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# The Effect of Trade Protection on Productivity in Uruguay

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# THE EFFECT OF TRADE PROTECTION ON PRODUCTIVITY IN URUGUAY

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## Abstract

We analyze the effect of trade protection on firm's performance using a panel of firms from the Annual Manufacturing Surveys of Uruguay from 1988 to 2005. We estimate total factor productivity using Levinsohn and Petrin (2003) methodology and relate such measures to protection. Firm-specific protection is measured as the average tariff within the four-digit harmonized system classes containing the firm's products (rather than the usual four-digit ISIC averages), tracking more closely the relevant markets, both for firm's product and input baskets, and separate indices are calculated. We find a positive effect of reduction in output protection on total factor productivity, while the effect of lower input protection, when significant, is negative, which we find related to the overall change in effective protection. Reductions in bilateral tariffs with Uruguay's large neighbors in the context of MERCOSUR are not found to have a significant productivity enhancing effect. The results are robust to alternative protection measures, specification and controls.

Keywords: Total factor productivity; Trade protection.

JEL classification: D24, F14.

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**Resumen**

Se analiza el efecto de la protección comercial en el desempeño de las empresas usando un panel con datos de las Encuestas Anuales de Actividad Económica de Uruguay para la industria manufacturera entre 1988 y 2005. Se estima indicadores a nivel de empresa de productividad total de factores usando la metodología de Levinsohn-Petrin (2003) y se relaciona dichas medidas con los aranceles. La protección específica de la empresa se mide como el arancel promedio dentro de las clases de actividad a cuatro dígitos de la CIIU que contienen los productos de la empresa (a diferencia de las medidas usuales basadas en promedios a cuatro dígitos de la CIIU). De esta manera se sigue de manera más precisa los mercados relevantes, tanto para los productos como para las materias primas y materiales, y se elabora índices separados para ambos. Se encuentra un efecto positivo de la reducción en la protección a los productos en la productividad total de factores, mientras que el efecto de reducir la protección a los insumos, cuando es significativo, es negativo, lo que se encuentra relacionado con los cambios en la protección efectiva. Las reducciones de los aranceles bilaterales con los grandes vecinos de Uruguay en el contexto del MERCOSUR no se encuentran significativamente asociadas a incrementos de productividad. Los resultados son robustos a diferentes medidas alternativas de la protección, especificaciones y controles.

Palabras clave: Productividad total de los factores; Protección comercial.

## 1. Introduction

Along the last two decades Uruguay continued to be engaged in its long trade openness process -started in the 1970s-, and significant developments took place, including the Southern Common Market (MERCOSUR) integration agreement, as well as reciprocal (multilateral and preferential) and unilateral measures (see Vaillant, 2006). In the early nineties a unilateral tariff reduction was enacted, lowering protection and tariff dispersion. Preferential liberalization advanced with the signature in 1991 of the Asuncion Treaty, which laid the foundations for the MERCOSUR and established an intra-zone tariff reduction schedule. A long list of excepted items was negotiated. The Ouro Preto protocol set in motion in 1994 the process of adoption of a Common External Tariff (CET) by all MERCOSUR members (Argentina, Brazil, Paraguay and Uruguay), also with exception lists. In 1994 the Uruguay Round Agreements were ratified by the Uruguayan parliament. Large macroeconomic changes also characterize the period. The manufacturing firm's environment was significantly modified and vast restructuring took place, leading to large scale labor and capital reallocation[1].

It has been traditionally argued that trade liberalization produced static gains from trade in developing economies. More recent literature stressed the more relevant dynamic benefits from productivity enhancement effects of openness, but the attempts to measure such effects are not frequent. Uruguay is an interesting case to test the impact of trade protection on economic efficiency. Newly available data allow addressing the issue based on firm-level specific measures, in line with the recent literature on firm heterogeneity, productivity and trade, differently from former empirical exercises based on sector-level tariff variation.

The effect of tariff reduction on productivity has been widely researched in the international literature. Trefler (2004) uses plant-level data to analyze the impacts of the North American Free Trade Area (NAFTA) on productivity and employment of Canadian firms. For Latin American countries recent references are Pavcnik (2002) using Chilean

[1] In the early 1990s, a stabilization program based on an exchange rate anchor was undertaken, resulting in a significative reduction of inflation (from an annual rate of more than 100 percent in 1990 to around 5 percent ten years later) and a considerable real appreciation of national currency. The economic crisis of 2002 led to a sharp devaluation of the peso and macroecnomic policy moved toward a managed floating exchange rate regime based on inflation-targeting rules.

firm data, Muendler (2004) who studies the case of Brazil, and López-Cordova and Mesquita (2003) for Brazil and Mexico. A valuable reference to our present study is Amiti and Konings (2007) who estimate the effects of trade liberalization on plant productivity in Indonesia, finding that reducing tariffs, especially input tariffs, has an enhancing effect on productivity, and that importers enjoy larger gains from liberalization (reflecting direct benefits from higher-quality foreign inputs, more differentiated varieties of inputs and/or learning effects).

Several papers analyze productivity using microdata in Uruguay, as López and Llambí (1998), Noya and Lorenzo (1999), and Cassoni, Fachola and Labadie (2001). However, such studies do not provide a link between trade protection and total factor productivity (TFP). The only study analyzing the effect of protection on productivity using microdata in Uruguay is Casacuberta, Fachola and Gandelman (2004). They provide a first approach to the study of the effect of trade policies on firm's behavior, exploring the relationship between trade openness and TFP. They find a significant productivity enhancing effect of tariffs' fall between 1988 and 1995. This paper builds on their work, while introducing data and methodology improvements.

The paper is organized as follows. In Section 2 we discuss the methodology applied to estimate TFP (first step) and trade protection effects (second step). In Section 3 we describe our manufacturing and protection data. In Section 4 we present the results of first and second step estimations and in Section 5 we conclude.

## 2. Identifying the effect of trade protection on productivity

### 2.1. Productivity estimation

We use a set of methodologies customary in measuring TFP by estimating production function parameters from microdata. These include ordinary least squares (OLS), the fixed

effects estimator, and Levinsohn and Petrin (2003) to control for simultaneity between productivity shocks and the input decisions[2].

The Cobb-Douglas first step production estimated equations are:

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

where $y_{it}$ is output, $l_{it}$ labor, $k_{it}$ capital and $m_{it}$ intermediate inputs (all in logarithms) of firm $i$ in period $t$. From the estimated coefficients, TFP is retrieved as:

$$tfp_{it}^{j} = y_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_m m_{it}$$

where $tfp_{it}^{j}$ is (log) of TFP of firm $i$ from industry $j$ in period $t$.

### 2.2. Second step regressions and identification strategy

Using our productivity estimates we run a second step regression of TFP on product and input tariffs, all at the firm level (i.e. computing firm-specific protection measures). This follows Amiti and Konings (2007). To see whether trade liberalization has a larger effect on input importing firms, we interact input tariffs with an indicator of such imports. We aim to disentangle productivity gains that arise from reducing tariffs on final goods from those obtained from reducing tariffs on intermediate inputs. Protection measures are separated in final goods (*FG*) and intermediate inputs (*II*).

Our second step estimated equation is:

$$tfp_{it}^{j} = \gamma_0 + \alpha_i + \gamma_1 \left(tariff_{FG}\right)_{it}^{j} + \gamma_2 \left(tariff_{II}\right)_{it}^{j} + \gamma_3 \left(tariff_{II}\right)_{it}^{j} FM_{it} + \gamma_4 FM_{it} + \varepsilon_{it}$$

where $\alpha_i$ are fixed effects to control for unobservable heterogeneity at firm level, and $FM_{it}$ indicates whether the firm imported intermediate inputs in period $t$.

[2] When firms receive a positive productivity shock, they may respond by using more inputs. Under these conditions, OLS will result in biased parameter estimates and, consequently, in biased estimates of productivity.

A reduction in protection on final goods would induce productivity enhancement ( $\gamma_1 < 0$ ), due to import competition compelling domestic firms to increase their efficiency or forcing the exit of the least productive.

Regarding reduced protection on firm's inputs, there might be two views on its effect. In the spirit of Corden (1971), lower input tariffs could lead to lower productivity since the effective protection increases, and incentives to shift to more efficient production techniques are reduced. On the other hand, lower input tariffs may lead to productivity gains as firm obtains access to better quality and/or larger variety of inputs. Coefficient $\gamma_2$ will reflect these effects.

We also interact input tariffs with an indicator of the importing status of firms. A negative $\gamma_3$ would imply that input importing firms reap larger direct benefits from lower tariffs than non importers, while a positive $\gamma_4$ would reflect technological externalities derived from importing.

An important issue in econometric estimation of the causal influence of trade policy on productivity is that a vast literature has argued in support of the endogeneity of this policy. In this study we treat tariff reductions as an exogenous stimulus to firms and sectors. The signature of binding international treaties (MERCOSUR and World Trade Organization) significantly curtailed the ability of Uruguayan government to provide discretionary protection to specific sectors. Given the relative bargaining powers of MERCOSUR partners, the endogeneity of the CET is likely to be a problem for studies of large countries like Argentina and fundamentally Brazil, but not for the smallest partners Paraguay and Uruguay, in which firms may have had little chance to influence the general convergence scheme. This conclusion can be drawn from Olarreaga and Soloaga (1998), an application of a Grossman and Helpman "protection for sale" model to the MERCOSUR CET, in which it is shown that the customs union external tariff follows closely the Brazilian tariff structure. A paper analyzing the relative inability of firms in influencing protection level in the case of Indonesia (Mobarak and Purbasari, 2005) explains this result by arguing that it is difficult for governments in developing countries 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 (IMF). Instead, political favors are given at the firm

level in a less transparent way. In the case of Uruguay this might be the case of more discretionary use of non-tariff barriers[3].

We first regress TFP only on output tariffs, next we also include input tariffs. The next step is to interact input tariffs with the indicator of importing status to check whether the reduction of input tariffs impacts on importing firms' productivity through the technology embodied in foreign inputs.

In order to capture other possible influences on between-firm evolution of TFP, we include firm-level characteristics as controls. In particular, we consider exporting status (using a dummy variable and the share of exports in firm' sales).

Additionally, using firm-level data we replicate the usual studies that include sector tariff averages as right hand side variables (computed as the ISIC four-digit simple averages), to see if these estimates differ significantly from those obtained using firm-level protection measures. Each firm is classified into the sector with the largest share in its sales. Results are compared with those obtained using firm-specific protection estimates, which also help to assess the importance of between effects. The estimated equation is the following:

$$tfp_{it}^{j} = \gamma_0 + \alpha_i + \gamma_1 \left(tariff_{FG}\right)_t^j + \gamma_2 \left(tariff_{II}\right)_t^j + \gamma_3 \left(tariff_{II}\right)_t^j FM_{it} + \gamma_4 FM_{it} + \varepsilon_{it}$$

The calculation of sector-level protection measures is also informative regarding the exogeneity of tariffs. If firms are really not capable of influencing the tariffs that particularly affect their specific products (or inputs), then firm-specific tariffs should not fall substantially slower than sector averages do.

[3] It would have been desirable to investigate the extent of the separate effects of tariff and non-tariff protection. However, to our knowledge there are no ad-valorem equivalent of non-tariff measures estimated for Uruguay before 2006 (these can be found in the dataset provided by Kee, Nicita and Olarreaga (2009)).

## 3. Data

### 3.1. Manufacturing

We use a 1997 constant price firm-level panel for the period 1988-2005, constructed using data from the National Statistics Institute (INE), that becomes available for research for the first time.

The Manufacturing Survey database of the INE includes a sample of firms with a detailed questionnaire on production, sales, input and factor usage. For 1988-1996 the data source for the panel was the *Encuesta Industrial Anual* (Annual Manufacturing Survey, EIA), which encompasses formal manufacturing firms. For each five-digit ISIC2 manufacturing sector, all firms with 100 or more employees (compulsory range) were surveyed, while for the group of firms with a number of employees between 5 and 99 (random range) a probabilistic sample was drawn[4].

For 1997-2005 the source was the *Encuesta de Actividad Económica* (Economic Activity Survey, EAE), which captures formal firms with 5 or more employees in a wide number of four-digit ISIC3 sectors, including not only manufacturing but also several services and commerce sectors (although the panel for this study comprises only manufacturing firms). For this period, the compulsory sampling range includes all firms with 50 or more employees[5].

The panel contains consistent annual data on output, revenues, intermediate inputs, labor, capital and other expenditures[6]. The data were deflated using detailed price indices. For output and materials we computed firm-specific deflators by weighting the four-digit ISIC price indices with the share of each sector in firm's sales/costs. Components of

[4] For details see Instituto Nacional de Estadística (1988).
[5] For details see Instituto Nacional de Estadística (1997).
[6] We had to deal with changes in the sampling unit and the valuation criterion between both surveys. In the EIA the sampling unit was the *Unidad de Clase de Actividad* (UCA), defined as a group of plants belonging to a firm that carry out the same activity. Consequently, a firm with two or more activities had two or more records in each annual dataset. In the EAE, in contrast, the sampling unit was the firm. The construction of a homogeneous firm-level panel required the split of data from 1997-2005 in order to separate manufacturing from other firm's activities, whereas 1988-1996 data were aggregated by firm. With regards to valuation, the EIA data included the value added tax (VAT), while the EAE data did not. To obtain a consistent panel we subtracted this tax from EIA data.

intermediate input consumption such as electricity, fuel and water were deflated by their individual price indices.

The estimation of capital stock was carried out applying the following equation:

$$K_{it} = K_{it_0}^{1997}(1-d_i)^{t-t_0} + \sum_{t_0+1}(I_{it}/IP_{it})(1-d_i)^{t-t_0}$$

The sub-index *i* denotes asset type (in our case, buildings or machinery and equipment), $K_{it_0}^{1997}$ is the initial asset stock measured at 1997 prices[7], $d_i$ is an asset specific decay rate, $I_{it}$ is current price investment, $IP_{it}$ is the asset specific implicit deflator (computed using BCU data[8]), and $t_0$ denotes the stock's initial year. The decay rates were defined following Oulton and Srinivasan (2003), who replicate the values used by the U.S. Bureau of Economic Analysis (BEA).

This study is based on matching manufacturing product data with detailed item-level tariff databases. Manufacturing data include a "product sheet" that contains the value of each product of the firm, and an "input sheet" with the same information for firm's intermediate inputs.

In Table A1 in the appendix we present descriptive statistics of our database.

### 3.2. Trade policy

We use a detailed tariff database compiled by the *Secretaría del MERCOSUR* for 1991-2004. It includes most-favored-nation (MFN) tariffs by eight-digit trade classification (ALADI for 1991-1994 and MERCOSUR for 1995-2004), a six-digit Harmonized System (HS) classification common to both periods, and the ISIC four-digit code. It also includes bilateral residual tariffs by item with all three MERCOSUR partners in 1991-1994, and the

[7] The surveys' asset stock information is only available for 1988, 1990 and 1997-2005. We took as starting point assets' values of the first year available for each firm.

[8] The BCU issues an investment (implicit) deflator (not sector-specific) that incorporates construction costs in the case of buildings, and a weighted average of domestically produced and imported asset prices for machinery and equipment.

(common) intra-zone tariffs between 1995 and 2004. For 1988-1990 we use data from ALADI, at a four-digit level HS classification.

The general evolution of Uruguay's trade policy between 1988 and 2004 is shown by the falling path of its MFN tariffs shown in Table 1. We construct our yearly statistics using four-digit HS class averages. We also present the standard deviation within four-digit classes and the number of HS items per year.

**Table 1: Uruguayan trade policy indicators 1988-2004**

| Year | MFN tariffs across 4-digit averages | | | Number of HS items |
|---|---|---|---|---|
| | mean | median | sd | |
| 1988 | 27.80 | 28.00 | 11.79 | 7,691 |
| 1989 | 24.61 | 24.53 | 9.43 | 7,705 |
| 1990 | 28.12 | 28.33 | 7.96 | 7,730 |
| 1991 | 21.72 | 21.67 | 7.15 | 6,522 |
| 1992 | 18.20 | 18.17 | 5.01 | 6,522 |
| 1993 | 18.20 | 18.17 | 5.01 | 6,522 |
| 1994 | 14.69 | 15.31 | 5.00 | 6,522 |
| 1995 | 10.84 | 10.67 | 6.61 | 9,099 |
| 1996 | 10.77 | 10.34 | 6.43 | 9,112 |
| 1997 | 10.85 | 10.40 | 6.14 | 9,306 |
| 1998 | 13.23 | 13.00 | 6.39 | 9,346 |
| 1999 | 13.28 | 13.00 | 6.26 | 9,376 |
| 2000 | 13.40 | 13.00 | 6.15 | 9,391 |
| 2001 | 13.13 | 12.50 | 5.93 | 9,414 |
| 2002 | 12.31 | 11.50 | 5.81 | 9,622 |
| 2003 | 12.31 | 11.50 | 5.81 | 9,622 |
| 2004 | 10.39 | 10.00 | 6.22 | 9,752 |

Source: MERCOSUR database

We observe average tariffs falling and its dispersion reducing along the period. The downward trend of tariffs reverses in 1998 due to a transitory increase in CET agreed by MERCOSUR members[9]. The variation in the number of HS items is explained by changes in the trade classification system (periodic revisions of the classification system introduce new items, expand some categories into more detailed sets with a larger number of them and collapse some others into broader categories with less items).

Exceptions and convergence to intra-zone zero tariffs are captured by the evolution of Uruguay's bilateral residual (over MFN) tariffs with its largest neighbors, Argentina and

[9] The transitory increase, applied between 1998 and 2003 to most products, implied an addition to CET of 3% in 1998-2000, 2.5% in 2001 and 1.5% in 2002-2003.

Brazil (see Table 2). It can also be observed a very high correlation between both average residual tariffs.

**Table 2: Bilateral residual tariffs with respect to Argentina and Brazil across 6-digit HS class**

| | With Argentina | | With Brazil | | |
|---|---|---|---|---|---|
| **Year** | **mean** | **median** | **mean** | **median** | **Correlation** |
| 1991 | 12.42 | 10.60 | 12.70 | 10.60 | 0.916 |
| 1992 | 8.81 | 6.63 | 9.03 | 6.63 | 0.945 |
| 1993 | 6.96 | 4.25 | 7.10 | 4.25 | 0.975 |
| 1994 | 3.74 | 1.65 | 3.76 | 1.65 | 0.994 |
| 1995 | 2.69 | 0.00 | 2.69 | 0.00 | 1.000 |
| 1996 | 2.51 | 0.00 | 2.51 | 0.00 | 1.000 |
| 1997 | 1.93 | 0.00 | 1.93 | 0.00 | 1.000 |
| 1998 | 1.28 | 0.00 | 1.28 | 0.00 | 1.000 |
| 1999 | 0.69 | 0.00 | 0.69 | 0.00 | 1.000 |
| 2000 | 0.01 | 0.00 | 0.01 | 0.00 | 1.000 |
| 2001 | 0.01 | 0.00 | 0.01 | 0.00 | 1.000 |
| 2002 | 0.01 | 0.00 | 0.01 | 0.00 | 1.000 |
| 2003 | 0.01 | 0.00 | 0.01 | 0.00 | 1.000 |
| 2004 | 0.01 | 0.00 | 0.01 | 0.00 | 1.000 |

Source: MERCOSUR database

To adequately capture the relevant product and input neighborhood we determine for each firm the set of four-digit HS classes that contain all the goods produced (used as inputs) throughout all sample years (except 2002, for which neither output nor input disaggregated information were recorded)[10]. The specific relevant tariff for firm *i* in period *t* is the simple average in period *t* of the tariffs for four-digit HS classes that encompass all items produced (used as input) by the firm across all sample years.

In Table 3 we provide descriptive statistics of MFN output and input tariff rates computing averages across firms. We observe that input tariffs were along the period lower than output tariffs, with an average correlation of 0.6 between both firm-level tariffs.

[10] Data collection was affected by the economic crisis of 2002 and INE was able to obtain the 2002 data only in 2004, along with the 2003 survey. Records for 2002 are sometimes incomplete and only aggregate variables are available at the firm level. The product set was determined for each firm using information from all years except 2002, and remained the same across years to calculate firm-specific average protection.

**Table 3: Average firm-level output and input MFN tariffs**

| Year | Output tariff | Input tariff | Correlation coefficient |
|---|---|---|---|
| 1988 | 31.82 | 26.93 | 0.52 |
| 1989 | 27.72 | 23.71 | 0.51 |
| 1990 | 30.66 | 27.38 | 0.51 |
| 1991 | 24.67 | 21.19 | 0.55 |
| 1992 | 20.27 | 17.86 | 0.56 |
| 1993 | 20.12 | 17.79 | 0.56 |
| 1994 | 16.67 | 14.23 | 0.53 |
| 1995 | 13.76 | 11.09 | 0.60 |
| 1996 | 13.61 | 10.85 | 0.62 |
| 1997 | 13.71 | 10.79 | 0.63 |
| 1998 | 15.99 | 12.95 | 0.63 |
| 1999 | 16.13 | 12.99 | 0.64 |
| 2000 | 16.19 | 13.07 | 0.63 |
| 2001 | 15.70 | 12.50 | 0.64 |
| 2002 | 14.83 | 11.61 | 0.66 |
| 2003 | 14.92 | 11.60 | 0.67 |
| 2004 | 13.02 | 10.06 | 0.64 |

Source: INE manufacturing database and MERCOSUR trade database

In summary, capturing the political economic features of trade policy determination, it is always the case that average protection measured at firm level is higher than averages over the complete set of trade classification items (see tables 1 and 3). Comparison of the evolution of trade protection measures with respect to Uruguay's neighbors and the rest of the world shows distinct periods of trade policy (see tables 1 and 2). First, before 1995, both protection *vis a vis* the region and the rest of the world were falling ("open regionalism"), hence preferences for Brazil and Argentina did not change significantly. Between 1995 and 2000, convergence to the CET led MFN tariff to remain fairly constant or even increase, while the residual bilateral tariffs fell sharply, hence bilateral preferences increased considerably[11]. In the final period in our data -after 2000- intrazone tariffs are zero, while the action in the CET (MFN tariff) is very little.

[11] This broadly corresponds to the schedule negotiated in Ouro Preto in 1994.

## 4. Results

### 4.1. Productivity estimation

Table 4 presents the results for the estimation using the gross revenue version of Levinsohn-Petrin (2003) methodology (LP) for the whole sample. We also estimated separately the production function parameters within the following seven groups of two-digit ISIC sectors: Food, beverages and tobacco (Sector 1), Textiles and apparel (Sector 2), Wood, paper and print (Sector 3), Carbon, oil, chemical, rubber and plastic (Sector 4), Basic metal and metal product industries (Sector 5), Machinery, equipment and automobile (Sector 6) and Other (Sector 7)[12], obtaining similar results (see Table A5 in the appendix)[13].

We also undertook OLS and within-group estimations of the gross revenue production function (see Table A6 in the appendix). As expected, in the OLS case the estimated labor coefficients are higher and those of capital somewhat smaller than the LP estimates.

**Table 4: Production function:**
**Levinsohn-Petrin estimates 1988-2005**
**(dependent variable: gross deflated revenue)**

| Variable | Coefficient |
|---|---|
| Labor | 0.311*** |
| | (0.0163) |
| Materials | 0.536*** |
| | (0.0141) |
| Capital (machinery) | 0.130*** |
| | (0.0373) |
| Observations | 12,992 |
| Returns to scale | 0.977 |
| Wald CRS (p-value) | 0.795 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Using the firm-level productivity measures obtained, we describe the TFP evolution in each sector by computing mean levels, using weighted averages:

[12] The following ISIC3 divisions correspond to each sector: Sector 1: 15 and 16, Sector 2: 17 to 19, Sector 3: 20 to 22, Sector 4: 23 to 25, Sector 5: 27 and 28, Sector 6: 29 to 35, Sector 7: 26, 36 and 37.
[13] We also run the value added version of the LP estimator (results not reported), obtaining generally high by-sector correlations between gross revenue and value added TFP estimations.

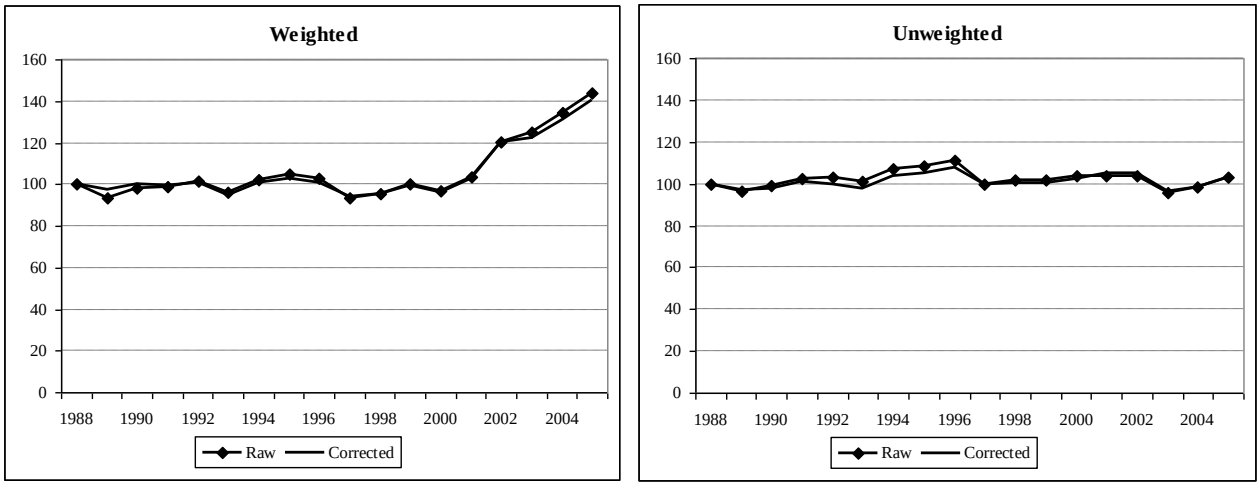
$$tfp_t^j = \sum_i \varphi_{it}^j tfp_{it}^j$$

where $\varphi_{it}^j$ is firm *i*'s share in sector *j*'s value added. We also compute the yearly unweighted means.

We present in what follows brief descriptive evidence on TFP evolution in the period under analysis. We take the differences in (mean) logarithms of TFP as growth rates of TFP levels and construct indices based on the first year in our sample. Since our data combines samples, we construct corrected differences using continuers and exiting firms of period *t-1* and continuers and born firms of period *t* (hence excluding firms entering the sample due to composition changes or firms temporarily not present in the sample due to omitted responses).

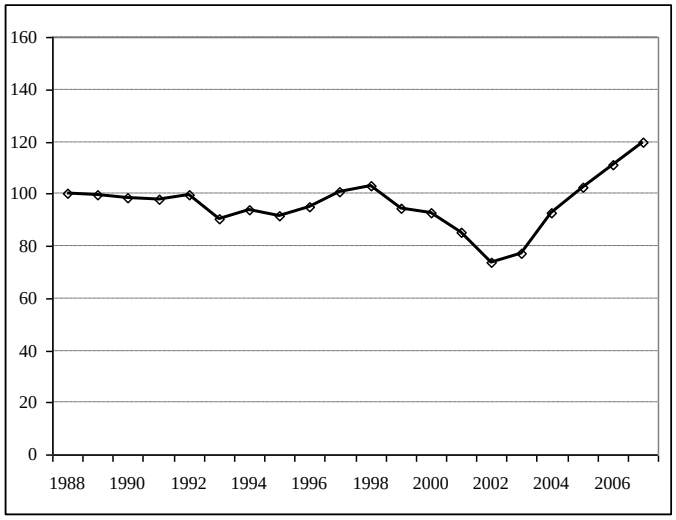
Figure 1 shows an only slightly increasing pattern of TFP in the first half of the 1990's decade. This increase is smoother than the one obtained by Casacuberta et al. (2004), who report an average annual TFP growth of 3% in 1988-1995 using Levinsohn-Petrin and Olley-Pakes methodologies. Mean TFP shows a sharp increase since 2000 when considering value added weighted data, while unweighted data display a much smoother path. Raw and composition-corrected data show similar behaviors.

**Figure 1: Mean TFP levels index 1988-2005 (1988=100)**
**Raw and composition corrected values, weighted and unweighted**



An exercise of constructing TFP measures using Törnqvist indices and aggregate data for manufacturing also provides a similar picture[14]. This pattern resembles as well the path of aggregate real manufacturing GDP (Figure 2). In the appendix we present the evolution of sector TFP where more heterogeneity is observed (see figure A1).

**Figure 2: Real Manufacturing GDP Uruguay 1988-2007**
**(index 1988=100)**




Source: Central Bank of Uruguay

### 4.2. The effect of trade policy on productivity

In tables 5 to 9 we present our second step fixed effects estimations[15]. First, we carried out firm level regressions of TFP on firm-specific output and input tariffs. In Table 5 we report the results obtained considering only MFN tariffs (period 1988-2004).

These results show that a reduction in output tariffs has a positive effect on Uruguayan firms' productivity. A fall in final goods tariffs of ten percentage points brings about a 5 percent increase in TFP. We consider time and sector dummy variables, hence we can read off the firm-specific effects. Sectors are defined at a four-digit ISIC level and correspond for each firm to the product with the highest share in yearly gross output (hence firms may change sector).

We also observe that firm-specific input tariffs have a positive effect on TFP, i.e. higher protection is associated with higher productivity. An increase in input tariffs of ten

[14] Carracelas et al. (2009).
[15] Robust (White) standard errors are reported in our second step regressions.

percentage points brings about a nearly 4 percent increase in productivity. When we incorporate the indicator of input importing firms (columns 3 and 4) the tariffs' impacts do not vary considerably; we obtain a significant and negative coefficient in the importing indicator (*FM*), while the coefficient of *FM* interacted with input tariff is not significant. There may be some concern as to the import status of the firm being endogenous to protection. An alternative would be to use the initial import status of the firm, though this is not compatible with our estimation method.

**Table 5: Fixed effects firm level regressions on firm-specific MFN tariffs 1988-2004 (dependent variable: $lnTFP_{it}$)**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| MFN output tariff | -0.495*** | -0.592*** | -0.565*** | -0.550*** |
| | (0.172) | (0.184) | (0.183) | (0.183) |
| MFN input tariff | | 0.411* | 0.386* | 0.355 |
| | | (0.226) | (0.226) | (0.227) |
| FM | | | -0.0349*** | -0.0560*** |
| | | | (0.0125) | (0.0217) |
| Input tariff * FM | | | | 0.139 |
| | | | | (0.127) |
| Time dummies | yes | yes | yes | yes |
| Sector dummies | yes | yes | yes | yes |
| Observations | 12,043 | 12,024 | 11,979 | 11,979 |

FM=1 for input importing firms
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The inclusion of additional controls (Herfindahl index, alternative input importing indicators[16], exporting indicators, exit dummy) does not change these results (see Table A7 in the appendix).

While Muendler (2004) finds that the use of foreign inputs plays only a minor role in productivity change, Amiti and Konings (2007) find large productivity effects from reducing input tariffs and argue that importers gain from higher-quality or new varieties of foreign inputs and/or learning effects.

Our data on imported inputs only include those directly imported by the firm, excluding inputs of foreign origin supplied by commercial firms domestically. Hence our input

[16] We considered two alternative importing indicators: a dummy variable equal to one for input importing firms (*FM*), and the share of imports in firm's total inputs (*import share*). Results reported in tables 5 to 9 correspond to the *FM* indicator.

importer status only refers to direct imports. Direct input importers are more frequently large firms and, given our CRS results, they may not be the most productive (in fact, correlation between labor and TFP is very low).

In Table 6 we present the results obtained when adding into the equation bilateral residual tariffs with Brazil (the sample period is now 1991-2004)[17]. The inclusion of bilateral tariffs does not affect MFN output tariff coefficients' sign or significance, although their values increase slightly. On the other hand, the coefficient of MFN input tariff remains positive but it is not significant. Regarding bilateral tariffs themselves, the results obtained indicate that a reduction in output bilateral tariff has a negative impact on firms' productivity, while input bilateral tariffs do not show a significant effect (see Table A8 in the appendix for additional results)[18]. Yearly correlations between bilateral and MFN tariffs are above 0.65 before 2000 and drop to almost zero afterward.

The results seem to suggest that reducing protection with respect to Brazil did not impact firm's productivity. Our measurement of firm-specific protection rules out the possibility that Uruguayan firms could have isolated themselves from intra-zone tariff cuts through exceptions to tariff reductions schedules. Though firm-specific protection remains higher than across the board averages, it follows the same descending path and converges to zero with little delay wit respect to aggregate protection. However, the overall result may be related to the fact that trade liberalization followed a discriminatory pattern after the initial coincidence of openness with respect to the region and to the rest of the world. After 1995 bilateral preferences increased, while openness with respect to the rest of the world remained basically unchanged. This may have implied some degree of trade diversion in the context of the customs union process, which could explain the lack of clear productivity effects of reducing bilateral protection.

[17] Bilateral residual tariff data are only available for 1991-2004. Since Uruguay's bilateral tariffs with Argentina and with Brazil were highly correlated during the period under study, we consider only one of them in our regressions.

[18] We considered, additionally, model specifications that included only bilateral residual tariffs (results not reported). Both output and input bilateral tariffs turned out to be not significant.

**Table 6: Fixed effects firm level regressions on firm-specific MFN tariffs and bilateral residual tariffs 1991-2004**
**(dependent variable: $lnTFP_{it}$)**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| MFN output tariff | -0.593** | -0.720** | -0.634** | -0.596** |
| | (0.262) | (0.297) | (0.295) | (0.296) |
| MFN input tariff | | 0.453 | 0.405 | 0.232 |
| | | (0.430) | (0.431) | (0.450) |
| Bilateral tariff-Brazil output | 0.351* | 0.335* | 0.305 | 0.289 |
| | (0.183) | (0.188) | (0.187) | (0.188) |
| Bilateral tariff-Brazil input | | 0.0864 | 0.0815 | 0.163 |
| | | (0.254) | (0.254) | (0.326) |
| FM | | | -0.0412*** | -0.148*** |
| | | | (0.0129) | (0.0352) |
| Input tariff * FM | | | | 0.875*** |
| | | | | (0.292) |
| Bilateral tariff-Brazil input * FM | | | | -0.257 |
| | | | | (0.277) |
| Time dummies | yes | yes | yes | yes |
| Sector dummies | Yes | yes | yes | yes |
| Observations | 9,971 | 9,963 | 9,918 | 9,918 |

FM=1 for input importing firms
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

### *Alternative specifications and controls*

To control for the robustness of our results we run separate regressions (results not reported) for the pre and post MERCOSUR periods (1988-1994 and 1995-2004). We found that the output MFN tariff effect vanishes after 1994, while the negative effect of lower input MFN tariff increases post MERCOSUR (both in terms of coefficient's value and significance). Input bilateral tariffs have also a stronger impact on productivity in the post MERCOSUR period.

In order to address a possible endogeneity problem regarding protection measures being dependent on a changing product mix, we calculated firm's average tariffs considering the product (input) basket of items produced (used as input) by the firm in its first sample year, instead of considering a fixed product (input) set of all items produced (used as input) by the firm in the period of study. The results obtained when using this alternative protection measure are reported in Table A9 in the appendix. We do not find changes in the MFN output tariff coefficients' signs or significance, though their values are smaller (a ten

percentage points fall in output tariff now implies a 4 percent increase in firms' productivity), whereas the impact of MFN input tariffs is not significant. The negative effect of lower output bilateral tariffs is stronger in this case.

The general results obtained regarding the effect of input tariffs on productivity can be interpreted in the framework of the effective protection analysis proposed by Corden (1971). According to this author, lower input tariffs could increase effective protection, reducing firms' incentives to shift to more efficient production techniques. To check this hypothesis we followed Amiti and Konings (2007) computing the effective rate of protection for each firm as:

$$erp_{it} = \frac{\left(tariff_{it}^{FG} - a_{it}\, tariff_{it}^{II}\right)}{\left(1 - a_{it}\right)}$$

where $a_{it}$ is the ratio of inputs to output for firm *i* at time *t*.

This indicator, developed by Corden (1971), measures the net effect of tariffs on intermediate inputs and final goods. A lower output tariff decreases the protection that firm *i* receives, whereas a lower input tariff increases this protection by reducing the cost of final goods production. Lower effective protection -generated by lower output tariffs, higher input tariffs or changes in input intensity- would increase productivity, while higher protection would have the opposite effect.

In Table 7 we present the results obtained when including the effective protection indicator in our second step estimates. The effect of this variable on firms' productivity turns out to be negative and significant, implying that a fall in effective protection leads to an increase in productivity. When we control for output and input tariffs (column 7) the impact of effective protection persists but tariffs are not significant. This result could be explained by the fact that the effective protection measure is already capturing the effect of both output and input tariffs, that is ultimately the one firms receive (i.e. most firms are affected by both types of tariffs, direct and/or indirectly).

**Table 7: Fixed effects firm level regressions on effective protection 1988-2004 (dependent variable: $lnTFP_{it}$)**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| Effective protection | -0.248*** | -0.247*** | -0.246*** | -0.245*** | -0.246*** | -0.246*** | -0.260*** |
| | (0.0555) | (0.0554) | (0.0551) | (0.0550) | (0.0551) | (0.0552) | (0.0678) |
| FM | | -0.0261** | -0.0264** | -0.0250* | -0.0265** | -0.0259** | -0.0607*** |
| | | (0.0132) | (0.0131) | (0.0132) | (0.0131) | (0.0131) | (0.0232) |
| Herfindahl index | | | 0.234*** | 0.234*** | 0.234*** | 0.233*** | |
| | | | (0.0566) | (0.0566) | (0.0566) | (0.0566) | |
| Exporting dummy | | | | -0.0147 | | | |
| | | | | (0.0149) | | | |
| Export share | | | | | 0.00269 | 0.00285 | |
| | | | | | (0.00902) | (0.00902) | |
| Exit | | | | | | 0.0269 | |
| | | | | | | (0.0226) | |
| MFN output tariff | | | | | | | 0.133 |
| | | | | | | | (0.226) |
| MFN input tariff | | | | | | | 0.136 |
| | | | | | | | (0.255) |
| Input tariff * FM | | | | | | | 0.229* |
| | | | | | | | (0.131) |
| Time dummies | yes | yes | yes | yes | yes | yes | yes |
| Sector dummies | yes | yes | yes | yes | yes | yes | yes |
| Observations | 9,849 | 9,849 | 9,849 | 9,849 | 9,849 | 9,849 | 9,849 |

FM=1 for input importing firms
Exit=1 if firm exits in t+1
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In order to compare the firm-specific protection measures' results with those obtained when protection is measured in the traditional way, i.e. averaging tariffs by the ISIC class in which the firm is classified, we regressed firms' TFP on four-digit ISIC class average tariffs. The results obtained, reported in Table 8, show that the effect of average sector tariffs on productivity is similar, regarding coefficients' signs, than that of firm-specific output tariffs, but they turn out to be not significant. Input importing indicators still reflect a negative impact on TFP.

**Table 8: Fixed effects firm level regressions on sector average MFN tariffs 1988-2004 (dependent variable: $lnTFP_{it}$)**

| | (1) | (2) | (3) |
|---|---|---|---|
| MFN tariff | -0.354 | -0.343 | -0.408 |
| | (0.689) | (0.688) | (0.674) |
| FM | | -0.0368* | -0.0780 |
| | | (0.0193) | (0.0495) |
| MFN tariff*FM | | | 0.227 |
| | | | (0.253) |
| Time dummies | yes | yes | yes |
| Sector dummies | yes | yes | yes |
| Observations | 12,169 | 12,111 | 12,111 |

FM=1 for input importing firms
Robust standard errors (clustered by four-digit ISIC sector) in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The effect of bilateral residual tariffs, when introduced in average protection regressions, can be assessed from the results reported in Table 9. Compared to the results obtained using firm-specific protection measures, the impact of bilateral tariffs is weaker[19].

**Table 9: Fixed effects firm level regressions on sector average MFN tariffs and bilateral residual tariffs 1991-2004 (dependent variable: $lnTFP_{it}$)**

| | (1) | (2) | (3) |
|---|---|---|---|
| MFN tariff | 0.444 | 0.496 | 0.302 |
| | (0.498) | (0.497) | (0.519) |
| Bilateral tariff-Brazil | -0.503 | -0.461 | -0.478 |
| | (0.464) | (0.459) | (0.469) |
| FM | | -0.0414** | -0.126** |
| | | (0.0180) | (0.0562) |
| MFN tariff*FM | | | 0.544* |
| | | | (0.309) |
| Bilateral tariff-Brazil * FM | | | 0.00697 |
| | | | (0.276) |
| Time dummies | yes | yes | yes |
| Sector dummies | yes | yes | yes |
| Observations | 10,024 | 9,966 | 9,966 |

FM=1 for input importing firms
Robust standard errors (clustered by four-digit ISIC sector) in parentheses
*** p<0.01, ** p<0.05, * p<0.1

When TFP estimation is based on deflated revenues, like in this case, changes in measured productivity may reflect both efficiency effects and changes in mark up. In order to provide some evidence on this issue we added a sector Herfindahl index (sum of squared shares) calculated on firm revenues to our second step regressions (see tables A7, A8 and

[19] For additional results see Table A10 in the appendix.

A10 in the appendix). The coefficient was positive and significant; however, none of the signs, magnitudes or significances of tariff coefficients was affected.

With respect to tariff exogeneity and the role of political economic considerations, as it was pointed out in Section 2 if firms were really not capable of influencing the tariffs that affect their specific products (or inputs), firm-specific tariffs should not fall substantially slower than sector averages do. In tables A2 and A4 in the appendix it can be seen that it is generally the case that average firm-specific protection is higher than sector-level protection. We computed for each firm the difference between its own specific output protection and that corresponding to its sector. In Table A4 we report the average differences by sector/year. Overall, such differences are positive though not particularly large, except for some sectors -like Sector 3- where differences are of several percentage points.

## 5. Conclusions

The data point to a significant impact of protection as measured by MFN tariffs on Uruguayan firms' TFP. Output tariff reductions significantly enhance productivity. A feature of this paper is to introduce an independent effect of input protection. Our measured effects when considering MFN input tariffs on their own are negative, though not statistically significant in most of the model specifications considered. Moreover, input importing firms are less productive on the average, and the interaction of importer status with lower protection has a negative effect on productivity.

This effect can be interpreted according to effective protection analysis (Corden, 1971), in the sense that lower input tariffs could lead to increased effective protection and less incentives to shift to more efficient production techniques. Separate estimations integrating input and output protection measures in a single combined effective protection indicator confirm this.

Reductions in bilateral output tariffs *vis a vis* the MERCOSUR partners do not seem to have a productivity enhancing effect. On the other hand, input protection reductions with the MERCOSUR partners increase productivity. This can be seen as a sign of the

ambiguous effect of discriminatory openness processes, since for different time sub-periods openness with respect to the region and to the rest of the world did not coincide in Uruguay.

A relevant feature of this paper is using firm-specific protection measures. As tariffs were measured averaging items in the four-digit HS classes of products in the neighborhood of the firm's product set, the results were compared to those obtained when protection was measured in the traditional way, i.e. averaging tariffs for the positions in the ISIC class in which the firm is classified according to its main products. In our case the average protection effect weakens in second step TFP regressions. This seems to reinforce the importance of obtaining protection measures that reflect more closely the firms' specific markets.

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# Appendix

## Table A1: Manufacturing database - Descriptive statistics (logs)

| Year | Observations | Gross revenue | | Value added | | Materials | | Capital | | Labor | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mean | sd | mean | sd | mean | sd | mean | sd | mean | sd |
| 1988 | 992 | 16,27 | 1,75 | 15,41 | 1,82 | 15,09 | 1,95 | 13,45 | 2,21 | 3,86 | 1,24 |
| 1989 | 737 | 16,38 | 1,84 | 15,52 | 1,86 | 15,21 | 2,02 | 13,58 | 2,36 | 3,98 | 1,33 |
| 1990 | 715 | 16,41 | 1,81 | 15,55 | 1,91 | 15,23 | 1,99 | 13,58 | 2,31 | 3,99 | 1,30 |
| 1991 | 733 | 16,34 | 1,80 | 15,48 | 1,92 | 15,06 | 2,02 | 13,44 | 2,32 | 3,88 | 1,29 |
| 1992 | 725 | 16,34 | 1,80 | 15,45 | 1,89 | 15,07 | 2,05 | 13,53 | 2,31 | 3,86 | 1,28 |
| 1993 | 762 | 16,37 | 1,76 | 15,43 | 1,78 | 15,16 | 2,00 | 13,53 | 2,32 | 3,84 | 1,26 |
| 1994 | 791 | 16,37 | 1,82 | 15,44 | 1,84 | 15,12 | 2,08 | 13,39 | 2,40 | 3,78 | 1,27 |
| 1995 | 814 | 16,36 | 1,86 | 15,43 | 1,83 | 15,07 | 2,19 | 13,40 | 2,41 | 3,76 | 1,28 |
| 1996 | 828 | 16,45 | 1,87 | 15,57 | 1,82 | 15,14 | 2,20 | 13,37 | 2,44 | 3,75 | 1,31 |
| 1997 | 1,333 | 16,10 | 1,72 | 15,08 | 1,67 | 15,06 | 1,93 | 13,23 | 2,27 | 3,39 | 1,18 |
| 1998 | 1,003 | 16,39 | 1,77 | 15,30 | 1,73 | 15,40 | 1,91 | 13,70 | 2,30 | 3,49 | 1,29 |
| 1999 | 982 | 16,30 | 1,81 | 15,23 | 1,81 | 15,29 | 1,95 | 13,73 | 2,31 | 3,42 | 1,32 |
| 2000 | 976 | 16,29 | 1,87 | 15,28 | 1,87 | 15,24 | 2,05 | 13,70 | 2,36 | 3,36 | 1,37 |
| 2001 | 950 | 16,17 | 1,86 | 15,23 | 1,90 | 15,06 | 2,05 | 13,57 | 2,37 | 3,29 | 1,30 |
| 2002 | 1,029 | 16,18 | 1,85 | 15,17 | 1,85 | 15,20 | 2,04 | 13,58 | 2,32 | 3,17 | 1,26 |
| 2003 | 1,031 | 16,19 | 1,85 | 15,02 | 1,86 | 15,29 | 2,08 | 13,49 | 2,36 | 3,30 | 1,23 |
| 2004 | 947 | 16,36 | 1,85 | 15,16 | 1,89 | 15,48 | 2,09 | 13,48 | 2,43 | 3,38 | 1,27 |
| 2005 | 978 | 16,47 | 1,80 | 15,35 | 1,81 | 15,55 | 2,06 | 13,47 | 2,44 | 3,47 | 1,26 |

Source: INE manufacturing database

## Table A2: Firm-specific average output tariffs

| Year | All | Sector 1 | Sector 2 | Sector 3 | Sector 4 | Sector 5 | Sector 6 | Sector 7 |
|---|---|---|---|---|---|---|---|---|
| 1988 | 31.82 | 33.10 | 35.48 | 33.80 | 25.47 | 27.76 | 26.26 | 35.67 |
| 1989 | 27.72 | 28.19 | 30.05 | 29.72 | 23.84 | 24.62 | 24.10 | 31.24 |
| 1990 | 30.66 | 31.36 | 32.85 | 31.85 | 27.05 | 27.96 | 27.55 | 33.77 |
| 1991 | 24.67 | 24.50 | 27.14 | 25.88 | 22.27 | 22.36 | 21.50 | 26.74 |
| 1992 | 20.27 | 20.26 | 21.89 | 21.31 | 18.60 | 18.55 | 18.16 | 21.68 |
| 1993 | 20.12 | 20.11 | 21.62 | 21.05 | 18.43 | 18.41 | 18.03 | 21.60 |
| 1994 | 16.67 | 16.79 | 17.73 | 17.79 | 14.86 | 15.25 | 14.91 | 18.08 |
| 1995 | 13.76 | 12.87 | 18.06 | 10.74 | 11.81 | 12.16 | 10.59 | 14.70 |
| 1996 | 13.61 | 12.54 | 17.85 | 10.55 | 11.69 | 11.92 | 10.95 | 14.57 |
| 1997 | 13.71 | 13.36 | 17.96 | 10.74 | 11.68 | 13.05 | 11.72 | 14.68 |
| 1998 | 15.99 | 16.12 | 20.23 | 12.14 | 14.12 | 15.11 | 14.30 | 16.56 |
| 1999 | 16.13 | 16.15 | 20.22 | 13.33 | 14.23 | 15.10 | 14.84 | 16.16 |
| 2000 | 16.19 | 16.25 | 20.12 | 13.36 | 14.46 | 15.37 | 14.66 | 16.12 |
| 2001 | 15.70 | 15.76 | 19.76 | 13.13 | 13.91 | 15.12 | 14.85 | 15.67 |
| 2002 | 14.83 | 15.09 | 18.67 | 11.28 | 13.26 | 14.47 | 14.42 | 14.24 |
| 2003 | 14.92 | 15.11 | 18.67 | 12.12 | 13.29 | 14.64 | 14.26 | 14.25 |
| 2004 | 13.02 | 13.65 | 16.99 | 9.54 | 11.77 | 12.12 | 11.19 | 12.45 |

**Table A3: 4-digit ISIC sector average tariffs**

| Year | All | Sector 1 | Sector 2 | Sector 3 | Sector 4 | Sector 5 | Sector 6 | Sector 7 |
|---|---|---|---|---|---|---|---|---|
| 1988 | 28.72 | 35.83 | 34.84 | 32.88 | 23.52 | 26.95 | 23.81 | 31.21 |
| 1989 | 25.46 | 30.85 | 29.46 | 29.70 | 21.38 | 24.22 | 22.20 | 27.51 |
| 1990 | 28.68 | 33.35 | 32.14 | 32.35 | 25.05 | 27.12 | 25.94 | 30.52 |
| 1991 | 22.39 | 25.56 | 26.46 | 25.39 | 20.59 | 21.18 | 19.66 | 24.06 |
| 1992 | 18.67 | 20.95 | 21.52 | 21.15 | 17.42 | 17.75 | 16.82 | 19.84 |
| 1993 | 18.66 | 20.95 | 21.48 | 20.78 | 17.40 | 17.77 | 16.81 | 19.83 |
| 1994 | 15.06 | 17.22 | 17.67 | 17.36 | 13.89 | 14.20 | 13.54 | 16.37 |
| 1995 | 10.06 | 14.46 | 17.94 | 10.03 | 9.17 | 11.74 | 8.09 | 11.02 |
| 1996 | 10.04 | 14.19 | 17.88 | 9.94 | 9.25 | 11.83 | 8.31 | 10.80 |
| 1997 | 10.26 | 14.17 | 17.75 | 10.02 | 9.61 | 11.54 | 9.17 | 10.62 |
| 1998 | 12.39 | 16.91 | 20.43 | 12.03 | 11.51 | 14.23 | 10.87 | 12.77 |
| 1999 | 12.49 | 16.92 | 20.27 | 12.18 | 11.55 | 14.35 | 11.24 | 12.72 |
| 2000 | 12.65 | 16.95 | 20.29 | 12.08 | 12.17 | 14.07 | 11.70 | 12.66 |
| 2001 | 12.52 | 16.43 | 19.83 | 12.14 | 11.67 | 13.99 | 12.20 | 12.19 |
| 2002 | 11.86 | 15.56 | 18.84 | 11.08 | 10.88 | 13.15 | 11.78 | 11.95 |
| 2003 | 11.87 | 15.55 | 18.84 | 11.18 | 10.88 | 13.14 | 11.80 | 11.89 |
| 2004 | 9.74 | 14.11 | 17.35 | 9.39 | 9.64 | 10.71 | 8.07 | 10.11 |

**Table A4: Average difference between firm-specific output tariff and sector average tariffs**

| Year | All | Sector 1 | Sector 2 | Sector 3 | Sector 4 | Sector 5 | Sector 6 | Sector 7 |
|---|---|---|---|---|---|---|---|---|
| 1988 | 0.14 | -0.85 | -0.86 | 3.75 | 0.66 | 1.31 | -0.09 | 0.76 |
| 1989 | 0.00 | -0.74 | -0.73 | 2.81 | 0.60 | 1.02 | -0.37 | 0.50 |
| 1990 | 0.07 | -0.54 | -0.42 | 2.08 | 0.50 | 1.08 | -0.34 | 0.42 |
| 1991 | 0.00 | -0.55 | 0.21 | 2.39 | -0.23 | -2.02 | 0.36 | 0.20 |
| 1992 | 0.01 | -0.35 | 0.10 | 1.79 | -0.06 | -1.48 | 0.38 | 0.00 |
| 1993 | -0.04 | -0.51 | 0.05 | 1.93 | -0.09 | -1.38 | 0.41 | -0.11 |
| 1994 | 0.01 | -0.15 | 0.00 | 1.09 | -0.09 | -1.09 | 0.55 | -0.18 |
| 1995 | 0.38 | -0.22 | -0.10 | 3.28 | 0.48 | -0.96 | 1.68 | 0.01 |
| 1996 | 0.36 | -0.28 | -0.16 | 3.13 | 0.43 | -1.10 | 1.90 | 0.21 |
| 1997 | 0.69 | 0.05 | -0.12 | 3.79 | 0.30 | -0.23 | 1.95 | 0.86 |
| 1998 | 0.55 | -0.17 | -0.21 | 3.68 | 0.18 | 0.07 | 2.22 | 0.45 |
| 1999 | 0.72 | -0.18 | -0.08 | 4.84 | 0.31 | -0.01 | 2.31 | 0.16 |
| 2000 | 0.69 | -0.12 | -0.12 | 4.76 | 0.29 | -0.06 | 1.88 | 0.63 |
| 2001 | 0.73 | -0.10 | -0.20 | 4.53 | 0.32 | -0.37 | 2.04 | 0.60 |
| 2002 | 0.58 | 0.06 | -0.09 | 3.31 | 0.39 | -0.35 | 1.83 | 0.02 |
| 2003 | 0.67 | 0.08 | -0.08 | 4.15 | 0.31 | -0.16 | 1.64 | 0.23 |
| 2004 | 0.59 | 0.17 | -0.16 | 3.08 | 0.46 | -0.33 | 1.78 | 0.00 |

**Table A5: Production function Levinsohn-Petrin sector estimates 1988-2005 (dependent variable: gross deflated revenue)**

| Variable | Sector 1 | Sector 2 | Sector 3 | Sector 4 | Sector 5 | Sector 6 | Sector 7 |
|---|---|---|---|---|---|---|---|
| Labor | 0.257*** | 0.253*** | 0.437*** | 0.506*** | 0.342*** | 0.394*** | 0.370*** |
| | (0.0313) | (0.0304) | (0.0812) | (0.0349) | (0.0511) | (0.0384) | (0.0684) |
| Materials | 0.576*** | 0.550*** | 0.561*** | 0.510*** | 0.510*** | 0.549*** | 0.393*** |
| | (0.0301) | (0.0327) | (0.0698) | (0.0278) | (0.0478) | (0.0276) | (0.0467) |
| Capital (machinery) | 0.0800* | 0.0100 | 0.0300 | 0.170** | 0.0100 | 0.160** | 0.160*** |
| | (0.0460) | (0.0840) | (0.0697) | (0.0702) | (0.0469) | (0.0667) | (0.0509) |
| Observations | 3,621 | 2,748 | 1,103 | 2,148 | 880 | 1,483 | 1,009 |
| Returns to scale | 0.913 | 0.813 | 1.028 | 1.186 | 0.862 | 1.103 | 0.923 |
| Wald CRS (p-value) | 0.497 | 0.155 | 0.476 | 0.001 | 0.423 | 0.095 | 0.431 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Table A6: Production function OLS and within-group estimates 1988-2005 (dependent variable: gross deflated revenue)**

| Variables | OLS | Within-group |
|---|---|---|
| Labor | 0.416*** | 0.427*** |
| | (0.00900) | (0.0123) |
| Materials | 0.553*** | 0.439*** |
| | (0.00724) | (0.0103) |
| Capital (machinery) | 0.0715*** | 0.0391*** |
| | (0.00324) | (0.00594) |
| Observations | 13,152 | 13,152 |
| Time dummies | yes | yes |
| Sector dummies | yes | yes |
| R-squared | 0.934 | 0.676 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

## Figure A1. TFP Evolution by sector - Unweighted (indices 1988=100)

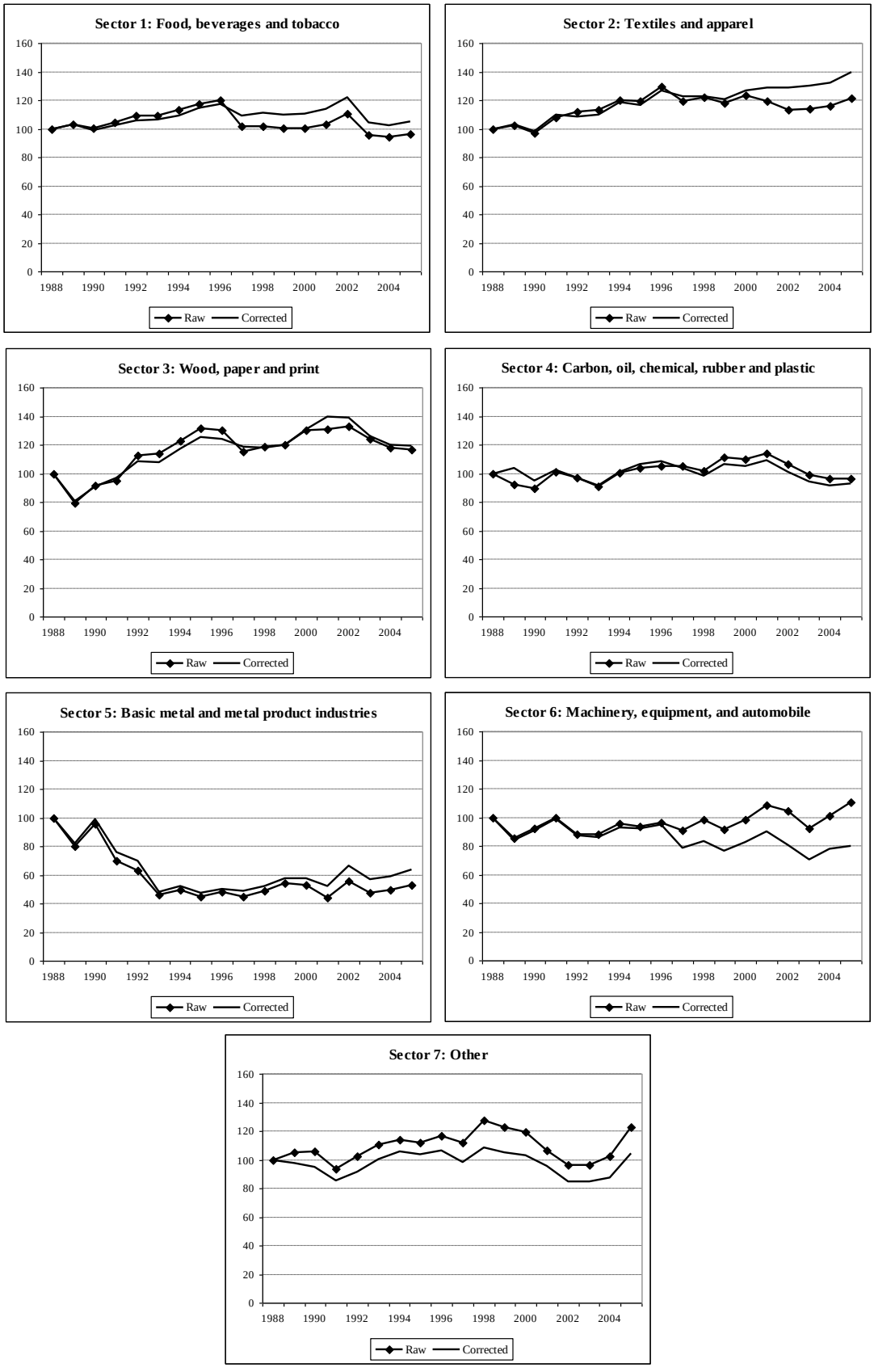

**Table A7: Fixed effects firm level regressions on firm-specific MFN tariffs 1988-2004**
**(dependent variable: $lnTFP_{it}$)**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| MFN output tariff | -0.521*** | -0.412** | -0.415** | -0.573*** | -0.573*** | -0.546*** | -0.429** | -0.433** | -0.433** |
| | (0.183) | (0.184) | (0.185) | (0.183) | (0.183) | (0.183) | (0.184) | (0.184) | (0.184) |
| MFN input tariff | 0.328 | 0.279 | 0.270 | 0.404* | 0.402* | 0.377* | 0.319 | 0.311 | 0.312 |
| | (0.227) | (0.228) | (0.228) | (0.226) | (0.226) | (0.226) | (0.227) | (0.227) | (0.227) |
| FM | -0.0567*** | -0.0458** | -0.0502** | | | | | | |
| | (0.0217) | (0.0216) | (0.0217) | | | | | | |
| Input tariff * FM | 0.148 | 0.132 | 0.136 | | | | | | |
| | (0.126) | (0.126) | (0.126) | | | | | | |
| Herfindahl index | 0.267*** | 0.282*** | 0.283*** | | | 0.270*** | 0.284*** | 0.285*** | 0.285*** |
| | (0.0525) | (0.0526) | (0.0526) | | | (0.0526) | (0.0527) | (0.0528) | (0.0528) |
| Exporting dummy | | -0.0377*** | | | | | -0.0409*** | | |
| | | (0.0138) | | | | | (0.0139) | | |
| Export share | | | -0.00394 | | | | | -0.00494 | -0.00489 |
| | | | (0.00836) | | | | | (0.00832) | (0.00832) |
| Import share | | | | 0.00005 | -0.00489 | -0.00555 | -0.00559 | -0.00541 | -0.00539 |
| | | | | (0.000136) | (0.00404) | (0.00399) | (0.00389) | (0.00393) | (0.00392) |
| Input tariff *import share | | | | | 0.0253 | 0.0291 | 0.0293 | 0.0284 | 0.0283 |
| | | | | | (0.0205) | (0.0202) | (0.0197) | (0.0199) | (0.0199) |
| Exit | | | | | | | | | 0.00476 |
| | | | | | | | | | (0.0224) |
| Time dummies | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Sector dummies | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Observations | 11,979 | 11,927 | 11,927 | 11,979 | 11,979 | 11,979 | 11,927 | 11,927 | 11,927 |

FM=1 for input importing firms
Exit=1 if firm exits in t+1
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Table A8: Fixed effects firm level regressions on firm-specific MFN tariffs and bilateral residual tariffs 1991-2004 (dependent variable: $lnTFP_{it}$)**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| MFN output tariff | -0.520* | -0.427 | -0.434 | -0.647** | -0.567* | -0.488* | -0.393 | -0.400 | -0.402 |
| | (0.296) | (0.295) | (0.294) | (0.295) | (0.295) | (0.295) | (0.293) | (0.293) | (0.293) |
| MFN input tariff | 0.199 | 0.117 | 0.105 | 0.409 | 0.514 | 0.481 | 0.396 | 0.373 | 0.374 |
| | (0.449) | (0.449) | (0.449) | (0.432) | (0.442) | (0.441) | (0.440) | (0.439) | (0.439) |
| Bilateral tariff-Brazil output | 0.283 | 0.223 | 0.232 | 0.314* | 0.303 | 0.296 | 0.235 | 0.245 | 0.247 |
| | (0.188) | (0.187) | (0.187) | (0.187) | (0.187) | (0.186) | (0.185) | (0.185) | (0.186) |
| Bilateral tariff-Brazil input | 0.120 | 0.195 | 0.145 | 0.0398 | 0.00469 | -0.0357 | 0.0520 | 0.00898 | 0.0113 |
| | (0.326) | (0.328) | (0.328) | (0.254) | (0.276) | (0.276) | (0.277) | (0.276) | (0.276) |
| FM | -0.143*** | -0.132*** | -0.134*** | | | | | | |
| | (0.0352) | (0.0350) | (0.0350) | | | | | | |
| Input tariff * FM | 0.830*** | 0.788*** | 0.752** | | | | | | |
| | (0.292) | (0.292) | (0.293) | | | | | | |
| Bilateral tariff-Brazil input * FM | -0.220 | -0.194 | -0.144 | | | | | | |
| | (0.276) | (0.277) | (0.278) | | | | | | |
| Herfindahl index | 0.229*** | 0.245*** | 0.249*** | | | 0.234*** | 0.250*** | 0.253*** | 0.253*** |
| | (0.0543) | (0.0546) | (0.0547) | | | (0.0542) | (0.0546) | (0.0546) | (0.0547) |
| Exporting dummy | | -0.0191 | | | | | -0.0221 | | |
| | | (0.0148) | | | | | (0.0148) | | |
| Export share | | | 0.0909** | | | | | 0.0937** | 0.0938** |
| | | | (0.0438) | | | | | (0.0438) | (0.0439) |
| Import share | | | | -0.0357 | -0.245*** | -0.238*** | -0.226*** | -0.229*** | -0.229*** |
| | | | | (0.0218) | (0.0538) | (0.0537) | (0.0536) | (0.0536) | (0.0536) |
| Input tariff *import share | | | | | 1.462*** | 1.391*** | 1.340*** | 1.299*** | 1.299*** |
| | | | | | (0.427) | (0.426) | (0.426) | (0.427) | (0.427) |
| Bilateral tariff-Brazil input *import share | | | | | 0.722* | 0.793* | 0.829** | 0.886** | 0.882** |
| | | | | | (0.419) | (0.419) | (0.419) | (0.421) | (0.421) |
| Exit | | | | | | | | | 0.00348 |
| | | | | | | | | | (0.0213) |
| Time dummies | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Sector dummies | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Observations | 9,918 | 9,875 | 9,875 | 9,918 | 9,918 | 9,918 | 9,875 | 9,875 | 9,875 |

FM=1 for input importing firms; Exit=1 if firm exits in t+1
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Table A9: Fixed effects firm level regressions on firm-specific MFN tariffs and bilateral residual tariffs**
**With initial product and inputs sets**
**(dependent variable: $lnTFP_{it}$)**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| MFN output tariff | -0.419*** | -0.451*** | -0.424*** | -0.418*** | -0.477** | -0.648** | -0.565** | -0.526** |
| | (0.142) | (0.148) | (0.147) | (0.148) | (0.230) | (0.253) | (0.251) | (0.252) |
| MFN input tariff | | 0.275 | 0.259 | 0.240 | | 0.561 | 0.542 | 0.411 |
| | | (0.198) | (0.198) | (0.201) | | (0.354) | (0.355) | (0.376) |
| FM | | | -0.0270** | -0.0378* | | | -0.0353*** | -0.127*** |
| | | | (0.0124) | (0.0212) | | | (0.0130) | (0.0334) |
| Input tariff * FM | | | | 0.0710 | | | | 0.739*** |
| | | | | (0.120) | | | | (0.278) |
| Bilateral tariff-Brazil output | | | | | 0.397** | 0.419*** | 0.421*** | 0.411*** |
| | | | | | (0.157) | (0.159) | (0.159) | (0.159) |
| Bilateral tariff-Brazil input | | | | | | -0.201 | -0.227 | -0.210 |
| | | | | | | (0.225) | (0.224) | (0.299) |
| Bilateral tariff-Brazil input * FM | | | | | | | | -0.143 |
| | | | | | | | | (0.267) |
| Period | 1988-2004 | 1988-2004 | 1988-2004 | 1988-2004 | 1991-2004 | 1991-2004 | 1991-2004 | 1991-2004 |
| Time dummies | yes | yes | yes | yes | yes | yes | yes | yes |
| Sector dummies | yes | yes | yes | yes | yes | yes | yes | yes |
| Observations | 11,746 | 11,678 | 11,636 | 11,636 | 9,750 | 9,702 | 9,660 | 9,660 |

FM=1 for input importing firms
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Table A10: Fixed effects firm level regressions on sector average tariffs (dependent variable: $lnTFP_{it}$)**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| MFN tariff | -0.387 | -0.330 | -0.297 | -0.294 | 0.377 | 0.368 | 0.451 | 0.375 | 0.367 |
| | (0.672) | (0.687) | (0.695) | (0.697) | (0.508) | (0.534) | (0.520) | (0.526) | (0.521) |
| FM | -0.0802 | | | | -0.126** | | | | |
| | (0.0489) | | | | (0.0561) | | | | |
| MFN tariff*FM | 0.243 | | | | 0.539* | | | | |
| | (0.250) | | | | (0.308) | | | | |
| Herfindahl index | 0.281* | 0.280* | 0.289* | 0.291** | 0.251 | | 0.263* | 0.277* | 0.281* |
| | (0.146) | (0.146) | (0.146) | (0.146) | (0.152) | | (0.151) | (0.151) | (0.151) |
| Import share | | -0.00185** | -0.00189** | -0.00180** | | -0.204** | -0.203** | -0.184** | -0.190** |
| | | (0.000804) | (0.000809) | (0.000796) | | (0.0836) | (0.0834) | (0.0792) | (0.0796) |
| MFN tariff*import share | | 0.00864** | 0.00883** | 0.00847** | | 0.844* | 0.822* | 0.730 | 0.710 |
| | | (0.00371) | (0.00374) | (0.00368) | | (0.468) | (0.466) | (0.448) | (0.452) |
| Exporting dummy | | | -0.0407 | | | | | -0.0205 | |
| | | | (0.0280) | | | | | (0.0258) | |
| Export share | | | | -0.00374 | | | | | 0.101 |
| | | | | (0.0134) | | | | | (0.0671) |
| Bilateral tariff-Brazil | | | | | -0.462 | -0.604 | -0.589 | -0.558 | -0.577 |
| | | | | | (0.464) | (0.511) | (0.508) | (0.508) | (0.508) |
| Bilateral tariff-Brazil * FM | | | | | 0.0253 | | | | |
| | | | | | (0.280) | | | | |
| Bilateral tariff-Brazil * import share | | | | | | 0.968** | 1.031** | 1.084** | 1.142*** |
| | | | | | | (0.423) | (0.428) | (0.415) | (0.421) |
| Period | 1988-2004 | 1988-2004 | 1988-2004 | 1988-2004 | 1991-2004 | 1991-2004 | 1991-2004 | 1991-2004 | 1991-2004 |
| Time dummies | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Sector dummies | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Observations | 12,111 | 12,111 | 12,022 | 12,022 | 9,966 | 9,966 | 9,966 | 9,900 | 9,900 |

FM=1 for input importing firms
Robust standard errors (clustered by four-digit ISIC sector) in parentheses
*** p<0.01, ** p<0.05, * p<0.1