce according to the above production function. The demand for these other inputs is a function of the efficiency variable ω_{it} and of the state variables, labor and capital. The usage of these other inputs is adjusted immediately to different states of the efficiency variable, or productivity. Labor and capital, on the other hand, take time to adjust due to adjustment costs.

$$m_{it} = f_t(\omega_{it}, lw_{it}, lb_{it}, k_{it})$$

It seems reasonable to assume[4] that the above function is monotonic in ω. That is, given the stock of capital and labor in time *t*, the higher the productivity or efficiency level, the higher the usage of materials, since the firm will produce more than another firm that has the same stock of capital and labor but lower productivity. Thus, we can invert the above equation and write ω_{it} as a function of the observed variables, materials, labor and stock of capital.

[4] Levinsohn and Petrin (2003) detail the necessary conditions for the monotonicity of this function.

$$\omega_{it} = h_t(m_{it}, lw_{it}, lb_{it}, k_{it})$$

Substituting this equation in the production function, we have

$$y_{it} = \varphi_t(m_{it}, lw_{it}, lb_{it}, k_{it}) + \varepsilon_{it}$$

where $\varphi_t(m_{it}, lw_{it}, lb_{it}, k_{it}) = \beta_0 + \beta_{lw} lw_{it} + \beta_{lb} lb_{it} + \beta_m m_{it} + \beta_k k_{it} + h_t(m_{it}, lw_{it}, lb_{it}, k_{it})$.

As in Olley and Pakes (1996) and Pavcnik (2002), the function φ_t is approximated by a polynomial series on the observed variables – materials, labor and capital stock. Since an underlying assumption is that the input market is not only the same for all firms but also that the market structure does not change over time, the function φ_t is estimated for three distinct periods (1986-1990, 1992-1994, 1995-1998) to take into account the changes observed in the Brazilian economy. Thus, the first stage of the O-P procedure is to estimate φ_t.

The assumption that the firm's efficiency follows a 1st order Markov process allows us to write its expected value as a function of its past value

$$E(\omega_{it}/\omega_{it-1}) = g(\omega_{it-1})$$

The g(.) function can then be expressed as a function of the past values of the observed variables by replacing ω_{it-1} with the functions h_{t-1} and φ_{t-1}.

$$g(\omega_{it-1}) = g(h_{t-1}(m_{it-1}, lw_{it-1}, lb_{it-1}, k_{it-1}))$$

$$= g(\varphi_{t-1}(m_{it-1}, lw_{it-1}, lb_{it-1}, k_{it-1}) - \beta_0 - \beta_{lw} lw_{it-1} - \beta_{lb} lb_{it-1} - \beta_m m_{it-1} - \beta_k k_{it-1})$$

Using the predicted values of φ_{t-1} estimated in the first stage, we can then estimate in a second stage the coefficients associated with the observed variables by non-linear least squares of the function below

$$y_{it} = \beta_0 + \beta_{lw} lw_{it} + \beta_{lb} lb_{it} + \beta_m m_{it} + \beta_k k_{it} +$$

$$+ g\left(\varphi_{t-1}\left(m_{it-1}, lw_{it-1}, lb_{it-1}, k_{it-1}\right) - \beta_0 - \beta_{lw} lw_{it-1} - \beta_{lb} lb_{it-1} - \beta_m m_{it-1} - \beta_k k_{it-1}\right) + \zeta_{it} + \varepsilon_{it}$$

4.2 Estimation

A production function was estimated for each of the 27 industries using the equation and methodology discussed above. In table 2 the estimated coefficients for each industry and corresponding OLS estimates are displayed.

Most of the coefficients associated with the capital stock estimated by the O-P methodology are larger than the OLS estimates (23 out of 27), which evidences that the simultaneity bias is strong with OLS estimation.[5]

The standard errors shown are not corrected for the fact that in the second stage the non-linear least squares uses estimated variables instead of the true ones. Although in Olley and Pakes (1996) there is not much difference between the corrected and the uncorrected standard deviation when using the series approximation, it seems important to confirm their findings. Bootstrapped standard deviations were calculated for only one fifth of the industries due to the heavy computational time required. Although they are higher than the analytical ones, they do not seem to change either the significance of the estimated coefficients or the conclusion that the O-P algorithm produces higher capital coefficient estimates than the OLS ones.

To have a measure of firm productivity, I followed Pavcnik (2002) and Aw et al. (2001) and constructed a productivity index that can describe both the evolution of the productivity of the firm over time and its relative position compared to a reference firm in a reference year.

[5] If capital stock and labor usage are positively correlated, and both capital and labor are correlated to the productivity variable, (which seems to be the case) then the estimated coefficient on capital tends to be under-estimated and the labor coefficient tends to be over-estimated. Levinsohn and Petrin (2000) discuss further the sign of the bias.

In this case the reference firm is a synthetic firm, which has the mean output, labor, capital and materials usage of each industry in 1986. To put it more clearly, the productive measure $prod_{it}$ is calculated as follows

$$prod_{it} = y_{it} - \hat{\beta}_{lb} lb_{it} - \hat{\beta}_{lw} lw_{it} - \hat{\beta}_{m} m_{it} - \hat{\beta}_{k} k_{it} - (y_r - \hat{y}_r)$$

where $y_r = \overline{y}_{it}$ and $\hat{y}_r = \hat{\beta}_{lb} \overline{lb}_{it} + \hat{\beta}_{lw} \overline{lw}_{it} + \hat{\beta}_{m} \overline{m}_{it} + \hat{\beta}_{k} \overline{k}_{it}$. The bar over each variable denotes the simple average of all firms of each industry in 1986.

Table 3 shows that there is a lot of heterogeneity of productivity evolution between different manufacturing industries in this period. It is also important to point out that the evolution of productivity within an industry over time is far from regular. From one year to another, productivity measures change a lot in most of the industries. That is not surprising, given the huge macroeconomic instability and several different policies that were implemented in Brazil over the 13 years that the data set covers.

5. Productivity and Tariffs

The first empirical concern, when addressing the question of whether the reduction of tariff barriers observed over the last years of the 80's and the first years of the 90's affected firms' productivity, is how to disentangle the effects of trade liberalization from other changes in macroeconomic policy. One way to do that is to include year (or period, or before-and-after) dummies as explanatory variables in the regressions. This treatment is sufficient to guarantee consistent estimators if we believe that the sector-specific impact of other macroeconomic policies is not correlated with the sector-specific tariff reduction observed in the period. Certainly, there is a connection between reduction of tariffs and other policies adopted over this period (privatization, disinflation, financial liberalization), but it is reasonable to assume that the reduction of trade protection across industries is relatively independent from other kinds of macro policy. Given this assumption, I used year dummies to control for any other policy that affected all industries over this period (although each industry responded differently to these policies, I assume that they are not correlated with the tariff structure).

Another concern relates to the political economy of tariff reduction. From the policy maker's point of view, the choice regarding which industry should be more protected and which industry needs more competition is far from random. On the other hand, it is reasonable to assume that firms pressure policy makers for more protection, either through higher tariffs on its competing imported goods, or through a reduction in tariffs on the inputs they use. Ferreira (2000) argues that there is a positive correlation between nominal tariffs and industry concentration in Brazil. Using a panel data set of Brazilian industries from 1988 to 1994, he shows that the more concentrated the industry, the higher its nominal tariff in relation to other industries. As a result, it is difficult to assume that tariffs are exogenous in a regression where productivity is on the left hand side. In both cases, from the policy makers' or from the lobby's point of view, we can argue that the tariff is correlated with productivity. In the first case, policy makers may have used trade policy to induce more competition in industries in which they might have thought that the lack of foreign goods in the domestic market had had a negative impact on productivity. Lobbies in low productivity sectors, on the other hand, may have pressured for higher tariffs to maintain the domestic market closed to foreign competition.

It is not easy to find good instruments for nominal tariffs. A good instrument should be correlated not only with the time trend but also with the cross-industry pattern of the tariff structure and uncorrelated with the productivity measure. However, in the Brazilian case, the trade liberalization process changed the structure of protection very little. The Spearman rank correlation of nominal tariffs among the 27 industries between 1986 and 1998 is above 80%. From 1989 on, the year-by-year correlation is above 87%. It seems that the political economy behind the tariff reduction did not change much during the period analyzed. As a consequence, using industry dummies that control for these time-invariant characteristics of the political economy of trade liberalization can reduce significantly the bias in the OLS regression. This is the same assumption used in Goldberg and Pavcnik (forthcoming).

When estimating the relationship between protection and productivity, I left aside the period between 1986 and 1988. As Kume, Piani and Souza (2001) argue, the tariff reduction observed in these years was mainly due to the reduction of redundant tariffs. There was not much change in the environment of protection that most domestic firms were facing. Thus, including this data will bias the estimated relation between productivity and protection, since productivity changes over this period are not related to changes in protection.

Table 4 shows the results of OLS regressions of productivity on nominal tariffs. Once industry dummies are included, the sign of the coefficient related to nominal tariffs changes from positive to negative, although it is not significant. When firms' fixed-effects were included to correct a bias that may arise because the production function is estimated for each industry and not for each firm, the coefficient not only is negative but is also significant at 1%. This result confirms that using dummies (for industries and firms) reduces the bias found in the OLS regression. This result is maintained when the OLS productivity measure is used.

The fact that nominal tariffs are negatively correlated with productivity was often associated with competition being the main source of increased productivity observed in some industries. Even the reduction of productivity in some other industries could be explained by the inability of domestic firms to compete with more productive foreign firms. Those firms reduced production, which in the short run (given that labor and capital take time to adjust) means lower productivity.

However, the reduction in tariffs leads to a reduction also in the price of imported inputs necessary for production. It also certainly increases the supply of these inputs, which are often thought of as having a better quality-price ratio, and which can increase productivity through the embodied technology transferred from more advanced economies. To proxy this greater availability of foreign inputs I used a measure of tariffs on inputs. The measure of the tariffs on inputs was constructed using the nominal tariff of each industry and input-output tables.

Adding this measure of tariffs on inputs to the above regression (table 5), the sign of the coefficient of nominal tariffs (using industry dummies and firms' fixed-effects) did not change. The magnitude, however, is much lower. Part of the effect is now captured by the coefficient related to tariffs on inputs.

In general, the sizes of the coefficients associated with each of the tariff measures are similar. This result can be interpreted as evidence that the availability of imported inputs also plays a role in enhancing firms' productivity. We can also say that it is likely that the impact of increased competition on productivity is not much larger than the impact of the possibility of using imported inputs in production.

6. Heterogeneous Response to Tariff Reduction

One stylized fact of the manufacturing sector is that there is huge heterogeneity between firms in different industries and also among firms in the same industry. The Brazilian case is no exception. Therefore, the above results, although true for an average firm, are not sufficient to disentangle the effects of tariff reduction on firms' productivity.

Thus, I make here an attempt to have a more precise answer concerning the relationship between productivity and tariffs, by conditioning the above results on the firms' characteristics. First, the firms were classified according to some observed characteristics such as size, type of good produced (capital, intermediate, transport and consumer goods), type of technology used (capital, labor, natural resources and technology intensive), industry concentration (Herfindahl), initial nominal tariffs and imports and exports as a percentage of production, as table 6 shows.

Firms were considered small when they have less than 50 workers the first year they are sampled and large if they have more than 500 workers at that time. Firms were classified as having low or high import and export share, Herfindahl index and initial tariffs, if they belong to industries in the first and last quarter of the distribution of these variables in 1986.

When conditioning for the firms' characteristics, the general result that productivity is higher with lower nominal tariff and lower tariff on inputs is no longer true. Not only are some of the estimated coefficients not statistically significant, but also some of them have the opposite sign (higher tariffs implies higher productivity). Table 7 presents the marginal effects of an increase of nominal tariff and on tariffs on inputs for different firm characteristics. Although this is a very interesting point, the results are in general not very robust to different specifications.

Table 8 shows that productivity dispersion is extremely high among firms of the same industry, which raises the hypothesis that there are still significant differences among these firms that are not explained by characteristics related to specific industries. These unobserved characteristics can possibly affect the relationship between productivity and tariffs. To capture those unobserved characteristics quantile regressions[6] were estimated. The assumption is that the relative position of the firm in the industry productivity distribution is related to some of these unobserved characteristics such as management quality.

The quantile regression results for the nine deciles of the productivity distribution are shown at table 9. There is a clear-cut distinction between the effect of nominal tariffs and of tariffs on inputs on the productivity of the firms when they are classified according to their relative productivity. The productivity of the less productive firms (the first decile) increases when both nominal tariffs and tariffs on inputs are reduced. For more productive firms, the marginal effect of a reduction in nominal tariffs is positive.

The general result is that while a reduction in tariffs on inputs has a similar and positive effect on firm productivity, the marginal effect of the reduction of nominal tariffs varies significantly across firms. It is positive for firms at the lower end of the distribution but turns out to be negative for the most productive firms. Unlike the analysis concerning observed characteristics, the above results are robust to different specifications.

The first impact of a tariff reduction is to reduce productivity of domestic firms due to the lower production resulted from a reduced market share. Since some inputs are fixed in the short run, lower production means lower productivity. However, firms at the lower end of productivity distribution cannot stay in the newly liberalized market unless they increase productivity. Muendler (2002) shows that when tariffs are reduced, higher competition from foreign firms leads to a higher probability of firms with low productivity exiting the market. Thus, firms at the lower end of productivity distribution have to work hard and fast to increase productivity. The same does not happen to firms with higher productivity.

In the quantile regression, only firms at the low end of productivity distribution that were able to increase productivity are sampled. Firms that were not successful in increasing productivity left the market. This can be an explanation for the results from quantile regressions: firms that face higher probability of exiting the market are the ones that respond faster to higher foreign competition from tariff reduction.

[6] A complete reference for quantile regression is Buchinsky (1998).

Where tariffs on inputs are concerned, both firms with high and low productivity adapt at the same pace, increasing the share of foreign inputs, which in turn leads to higher productivity.

7. Summary and Conclusions

This paper studies the effects of trade liberalization in Brazil on the evolution of firm productivity. The productivity of each firm was estimated using an econometric framework that avoids the endogeneity bias incurred by the ordinary OLS production function estimation. Using an unbalanced panel data of 4,484 Brazilian manufacturing firms from 1986 to 1998, I estimated 27 industry production functions, following the procedure first proposed by Olley and Pakes (1996) and further developed by Levinsohn and Petrin (2003).

The fact that nominal tariff changes are not independent from firms' productivity is usually a problem in OLS regressions, where productivity is on the left hand side of the equation. The bias introduced by the political economy of trade protection cannot be known a priori, since policy makers and firms may have different incentives to lobby for tariff movements. The choice of good instruments for nominal tariffs is always problematic. In the Brazilian case, however, the fact that the structure of protection did not seem to have changed much after trade liberalization means that, by using industry dummies, the OLS bias can be significantly reduced. The positive correlation between productivity levels and nominal tariffs turns out to be negative when such fixed effects are added to the estimated equation.

Due to the estimated negative marginal effect of nominal tariffs on productivity, it is usually agreed that trade liberalization promotes productivity gains by inducing domestic firms to reduce X-inefficiencies and trim their fat in order to compete with more productive foreign firms. However, using tariffs on inputs to proxy for the increased availability of foreign inputs with better foreign technology, I found that tariffs on inputs also have a negative marginal effect on productivity. Thus, it seems that, along with the higher competition, new access to better inputs also contributes to productivity gains after trade liberalization.

The above statement, however, is not valid for every firm. There is a huge degree of heterogeneity of responses to trade liberalization. The effect of tariff reductions depends on the characteristics of the firm, such as size, type of good it produces, type of technology it uses, degree of concentration of the industry it belongs to, initial nominal tariffs and the share of imports and exports. It also depends on unobserved characteristics here proxied by the relative position in the productivity distribution of the industry the firm belongs to.

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TABLE 1 - BRAZILIAN MANUFACTURING FIRMS - Pesquisa Industrial Anual (IBGE)

	Average Tariff		Production		Workers (Production)		Capital		Other Inputs		# Firms
	final goods	inputs	mean	s.d	mean	s.d	mean	s.d	mean	s.d	
All firms											
87-90	45.9%	39.6%	62.0	334.0	683	1395	19.8	165.0	22.5	139.0	4251
92-94	15.1%	13.2%	70.8	327.0	683	1373	30.2	206.0	26.5	124.0	3074
95-98	15.0%	14.7%	84.7	494.0	575	1396	35.7	229.0	34.8	179.0	2765
4 *Non-metal mineral products*											
87-90	41.0%	32.0%	33.0	47.2	709	788	9.6	15.3	7.9	11.3	181
92-94	10.5%	9.7%	28.5	40.0	632	735	14.7	25.2	7.7	11.6	125
95-98	11.9%	11.5%	24.3	37.3	394	560	12.8	20.5	7.8	12.1	124
5 *Basic metal products*											
87-90	16.0%	34.7%	248.0	488.0	1780	2763	252.0	783.0	79.7	144.0	72
92-94	2.9%	12.9%	240.0	479.0	1506	2391	324.0	880.0	83.1	143.0	64
95-98	5.6%	14.3%	269.0	478.0	1459	2176	367.0	805.0	111.0	188.0	59
6 *Non-ferrous metal products*											
87-90	25.4%	35.2%	75.9	150.0	834	1257	46.5	148.0	30.0	61.3	82
92-94	7.8%	12.6%	80.9	157.0	717	918	58.5	154.0	31.0	64.3	67
95-98	10.0%	13.5%	96.7	191.0	645	1019	75.2	158.0	46.9	89.1	56
7 *Metal products*											
87-90	43.3%	36.9%	30.9	45.1	559	735	8.1	15.8	7.8	12.0	78
92-94	16.8%	14.2%	30.3	46.4	542	635	15.4	33.5	9.8	16.9	51
95-98	17.1%	14.8%	30.5	56.2	476	752	18.2	36.9	11.3	22.7	41
8 *Machinery and equipment*											
87-90	43.0%	34.2%	62.6	113.0	932	1522	15.5	27.3	17.5	33.8	295
92-94	19.4%	12.1%	60.5	125.0	765	1334	20.7	45.6	18.1	50.3	230
95-98	16.7%	13.3%	48.2	85.6	479	902	17.5	37.1	19.3	34.6	231
10 *Electrical equipment*											
87-90	49.9%	35.5%	32.3	48.5	927	1172	12.6	22.0	19.7	33.0	62
92-94	20.2%	14.9%	78.7	141.0	911	1183	21.7	39.0	31.9	69.8	52
95-98	19.5%	15.0%	159.0	360.0	953	1479	28.7	58.8	55.5	122.0	53
11 *Electronic equipment*											
87-90	45.4%	40.8%	38.6	70.9	576	865	9.7	20.6	11.4	21.9	152
92-94	21.2%	18.4%	59.7	127.0	505	793	13.2	30.0	18.5	40.9	94
95-98	17.8%	16.0%	68.8	166.0	392	764	15.6	36.9	27.6	70.1	80
12 *Automobiles, trucks and buses*											
87-90	74.1%	50.0%	336.0	905.0	2266	4929	54.1	146.0	160.0	467.0	59
92-94	30.9%	20.3%	543.0	1420.0	2848	6540	78.5	204.0	270.0	778.0	38
95-98	44.8%	25.4%	990.0	2020.0	3665	6363	206.0	429.0	462.0	944.0	33
13 *Other Vehicles and parts*											
87-90	44.6%	53.7%	80.6	114.0	1372	1454	19.7	30.5	26.7	38.5	112
92-94	18.6%	22.1%	87.1	105.0	1161	1178	31.0	43.5	29.3	35.1	93
95-98	17.8%	29.3%	105.0	137.0	900	1130	30.6	39.3	38.1	51.7	100
14 *Wood and furniture*											
87-90	32.1%	31.9%	17.6	27.8	481	692	2.8	7.2	6.3	12.0	221
92-94	9.3%	10.6%	20.3	27.9	567	816	5.2	9.5	8.3	12.2	118
95-98	12.3%	12.6%	17.3	22.8	336	492	5.0	7.5	8.2	12.1	104
15 *Paper, pulp and cardboard*											
87-90	35.1%	32.2%	67.0	97.9	796	837	34.4	78.7	24.6	34.4	127
92-94	9.0%	9.6%	79.5	126.0	867	998	65.4	134.0	28.4	45.5	90
95-98	12.1%	11.7%	70.8	114.0	547	748	49.6	98.7	27.2	41.4	97
16 *Rubber products*											
87-90	55.9%	49.1%	72.4	208.0	560	931	9.9	28.0	21.5	73.5	122
92-94	16.0%	15.7%	70.8	163.0	746	1095	16.9	38.7	22.3	60.6	78
95-98	13.5%	16.1%	69.7	175.0	571	905	20.0	35.8	27.5	73.0	66
17 *Non-petrochemical chemical elements*											
87-90	38.6%	32.1%	57.2	77.1	640	813	26.7	40.7	25.4	29.5	145
92-94	12.0%	9.7%	66.6	73.9	626	736	30.4	36.6	32.5	36.6	117
95-98	13.8%	12.0%	57.2	76.0	489	739	34.5	51.7	26.3	30.1	117
18 *Basic petrochemical products*											
87-90	26.2%	32.7%	308.0	1770.0	878	4317	129.0	725.0	114.0	741.0	108
92-94	9.5%	10.9%	234.0	1420.0	657	3249	146.0	863.0	79.7	412.0	89
95-98	8.5%	10.6%	453.0	2520.0	897	4111	205.0	1140.0	149.0	762.0	63
19 *Chemical products*											
87-90	37.5%	33.7%	73.4	123.0	392	512	16.9	42.2	27.5	46.0	190
92-94	13.6%	10.8%	84.5	128.0	446	705	28.5	67.9	30.4	44.5	142
95-98	10.8%	12.6%	88.7	158.0	352	507	26.6	49.0	41.6	69.9	122
20 *Pharmaceutical products and perfume*											
87-90	46.6%	38.9%	59.9	94.6	220	250	6.1	11.6	9.8	19.2	127
92-94	10.2%	9.0%	54.7	81.8	237	244	10.8	18.2	10.1	15.9	109
95-98	9.2%	20.8%	59.5	94.5	198	216	14.4	22.2	17.4	30.1	99

Production, capital stock and other inputs: 1,000,000 reais as of August 1994.

TABLE 1 - BRAZILIAN MANUFACTURING FIRMS - Pesquisa Industrial Anual (IBGE) (continuation)

	Average Tariff		Production		Workers (Production)		Capital		Other Inputs		# Firms
	final goods	inputs	mean	s.d	mean	s.d	mean	s.d	mean	s.d	
21 *Plastics*											
87-90	43.4%	38.2%	33.5	54.5	589	821	6.6	14.4	10.2	17.1	204
92-94	17.2%	14.2%	40.2	64.2	685	493	11.2	21.6	11.7	17.8	142
95-98	16.5%	15.5%	31.5	54.7	405	605	14.3	25.5	12.1	20.2	137
22 *Textiles*											
87-90	62.9%	60.9%	28.8	47.5	732	1037	9.8	22.2	9.9	18.8	471
92-94	17.6%	18.5%	41.7	63.0	774	933	15.0	26.1	14.6	24.6	302
95-98	17.2%	16.4%	35.1	58.1	594	846	17.3	30.0	14.9	24.2	261
23 Apparel											
87-90	76.0%	42.3%	19.8	38.0	872	1451	3.6	8.6	7.3	14.6	290
92-94	22.8%	14.5%	28.1	56.8	807	1240	6.7	16.9	9.1	18.0	190
95-98	21.1%	15.5%	27.7	56.4	541	866	6.7	15.9	8.6	16.5	162
24 *Leather Products and footware*											
87-90	44.0%	44.7%	31.4	41.3	529	647	4.1	4.9	11.0	16.9	93
92-94	14.5%	14.7%	29.1	40.3	492	602	6.6	10.2	12.6	20.4	76
95-98	17.1%	17.1%	14.3	19.6	266	376	7.0	9.7	7.3	11.2	60
25 *Coffee products*											
87-90	41.0%	40.3%	17.0	26.7	101	148	2.4	5.2	7.2	13.4	129
92-94	12.1%	11.8%	17.2	24.0	84	96	3.3	6.5	8.6	15.3	90
95-98	12.2%	11.9%	19.8	30.2	91	126	4.5	6.3	11.4	17.1	80
26 *Processed edible products*											
87-90	*34.7%*	45.1%	58.2	271.0	252	575	5.9	11.4	19.7	27.8	151
92-94	9.8%	14.3%	69.8	340.0	241	487	13.1	38.7	23.2	41.5	125
95-98	*13.3%*	14.4%	95.0	375.0	288	648	18.8	64.7	34.6	74.4	100
27 *Meat and Poultry*											
87-90	28.8%	32.9%	60.5	117.0	656	1172	9.3	20.8	31.3	55.2	186
92-94	9.1%	10.3%	78.5	148.0	876	1511	20.9	45.1	45.2	76.2	129
95-98	10.3%	12.2%	78.0	165.0	883	1807	20.0	36.1	44.9	88.4	108
28 *Processed dairy products*											
87-90	45.0%	42.4%	97.8	326.0	433	775	8.5	24.1	47.0	114.0	99
92-94	18.8%	20.5%	96.7	319.0	461	879	14.7	44.3	43.4	91.3	82
95-98	16.5%	19.1%	114.0	351.0	493	1259	29.5	76.3	50.5	128.0	72
29 *Sugar*											
87-90	39.9%	39.7%	50.4	73.4	906	746	24.8	21.8	24.7	39.0	72
92-94	16.6%	15.1%	56.4	78.9	977	979	31.4	22.9	26.7	38.3	60
95-98	17.4%	16.0%	55.6	91.7	826	1111	31.1	23.3	29.1	59.5	60
30 *Vegetable oil*											
87-90	27.8%	34.5%	91.8	179.0	321	577	18.2	38.9	53.1	102.0	77
92-94	8.7%	10.7%	95.7	212.0	422	1135	35.0	84.5	54.9	119.0	52
95-98	9.6%	13.5%	144.0	378.0	671	2222	42.9	132.0	92.7	240.0	44
31 *Beverage and other food products*											
87-90	57.4%	27.5%	51.2	130.0	481	663	9.4	22.5	13.4	23.4	346
92-94	18.2%	7.9%	56.8	113.0	521	638	18.6	40.2	15.9	27.8	269
95-98	16.2%	9.0%	67.6	155.0	450	594	26.8	70.9	22.3	46.2	236

Production, capital stock and other inputs: 1,000,000 reais as of August 1994.

TABLE 2 - ESTIMATED PRODUCTION FUNCTIONS

	N. obs	Olley and Pakes Methodology lb	lw	m	k	OLS lb	lw	m	k
4		*Non-metal mineral products*							
	1468	0.1634	0.1668	0.5152	0.1553	0.1762	0.189	0.5753	0.1142
		(0.0102)	(0.0098)	(0.0109)	(0.0086)	(0.0159)	(0.0161)	(0.0146)	(0.0099)
5		*Basic metal products*							
	664	0.2861	0.1158	0.4976	0.1831	0.1924	0.1907	0.5828	0.0928
		(0.0207)	(0.0192)	(0.0122)	(0.0115)	(0.0261)	(0.0197)	(0.0271)	(0.0131)
6		*Non-ferrous metal products*							
	712	0.2838	0.1537	0.5268	0.1188	0.2073	0.1825	0.6032	0.0676
		(0.0277)	(0.0218)	(0.0165)	(0.0150)	(0.0201)	(0.0180)	(0.0167)	(0.0105)
7		*Metal products*							
	575	0.289	0.2475	0.5232	0.0695	0.2176	0.1992	0.5719	0.0699
		(0.0216)	(0.0173)	(0.0164)	(0.0157)	(0.0319)	(0.0243)	(0.0283)	(0.0134)
8		*Machinery and equipment*							
	2511	0.2654	0.1765	0.4767	0.1609	0.2218	0.1536	0.5439	0.1238
		(0.0186)	(0.0164)	(0.0125)	(0.0130)	(0.0121)	(0.0124)	(0.0106)	(0.0078)
10		*Electrical equipment*							
	537	0.3837	0.1647	0.4305	0.0667	0.0324	0.0535	0.6982	0.1687
		(0.0449)	(0.0313)	(0.0276)	(0.0306)	(0.0334)	(0.0299)	(0.0334)	(0.0186)
11		*Electronic equipment*							
	1033	0.1353	0.1361	0.5662	0.1692	0.0942	0.191	0.5637	0.1673
		(0.0148)	(0.0129)	(0.0103)	(0.0101)	(0.0153)	(0.0148)	(0.0151)	(0.0115)
12		*Automobiles, trucks and buses*							
	448	0.2988	0.0777	0.6341	0.0892	0.2488	0.0682	0.608	0.1304
		(0.0247)	(0.0230)	(0.0190)	(0.0163)	(0.0278)	(0.0244)	(0.0307)	(0.0153)
13		*Other Vehicles and parts*							
	1063	0.3121	0.1225	0.4941	0.2156	0.2366	0.0558	0.6044	0.1458
		(0.0226)	(0.0150)	(0.0153)	(0.0123)	(0.0188)	(0.0132)	(0.0191)	(0.0124)
14		*Wood and furniture*							
	1517	0.2366	0.1103	0.5288	0.1205	0.2313	0.1435	0.6071	0.0561
		(0.0197)	(0.0163)	(0.0139)	(0.0139)	(0.0172)	(0.0148)	(0.0152)	(0.0082)
15		*Paper, pulp and cardboard*							
	1083	0.3077	0.0026	0.654	0.0824	0.1887	0.1279	0.66	0.068
		(0.0165)	(0.0133)	(0.0124)	(0.0086)	(0.0168)	(0.0147)	(0.0173)	(0.0075)
16		*Rubber products*							
	894	0.3393	0.1776	0.4808	0.0924	0.3016	0.1994	0.5514	0.0658
		(0.0286)	(0.0232)	(0.0208)	(0.0169)	(0.0213)	(0.0175)	(0.0199)	(0.0114)
17		*Non-petrochemical chemical elements*							
	1385	0.1308	0.1164	0.5418	0.209	0.0414	0.0982	0.6613	0.1118
		(0.0170)	(0.0148)	(0.0167)	(0.0199)	(0.0132)	(0.0113)	(0.0154)	(0.0096)
18		*Basic petrochemical products*							
	873	0.1411	0.0297	0.7018	0.1987	0.1004	0.0966	0.7199	0.1003
		(0.0176)	(0.0124)	(0.0142)	(0.0123)	(0.0181)	(0.0161)	(0.0248)	(0.0105)
19		*Chemical products*							
	1537	0.1273	0.2163	0.5631	0.1194	0.1383	0.2253	0.5787	0.1045
		(0.0131)	(0.0114)	(0.0092)	(0.0088)	(0.0130)	(0.0146)	(0.0148)	(0.0086)
20		*Pharmaceutical products and perfume*							
	1099	0.1982	0.2835	0.5034	0.0826	0.1918	0.3037	0.5417	0.0577
		(0.0138)	(0.0097)	(0.0131)	(0.0071)	(0.0254)	(0.0210)	(0.0182)	(0.0131)

TABLE 2 - ESTIMATED PRODUCTION FUNCTIONS (continuation)

	N. obs	Olley and Pakes Methodology lb	lw	m	k	OLS lb	lw	m	k
21		*Plastics*							
	1585	0.1585	0.1924	0.5537	0.1253	0.1735	0.1897	0.5766	0.1023
		(0.0155)	(0.0118)	(0.0096)	(0.0076)	(0.0154)	(0.0130)	(0.0143)	(0.0082)
22		*Textiles*							
	3526	0.2052	0.1437	0.5581	0.1028	0.1854	0.1898	0.5788	0.0735
		(0.0049)	(0.0041)	(0.0034)	(0.0027)	(0.0086)	(0.0093)	(0.0082)	(0.0054)
23		*Apparel*							
	2187	0.2104	0.1707	0.5225	0.1823	0.1816	0.1494	0.5701	0.1392
		(0.0154)	(0.0138)	(0.0124)	(0.0119)	(0.0121)	(0.0110)	(0.0122)	(0.0077)
24		*Leather Products and footware*							
	777	0.3103	0.1937	0.5153	0.0761	0.2933	0.1421	0.6044	0.014
		(0.0110)	(0.0091)	(0.0082)	(0.0098)	(0.0242)	(0.0172)	(0.0188)	(0.0103)
25		*Coffee products*							
	920	0.2006	0.1017	0.5729	0.1326	0.1765	0.1708	0.6368	0.0562
		(0.0174)	(0.0156)	(0.0131)	(0.0138)	(0.0180)	(0.0159)	(0.0204)	(0.0140)
26		*Processed edible products*							
	1230	0.2487	0.1335	0.6263	0.0861	0.2717	0.1534	0.6164	0.0811
		(0.0123)	(0.0108)	(0.0077)	(0.0087)	(0.0211)	(0.0183)	(0.0183)	(0.0120)
27		*Meat and Poultry*							
	1393	0.3656	0.087	0.5745	0.0527	0.2752	0.0827	0.6471	0.0303
		(0.0110)	(0.0091)	(0.0068)	(0.0062)	(0.0175)	(0.0086)	(0.0156)	(0.0076)
28		*Processed dairy products*							
	855	0.3525	0.1696	0.4752	0.1472	0.3526	0.1721	0.5678	0.0309
		(0.0210)	(0.0191)	(0.0137)	(0.0135)	(0.0215)	(0.0164)	(0.0218)	(0.0100)
29		*Sugar*							
	725	0.1409	0.128	0.6302	0.0992	0.1359	0.1242	0.6821	0.0462
		(0.0111)	(0.0106)	(0.0103)	(0.0145)	(0.0174)	(0.0123)	(0.0205)	(0.0138)
30		*Vegetable oil*							
	551	0.1474	0.027	0.6475	0.1541	0.198	0.0858	0.6983	0.0652
		(0.0240)	(0.0168)	(0.0102)	(0.0173)	(0.0247)	(0.0206)	(0.0219)	(0.0151)
31		*Beverage and other food products*							
	2818	0.19	0.0956	0.608	0.1517	0.1165	0.1618	0.634	0.1422
		(0.0079)	(0.0068)	(0.0079)	(0.0048)	(0.0135)	(0.0098)	(0.0147)	(0.0077)

TABLE 3 - TOTAL FACTOR PRODUCTIVITY (1986 = 100)

	1986	1987	1988	1989	1990	1992
4 *Non-metal mineral products*	100.00	80.97	86.62	77.86	83.97	65.53
5 *Basic metal products*	100.00	111.11	133.24	134.21	131.93	124.28
6 *Non-ferrous metal products*	100.00	121.11	130.97	133.01	120.26	130.96
7 *Metal products*	100.00	116.43	132.52	134.83	129.37	112.55
8 *Machinery and equipment*	100.00	102.56	94.91	98.18	86.20	94.92
10 *Electrical equipment*	100.00	124.49	112.59	133.36	141.32	201.63
11 *Electronic equipment*	100.00	120.39	135.47	147.00	120.07	148.11
12 *Automobiles, trucks and buses*	100.00	95.48	111.06	116.95	93.62	107.32
13 *Other Vehicles and parts*	100.00	122.37	132.09	141.57	109.91	116.86
14 *Wood and furniture*	100.00	87.10	87.99	81.84	64.02	61.85
15 *Paper, pulp and cardboard*	100.00	111.48	110.29	113.08	108.58	111.16
16 *Rubber products*	100.00	113.20	133.28	161.48	136.86	120.91
17 *Non-petrochemical chemical elements*	100.00	103.81	114.35	118.55	101.65	104.91
18 *Basic petrochemical products*	100.00	95.31	93.78	89.37	76.51	71.19
19 *Chemical products*	100.00	107.46	129.66	142.38	123.55	123.31
20 *Pharmaceutical products and perfume*	100.00	120.99	115.69	132.25	114.81	99.36
21 *Plastics*	100.00	121.27	109.26	113.49	104.14	115.12
22 *Textiles*	100.00	110.05	119.41	117.21	113.11	115.80
23 *Apparel*	100.00	104.96	99.31	57.02	53.24	90.01
24 *Leather Products and footware*	100.00	102.59	90.21	86.16	77.65	75.69
25 *Coffee products*	100.00	144.73	158.48	139.39	118.22	128.08
26 *Processed edible products*	100.00	70.41	67.48	61.63	69.46	66.10
27 *Meat and Poultry*	100.00	108.46	108.66	98.87	106.48	93.74
28 *Processed dairy products*	100.00	95.45	103.03	96.77	82.26	81.05
29 *Sugar*	100.00	111.40	120.61	128.66	115.98	117.28
30 *Vegetable oil*	100.00	113.33	110.44	122.73	118.35	97.61
31 *Beverage and other food products*	100.00	99.60	127.70	125.02	110.88	98.06

TABLE 3 - TOTAL FACTOR PRODUCTIVITY (1986 = 100) (continuation)

	1993	1994	1995	1996	1997	1998
4 *Non-metal mineral products*	77.40	58.47	43.32	67.03	66.35	63.70
5 *Basic metal products*	126.49	120.16	110.28	122.90	132.69	134.22
6 *Non-ferrous metal products*	152.65	125.25	120.05	122.95	133.40	133.72
7 *Metal products*	106.04	103.18	107.98	110.48	123.02	134.24
8 *Machinery and equipment*	111.29	97.16	71.49	93.96	105.19	110.65
10 *Electrical equipment*	212.83	216.56	210.92	225.42	237.19	245.96
11 *Electronic equipment*	171.17	152.08	148.61	161.90	218.84	200.67
12 *Automobiles, trucks and buses*	123.05	126.81	101.50	117.58	123.42	130.10
13 *Other Vehicles and parts*	147.20	137.72	136.26	147.96	160.98	163.05
14 *Wood and furniture*	68.13	71.37	58.77	72.81	75.81	81.13
15 *Paper, pulp and cardboard*	114.49	111.63	101.12	123.73	122.80	132.48
16 *Rubber products*	122.92	103.53	96.15	108.12	116.27	127.54
17 *Non-petrochemical chemical elements*	107.20	107.00	100.08	112.93	111.03	116.20
18 *Basic petrochemical products*	88.95	78.38	65.09	70.83	74.44	85.77
19 *Chemical products*	134.46	124.10	125.28	144.62	139.86	140.04
20 *Pharmaceutical products and perfume*	96.67	83.88	70.48	73.03	63.82	56.91
21 *Plastics*	119.62	99.97	88.35	103.67	105.71	107.20
22 *Textiles*	129.32	110.97	99.50	103.65	110.18	112.14
23 *Apparel*	107.00	121.01	117.25	106.75	119.02	130.54
24 *Leather Products and footware*	77.86	61.72	47.09	62.89	70.72	72.58
25 *Coffee products*	127.21	103.49	97.01	96.29	94.10	114.84
26 *Processed edible products*	76.86	73.06	63.97	67.80	137.06	140.44
27 *Meat and Poultry*	92.75	89.97	84.24	101.56	96.52	91.46
28 *Processed dairy products*	85.86	72.36	68.07	78.88	83.12	79.60
29 *Sugar*	129.65	127.99	119.74	125.32	141.09	137.31
30 *Vegetable oil*	109.04	109.85	95.21	137.70	147.29	140.43
31 *Beverage and other food products*	99.27	85.81	74.19	82.96	77.37	89.68

TABLE 4 - EFFECT OF NOMINAL TARIFF ON LOG OF PRODUCTIVITY

Dependent Variable		Nominal Tariff	Year Effects	Industry Effects	Firm Effects
ln productivity	n=23589	0.3914 (0.0322)***	yes	no	no
ln productivity	n=23589	-0.0042 (0.0424)	yes	yes	no
ln productivity	n=23589	-0.1343 (0.0338)***	yes	yes	yes
ln productivity (estimated using OLS)	n=23589	-0.0847 (0.0339)***	yes	yes	yes

Robust standard errors into parenthesis.
***, **, *: significant at 1%, 5% and 10%, respectively.

TABLE 5 - EFFECT OF NOMINAL TARIFF AND TARIFFS ON INPUTS ON LOG OF PRODUCTIVITY

Dependent Variable		Nominal Tariff	Tariffs on Inputs	Year Effects	Industry Effects	Firm Effects
ln productivity	n=23589	0.2792 (0.0379)***	0.4343 (0.0565)***	yes	no	no
ln productivity	n=23589	0.0472 (0.0457)	-0.2712 (0.0727)***	yes	yes	no
ln productivity	n=23589	-0.0947 (0.0363)***	-0.1531 (0.0516)***	yes	yes	yes
ln productivity (estimated using OLS)	n=23589	-0.0432 (0.0364)	-0.1603 (0.0517)***	yes	yes	yes

Robust standard errors into parenthesis.
***, **, *: significant at 1%, 5% and 10%, respectively.

TABLE 6 - FIRM'S CHARACTERISTICS BY SECTOR

industry	initial tariff	initial import share	initial export share	type of industry	factor intensity	initial herfindahl
4	39.2%	1.0%	2.0%	intermediate	natural resources	0.0171
5	29.0%	1.5%	16.8%	intermediate	capital	0.0772
6	30.6%	4.9%	17.5%	intermediate	natural resources	0.0627
7	45.8%	1.1%	3.1%	intermediate	capital	0.0426
8	46.8%	6.7%	9.0%	capital	technology	0.0159
10	50.0%	11.4%	6.2%	capital	technology	0.0685
11	48.6%	14.4%	7.6%	consumer	technology	0.0322
12	65.0%	0.3%	13.6%	transport equipment	technology	0.1438
13	42.8%	9.0%	15.0%	transport equipment	technology	0.0271
14	30.3%	0.4%	4.6%	consumer	natural resources	0.0183
15	32.1%	1.9%	5.9%	intermediate	natural resources	0.0256
16	49.3%	3.8%	5.7%	intermediate	technology	0.1343
17	31.4%	12.3%	5.4%	intermediate	capital	0.0187
18	33.8%	4.1%	9.4%	intermediate	capital	0.4212
19	34.7%	5.9%	2.5%	intermediate	capital	0.0220
20	45.3%	5.0%	1.7%	consumer	labor	0.0330
21	57.1%	1.8%	2.6%	intermediate	labor	0.0211
22	57.3%	1.6%	5.6%	intermediate	labor	0.0086
23	76.0%	0.3%	1.5%	consumer	labor	0.0172
24	41.0%	2.7%	25.2%	intermediate	labor	0.0311
25	35.0%	0.0%	35.0%	consumer	natural resources	0.0326
26	42.0%	2.8%	7.3%	consumer	natural resources	0.0239
27	29.8%	1.0%	9.5%	consumer	natural resources	0.0294
28	40.3%	1.8%	0.0%	consumer	natural resources	0.1099
29	29.3%	0.0%	13.1%	consumer	natural resources	0.0409
30	20.5%	1.4%	25.2%	intermediate	natural resources	0.0693
31	51.8%	2.5%	2.4%	consumer	natural resources	0.0175

Initial import share, initial export share and type of industry are classified by nivel 80 - here grouped by nivel 50 just for simplicity

Factor intensity is classified by nivel 100 - here grouped by nivel 50 just for simplicity

TABLE 7 - PRODUCTIVITY AND TARIFFS - MARGINAL EFFECTS
Dependent Variable: log(productivity)

Firm's characteristics	Nominal Tariff	Tariff on Inputs
High Herfindahl	2.7280 (0.8460)***	-1.7484 (0.9892)***
Low Herfindahl	-0.2975 (0.2475)	0.0205 (0.2844)
High Import Penetration	-2.1946 (0.3779)***	1.9547 (0.4405)***
Low Import Penetration	-2.6878 (0.2513)***	2.0389 (0.2626)***
High Export Share	-0.1326 (0.6138)	0.4219 (0.6042)
Low Export Share	-0.9078 (0.1850)***	0.8100 (0.2686)***
Capital Goods	0.3882 (0.7800)	0.3519 (0.8740)
Intermediate Goods	-2.5662 (0.9799)***	3.4948 (1.1232)***
Consumer Goods	-0.8404 (1.0644)	1.6773 (1.2145)
Capital Intensive	3.3448 (0.0916)***	-2.5828 (0.9820)***
Labor Intensive	3.4297 (0.8832)**	-3.1061 (0.9628)***
Natural Resources Int.	2.4526 (0.8704)***	-1.4564 (0.9673)
Low Initial Tariff	0.8942 (0.4585)*	-0.7864 (0.4015)**
High Initial Tariff	-1.1735 (0.3163)***	1.8134 (0.3322)***
Small	0.1451 (0.1242)	0.3633 (0.1919)*
Large	-0.0266 (0.0772)	0.0127 (0.1038)

Includes year and industry fixed effects.
Robust standard errors into parenthesis.
***, **, *: significant at 1%, 5% and 10%, respectively.

TABLE 8 - FIRM'S PRODUCTIVITY BY INDUSTRY

	1988		1992		19998	
	Mean	Stand. Dev.	Mean	Stand. Dev.	Mean	Stand. Dev.
4 *Non-metal mineral products*	-0.316	0.522	-0.460	0.521	-0.577	0.501
5 *Basic metal products*	0.180	0.415	0.117	0.373	0.093	0.440
6 *Non-ferrous metal products*	0.128	0.418	0.115	0.358	0.137	0.347
7 *Metal products*	0.162	0.445	-0.073	0.344	0.086	0.354
8 *Machinery and equipment*	-0.146	0.502	-0.135	0.438	-0.078	0.425
10 *Electrical equipment*	0.078	0.494	0.867	0.567	1.304	0.430
11 *Electronic equipment*	0.149	0.545	0.178	0.341	0.420	0.551
12 *Automobiles, trucks and buses*	-0.023	0.454	-0.075	0.318	0.111	0.167
13 *Other Vehicles and parts*	0.260	0.379	0.171	0.286	0.596	0.335
14 *Wood and furniture*	-0.240	0.369	-0.491	0.360	-0.495	0.430
15 *Paper, pulp and cardboard*	-0.040	0.458	0.015	0.331	0.118	0.395
16 *Rubber products*	0.204	0.524	0.064	0.450	0.006	0.466
17 *Non-petrochemical chemical elements*	0.196	0.455	0.110	0.437	0.121	0.476
18 *Basic petrochemical products*	-0.071	0.363	-0.248	0.304	-0.205	0.284
19 *Chemical products*	0.239	0.500	0.143	0.375	0.161	0.459
20 *Pharmaceutical products and perfume*	0.122	0.519	-0.170	0.426	-0.591	0.480
21 *Plastics*	0.030	0.466	0.087	0.376	-0.036	0.395
22 *Textiles*	0.087	0.531	0.092	0.591	0.000	0.413
23 *Apparel*	0.011	0.537	-0.152	0.503	0.190	0.433
24 *Leather Products and footware*	-0.024	0.635	-0.273	0.363	-0.268	0.263
25 *Coffee products*	0.400	0.680	0.234	0.451	-0.041	0.299
26 *Processed edible products*	0.051	0.461	-0.152	0.569	-0.117	0.423
27 *Meat and Poultry*	-0.027	0.459	-0.142	0.315	-0.117	0.220
28 *Processed dairy products*	0.046	0.462	-0.241	0.316	-0.323	0.388
29 *Sugar*	0.293	0.405	0.040	0.466	0.249	0.419
30 *Vegetable oil*	0.025	0.409	-0.026	0.410	0.142	0.547
31 *Beverage and other food products*	0.172	0.712	0.047	0.520	-0.071	0.449

TABLE 9 - QUANTILE REGRESSION - RELATIVE PRODUCTIVITY AND TARIFFS

Dependent Variable log(prod) - decile	Nominal Tariff	Tariff on Inputs
1	-0.1969	-0.2447
	(0.0602)***	(0.1161)**
2	-0.1059	-0.2695
	(0.0478)**	(0.0894)***
3	-0.1102	-0.2420
	(0.0432)**	(0.0782)***
4	-0.0640	-0.2585
	(0.0442)	(0.0795)***
5	-0.0286	-0.2279
	(0.0450)	(0.0789)***
6	0.0933	-0.3209
	(0.0446)**	(0.0760)***
7	0.1484	-0.3646
	(0.0504)***	(0.0830)***
8	0.1955	-0.3691
	(0.0500)***	(0.0788)***
9	0.3305	-0.4196
	(0.0813)***	(0.1228)***

Include year and industry fixed effects.
Robust standard errors into parenthesis.
***, **, *: significant at 1%, 5% and 10%, respectively.