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by

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FIRM PRODUCTIVITY GAINS IN A PERIOD OF SLOW TRADE LIBERALIZATION: EVIDENCE FROM BRAZIL*

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Abstract

Existing literature recognizes the potential roles played by trade policy and firms' exposure to international trade as potential determinants of productivity. A strand of the literature sheds light on the effects of trade policy changes on firm-level productivity. Another, studies the relationship between trading status (exporting goods or importing intermediates, but usually not both simultaneously) and firm-level TFP dynamics. However, analyses that integrate both strands are scarce. This paper studies the effects of import tariffs (on outputs and inputs) and firms' trade status on productivity by assessing how the impact of trade policy on firm productivity depends on firms' trade status. The empirics use data on the Brazilian industrial sectors (manufacturing and mining firms) during 2000-2008. After estimating firm level total factor productivity (TFP) using updated methodologies, the paper estimates the impacts of both trade policy and trade status on TFP dynamics. The results suggest that trade liberalization (through reductions in input or output import tariffs) increases TFP. However, the impact of trade policy on TFP spreads among all firms, what is consistent with the existence of spillovers from trading firms to other firms or with the notion that liberalization exerts competitive pressures on all firms, regardless of their initial exposure to international trade. In addition, even after controlling for import tariffs and fluctuations of the real effective exchange rate, there is still evidence of both learning-by-exporting and learning-by-importing effects.

Key words: Brazil; TFP; output/input tariffs; exporters; input importers
JEL classification: F13, F14, F15, D24, C33, C14

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1. Introduction and literature review.

A substantial literature emphasizes the roles that trade policy and firms' exposure to international trade (whether the firm imports or exports) play as determinants of total factor productivity (TFP). However, most empirical studies analyse these elements separately or partially.

Regarding the firms' exposure to international trade, several contributions study the role of being involved in international trade through exports or imports, but not both simultaneously. For example, Van Biesebroeck (2005), De Loecker (2007, 2013) and De Loecker and Warzyniski (2012) only consider the role of the exporting status on the evolution of TFP; and, Kasahara and Rodrigue (2008) and Halpern *et al.* (2015) only analyse the role of importing inputs. This could be problematic if exposure to exports and imports are correlated. Only a little number of studies consider the impact of both exporting and importing on TFP (see, for example, Bernard *et al.*, 2009; and Kasahara and Lapham, 2013).

As for the effects of trade policy on firms' TFP, Schor (2004) and Fernandes (2007) analyse the impact of trade policy (proxied by import tariffs) on productivity. Yet, there are few studies that explore both firms' trade status and trade policy as coexistent determinants of productivity; Muendler (2004) and Amiti and Konings (2007) are exceptions.[1]

This paper strengthens the understanding about the impact of international trade on firm-level TFP by studying how trade policy changes along with firms' trading status affect TFP dynamics. In the process, it is worth describing some aspects of our work.

First, we estimate empirical models that disentangle the effects on firm-level productivity of changes in import tariffs on firms' final goods (output tariffs) from the effects of changes in tariffs on imported intermediate goods (input tariffs). We expect that these two effects of tariff changes

[1] Schor (2004) and Amiti and Konings (2007) consider both input and output import tariffs. Muendler (2004) uses output tariffs and Fernandes (2007) both output tariffs and Effective Rates of Protection.

work through distinct channels. Trade liberalization through reductions in output tariffs can increase import competition in domestic markets and exert pressure on firms to improve efficiency. In contrast, reductions in input tariffs affect firms' access to a wider range of potentially higher quality inputs with incorporated foreign technology that can also improve firms' TFP. To the extent that tariff reforms reduce both output and input tariffs for a given firm, estimates of the effect of one without the other might yield misleading results about the channel through which such policy reforms determine microeconomic productivity.

Second, in the relationship between firms' trade status and TFP we explicitly distinguish if the firm is an exporter and/or the firm imports intermediate inputs. Thus, we estimate models considering these two trade activities. This consideration allows examining the *learning-by-exporting* (LBE) and *learning-by-importing* (LBI) effects that have been studied in the trade literature. That is, exporters may exhibit efficiency gains from economies of scale, knowledge flows from foreign customers, and from increased competition in export markets forcing them to become more efficient. Likewise, importers of intermediate goods may benefit from the diffusion and adoption of new technologies, and knowledge embodied in imported inputs.

Third, we investigate the interaction between trade policy and firms' trade status, which can have additional effects on TFP. For example, exporting firms can reinforce the higher competition they face in foreign markets with more competition in the domestic market when output tariffs get reduced. Also, input tariffs effects on productivity could be larger for firms that relied on imported inputs prior to a change in tariffs. Hence, there are reasons to expect that trade policy effects on TFP can be different depending on firms' trade exposure.

Fourth, our methodological approach extends Olley and Pakes (1996) and Levinsohn and Petrin (2003) approaches to estimating firm-level TFP based on the typical control-function estimation methods. Our empirical strategy consists of two steps. The first step entails the estimation of firm-level TFP following De Loecker (2013) and Wooldridge (2009). We extend existing approaches in two ways: we allow the demand of intermediate materials to vary by firms' trade status (non-traders, only exporters, only importers and two-way traders); and, we specify an endogenous law of motion for productivity in which past trading experience affects productivity (following De Loecker, 2007, 2013). In the second step, similar to Amiti and Konings (2007), we regress our first-step TFP estimates against trade policy measures (input and output tariffs), trade status variables and their interactions.[2]

Finally, our study sheds light on the micro dynamics of productivity in a large developing economy, namely Brazil,[3] which industrial productivity has been low and stagnating in the 2000s (OECD, 2015). While most of the existing evidence comes from high-income economies, there are fewer related papers on developing economies or emerging markets, including Indonesia (Amiti and Konings, 2007), Colombia (Fernandes, 2007), Chile (Kasahara and Rodrigue, 2008, and Kasahara and Lapham, 2013), India (Topalova and Khandelwal, 2011) and Mexico (Luong, 2011). Muendler (2004) and Schor (2004) also use Brazilian data but from 1986 to 1998, when Brazil liberalized its trade policy regime. Schor (2004) finds positive effects of import-tariff reductions (either output or input tariffs) on TFP; Muendler (2004) obtains a negligible impact of foreign inputs on TFP but a positive effect of foreign competition (as measured by larger import penetration and lower output tariffs). The present paper differs from Muendler (2004) and Schor (2004) in two noteworthy aspects. First, as mentioned, we explore the interaction between trade policy and trade status as determinants of firm-level TFP. Second, we use data for Brazilian firms in manufacturing and mining sectors during 2000-2008, when the process of trade liberalization in Brazil slowed

[2] Amiti and Konings (2007) for Indonesia check whether input tariffs affect more to input importers, but do not check whether output tariffs affect differently exporters and non-exporters.

[3] Brazil is the LAC's (Latin America and the Caribbean) and South America's largest economy.

down in comparison to the years studied by Schor (2004) and Muendler (2004). As discussed further below, Brazilian import tariffs declined very slowly since 2000 and rebounded in 2008.

In sum, we improve the evidence on the relationship between import tariffs, firms' trading status and the dynamics of firm-level productivity in Brazil during a period of slow liberalization, which point out that even small changes in tariffs can have notable effects on firms' TFP. Brazil is a relevant country to study since although tariffs have gone down, its average tariff for manufacturing imports is more than twice the level of Colombia's or other BRICS countries, and more than six times higher than in the United States. This makes Brazil's industry more shielded from international competition. In addition, trade barriers on imports of intermediate inputs limit Brazil's benefits from global value chains, since almost 90 percent of the value added of Brazil's exports is domestically produced (OECD, 2015).

The evidence in this paper suggests that reductions in both output and input tariffs are associated with improvements in firms' productivity. Lower output tariffs increase productivity by increasing import competition, as firms are forced to improve efficiency. Lower input tariffs increase productivity by increasing, for instance, access to a wider range of foreign inputs, to higher quality inputs, or to foreign technology incorporated in imported inputs (Bustos, 2011). From our preferred specification, we obtain that a reduction of output tariffs by 10 percentage points is associated with a 0.16 percent increase in firm-level TFP. However, in the previous decade of strong liberalization in Brazil, analysed by Muendler (2004) and Schor (2004), the estimated increases were 6.13 and 0.95 percent, respectively. Regarding input tariffs, a 10 percentage-points fall is associated with a 0.58 percent increase in TFP. Schor (2004) found that this 10 percentage-points fall in input tariffs was associated with a 1.53 percent increase in TFP. Additionally, we find that even after controlling for the effects of tariffs, there is still evidence of both *learning-by-exporting* and *learning-by-importing*. Past import status (*learning-by-importing*) has a positive impact on current productivity ranging from 12.0 to 14.7 percent, and the effect of past export status (*learning-by-exporting*) ranges from 10.3 to 15.4 percent. These numbers are in line with Kasahara and Rodrigue (2008), who find that the increase in firms' productivity from importing inputs ranges from 12.9 to 22.0 percent for Chilean firms, and with Halpern *et al.* (2015) for Hungary, who find that importing inputs increases firms' productivity by 22.0 percent.

The results presented above confirm that there have been within-firm productivity improvements in Brazil arising from trade liberalization in the 2000s, although these are more modest than what has been reported in the literature for the previous decade when tariffs fell substantially. Furthermore, we also obtain some evidence about the existence of spillovers from foreign suppliers of inputs to domestic suppliers. Additionally, the paper also highlights challenges related to evaluating trade policy effects on productivity with synthetic measures such as the effective rate of protection and, thus, the necessity of using individual measures for output and input tariffs. Finally, our analysis further suggests that it is important to control for the effects of changes in the real effective exchange rate on importers and exporters incentives for efficiency, as reductions in tariffs can coexist with real appreciations of the domestic currency (as occurred in Brazil during the analysed period).

The rest of the paper is organized as follows. Section 2 explains key features of the two-step estimation strategy and the production function estimation method. Section 3 describes the data. Section 4 discusses results and some robustness checks. Section 5 concludes.

2. Methodology.

2.1. Methodological concerns.

In this section, before describing the methodology to estimate firms TFP, we discuss some key issues related to the inclusion of trade status and trade policy variables, both in the estimation of

TFP and in the second stage of our estimation strategy (where we regress TFP on a series of relevant variables). Let us consider first the suitability of including import and export decisions (i.e. trade status) as additional inputs into the production function. In the same vein than Amiti and Konings (2007), we do not include firms' trade status as inputs in the production function since this would imply, among other things, that a firm can substitute any traditional input either with being an exporter or an importer at a constant unit elasticity. We do not include trade policy variables either as additional regressors in the production function. This is so as the estimation of TFP is undertaken at the industry level and the production function estimation includes year dummies, thus industry-year tariffs would not be identified.

Second, and also similarly to Amiti and Konings (2007), we make the demand of materials function (used to invert out productivity) to depend not only on capital and unobserved productivity (as in Levinsohn and Petrin, 2003) but also on trading status.[4] Hence, the demand of materials function that one inverts to obtain the unobserved productivity is $m_{it} = m_{TS}\left(k_{it}, \omega_{it}\right)$, where m_{it}, k_{it} and ω_{it} denote materials input, capital and TFP, respectively, and the subscript *TS* indicates that function m is dependent on firms' trading status. In line with De Loecker (2007, 2013) we allow for different demands of materials for exporters, importers, two-way traders and non-traders, filtering out, for instance, differences in information and market structure (mode of competition and demand conditions) between domestic and exporting firms and/or between input importers and non-input importers within a given industry, which may potentially affect optimal input demand choices. Further, as pointed out by Amiti and Konings (2007), the modification we introduce in Levinsohn and Petrin methodology (in their case Olley and Pakes methodology) allows controlling for potential simultaneity between productivity shocks and firms' trading status. Again, we do not

[4] Amiti and Konings (2007) use the Olley and Pakes (1996) approach and use instead the capital investment function.

include in function *m* yearly tariffs at the industry level as they would not be identified when estimating industry production functions that include time dummies.

Third, we depart from Amiti and Konings (2007) and instead of using an exogenous Markov process for the law of motion of productivity, we use an endogenous one that allows firms' past trading experience to affect productivity (in this, we follow De Loecker, 2007, 2013, for export status; and, Kasahara and Rodrigue, 2008, for import status). Assuming an exogenous Markov process for the law of motion of productivity is only suitable when productivity shocks are exogenous to the firm but not if future productivity is determined endogenously by firm choices, such as firm export and import decisions. As regards tariffs, they are not included in the law of motion because they are not firm level productivity enhancing actions shaping the evolution of productivity.

Fourth, we also depart from Amiti and Konings (2007) to estimate TFP. Whereas they use the two-step methodology proposed by Olley and Pakes (1996), we use the demand of materials function and implement Wooldridge (2009) one-step estimation procedure. Wooldridge (2009) argues that both Olley and Pakes (1996) and Levinsohn and Petrin (2003) two-step estimation procedures can be reconsidered as consisting of two equations that can be jointly estimated by GMM in one-step. This joint estimation strategy has the advantage of increasing efficiency with respect to two-step procedures, makes unnecessary bootstrapping for the calculus of the standard errors, and solves the labour coefficient identification problem posed by Ackerberg *et al.* (2015).

Finally, after estimating the production functions at the industry level using firm-level data, we regress firms' TFP on trade policy variables (output and input tariffs) at the industry level and firms' trade status, and a set of interactions. With these interactions, we aim to check not only whether importers are more affected by input tariffs than other firms (as in Amiti and Konings, 2007) but also whether exporting firms are affected differently by output tariffs. In this final stage of estimation, identification of the effects of tariffs on productivity stems from their joint variation across industries and time, since we pool firms' TFPs from all industries. Let us recall that our main aim is to analyse the impact of input and output tariffs on firms' productivity and to examine whether it depends on firms' trading status.

2.2. Production function estimation.

We assume that firms produce using a Cobb-Douglas technology:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \mu_t + \omega_{it} + \eta_{it} \qquad (1)$$

where y_{it} is the log of production of firm *i* at time *t*, l_{it} is the log of labour, k_{it} is the log of capital, m_{it} is the log of intermediate materials, and μ_t are time effects. As for the unobservables in estimation, ω_{it} is productivity and η_{it} is a standard *i.i.d.* error term. As timing assumptions for estimation, it is assumed that capital in period *t* was actually decided in period *t-1*, and that labour and materials are chosen in period *t*.

Under all these assumptions we follow Wooldridge (2009) estimation method to jointly estimate by GMM the following two equations tackling the problem of endogeneity of labour and materials (correlated with current productivity) and dealing with the law of motion for productivity (required for identification purposes), respectively.[5] The first estimation equation is:

$$y_{it} = \beta_0 + \beta_l l_{it} + \mu_t + H_{TS}\left(k_{it}, m_{it}\right) + \eta_{it} \qquad (2)$$

where $H_{TS}(k_{it},m_{it})$=1(NT)$H_{NT}(k_{it},m_{it})$+1(E)$H_E(k_{it},m_{it})$+1(I)$H_I(k_{it},m_{it})$+1(EI)$H_{EI}(k_{it},m_{it})$, and 1(NT), 1(E), 1(I) and 1(EI) are indicator functions that take value one for non-traders, only exporters, only importers and two-way traders, respectively. We end up with four different unknown functions,

[5] The appropriate instruments and moment conditions are employed for each equation.

H_{NT}, H_E, H_I and H_{EI} , that will be proxy by second degree polynomials in their respective arguments.

The second estimation equation is

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \mu_t + F_{TS}\left(k_{it-1}, m_{it-1}\right) + u_{it} \quad (3)$$

where $u_{it} = \xi_{it} + \eta_{it}$ and $F_{TS}(k_{it\text{-}1},m_{it\text{-}1})=1(NT)F_{NT}(k_{it\text{-}1},m_{it\text{-}1})+1(E)F_E(k_{it\text{-}1},m_{it\text{-}1})+1(I)F_I(k_{it\text{-}1},m_{it\text{-}1})+1(EI)F_{EI}(k_{it\text{-}1},m_{it\text{-}1})$.[6] The unknown functions *F* are proxied by second degree polynomials in their respective arguments.

3. Data and descriptive analysis.

In order to analyse firm productivity and trade exposure we use a dataset that links firm characteristics, production and export data for Brazilian firms over the period 2000 to 2008. For production and firm characteristics, we use the survey PIA empresa (Pesquisa Industrial Anual). PIA is a firm level survey for manufacturing and mining sectors conducted annually by the Brazilian Statistical Office, IBGE (Instituto Brasileiro de Geografia e Estatistica). The sampling procedure is as follows. Firms with 30 or more employees are included in the sample. Firms with less than 30 employees are randomly included in the sample. In total PIA covers more than 40,000 firms.

Furthermore, we use two external sources of data. To identify exporters, we use a dataset created by the Brazilian Foreign Trade Office, SECEX (Secretaria Comercio Exterior). This dataset

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6 ξ_{it} (innovation uncorrelated with k_{it}) comes from the endogenous Markov process: $\omega_{it} = E\left[\omega_{it} \middle| \omega_{it-1}, TS_{it-1}\right] + \xi_{it} = f\left(\omega_{it-1}, TS_{it-1}\right) + \xi_{it}$, where productivity in *t* depends on productivity and firms' Trading Status in *t-1* and on ξ_{it}.

provides the universe of exporters. And for the tariffs information we use the TRAINS database (TRAINS is a database maintained by the UNCTAD).

Table A.1 in the Appendix shows the main variables in the analysis. We proxy capital with assets, and also include electricity and energy as intermediate inputs. We use sector specific producer price indices supplied by the IBGE to deflate the variables in the production function, with the exception of labour (as measured by the number of employees). In order to calculate tariffs for inputs we first calculate the average tariff for each of the Brazilian input-output sectors and, then, for each sector we use the input-output coefficients to weight the sector tariff for those sectors that provide inputs. These input tariffs are then mapped from input-output sectors to CNAE 4 digits sectors using the correspondence tables supplied by the IBGE national accounts.

Regarding tariffs on outputs, each firm is associated to a 4 digits CNAE industry based on its main sector of production. We first convert HS-8 trade codes with tariffs to the Prodlist code equivalent (product extension of CNAE classification) using the IBGE conversion table. Then, we average the tariff for Prodlist products for each 4 digits CNAE sector. Finally, since we do not have information regarding value added, we calculate the effective rate of protection (ERP) as the difference between tariffs on outputs and inputs.

Brazil underwent an intense period of trade liberalization during the 1980s and 1990s, but this process slowed down during the 2000s. Final good tariffs fell from an average of 17 percent in 2000 to an average of 15.34 percent in 2008, and input tariffs slightly increased from an average of 8.38 percent to 9.25 percent (see Figure 1). However, deeper inspection reveals that average tariffs rates decreased slowly until 2007, and suffered a rebound from 2007 to 2008. Up to 2007, both input and output average tariffs decreased, but the decrease in average output tariffs was higher (3.36 percentage points) than the one in input tariffs (0.63 percentage points). The 2008 tariffs upturn reversed the decreasing trend in average input tariffs observed in the period 2000-07, and as a result they were 1.42 percentage points higher in 2008 than in 2000. It also smoothed the decrease in average output tariffs. Thus, in 2008 they were only 1.66 percentage points lower than in 2000.[7] It is also noteworthy to underline that average output tariffs were higher than average input tariffs all along the period. Further, this is true for every industry of the sample (see Table 1). Finally, there exists more variation in average input and output tariffs between industries than within industries over time. In particular, the coefficient of variation across industries is about 27% for input tariffs and 28% for output tariffs. However, the coefficient of variation over time within industries is 19% for input tariffs and 15% for output tariffs.

[Insert Figure 1 and Table 1 about here]

As regards trade strategies, the majority of Brazilian manufacturing and mining firms do not export nor import (67 percent on average). Furthermore, we find that on average 15 percent of firms only export, 13 percent simultaneously export and import, and 4 percent only import. Figure 2 represents the evolution over time of the distribution of firms by trading status.

Table 2 reports the main features of our data set in terms of production function variables according to firms' trading status. As can be observed, two-way traders (firms that both export and import) are larger in terms of output, labour, capital and materials as compared to firms that only export or only import and to non-traders. Firms that only export or only import are, in general, more similar in all variables. If we compare these firms with non-traders we find that are larger in terms of output, labour, capital and materials.

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[7] Notice, however, that the rebound in input tariffs from 2007 to 2008 is driven by two industries (textiles and apparel), while for output tariffs is driven by three industries (textiles, apparel, and coal and petroleum manufacturing). For the case of coal and petroleum output tariffs, the rebound from 2007 to 2008 simply returns values to their previous ones in 2006 (see Table 1).

[Insert Figure 2 and Table 2 about here]

4. Results.

4.1. Main results.

In the first stage of our analysis, using the methodology explained above, we estimate the production function in (1) separately for firms in each of the 22 industries (CNAE 2 digits) and obtain an estimation of the log TFP of firm *i* at time *t* for each industry *s*, denoted tfp_{it}^{s}, as

$$tfp_{it}^{s} = y_{it} - \beta_0 - \beta_l l_{it} - \beta_k k_{it} - \beta_m m_{it} \qquad (4)$$

In a second stage, we use our log TFP estimates as the dependent variable of a series of equations that include as regressors either trade policy variables, or both trade policy and trade status variables to allow for the effects of input and output tariffs on firms' productivity to depend on whether firms import inputs and/or export goods, and also for LBI and LBE.

In this second stage regression analysis, we pool TFP estimates for firms over time from all industries and use panel data fixed effects estimation to simultaneously control for individual firm and industry fixed effects. Using firm level fixed effects allows controlling for the existence of a self-selection mechanism that would arise only if the (*a priori*) more efficient firms participate in international markets either as buyers of inputs, sellers of outputs or both. This self-selection process is based on the existence of higher sunk entry costs in international markets that can only be overcome by the more productive firms (see, for instance, Bernard and Jensen, 1999, and Melitz, 2003). These estimation results are reported in Table 3.[8]

[8] Estimating the specification by OLS suggests that coefficients for the export and import status variables suffer from an upward bias due to the existence of self-selection of the more productive firms into exporting and importing. This problem is avoided with fixed effects estimation. For the sake of brevity these results are not presented in the paper.

Some works point out that country policy related to tariffs might be endogenous with respect to productivity (due to possible policy pressure from particular industries). In our case, controlling for industry fixed effects, among other things, allows to account for time-invariant characteristics coming from trade policy. This is the way we control for time-invariant political economy factors that could explain both industry protection and productivity.

It is important to note that we also include a vector of time dummies (λ_t). Controlling for time effects is crucial in this setup as we are interested in disentangling the effects of trade policy from other possible changes in macroeconomic policy or macroeconomic instability, or even from any other uncontrolled events that occurred in Brazil during our sample period that go along with changes in tariffs. Not considering them may lead to spurious correlation between tariffs and productivity.

Furthermore, there could be also a concern about the presence of other factors affecting productivity and being systematically correlated with tariffs changes in each industry. This points to time-variant industry specific factors. However, since our estimation method is panel data with fixed effects, in our productivity regressions we control simultaneously for industry and firm fixed effects (that is, for industry and firm time-invariant unobserved heterogeneity). Consequently, we rely solely on the within-industry/firm variation to identify the effect of tariffs on productivity. Hence, fixed effects estimation should mitigate the expected bias in the tariff coefficients if political economy factors do not change much over time. This would be the case if the structure of protection does not change much in the sample period. We find some evidence in this direction when looking at the Spearman rank correlations of tariffs among the 22 industries between 2000 and 2008 (2007), which are equal to 64% (68%) and 89% (78%) for input and output tariffs, respectively. Additionally, the year-by-year correlation from 2000 onwards is on average 63% for input tariffs and 95% for output tariffs. Therefore, the slow process of trade liberalization during this period does not seem to have changed significantly the initial Brazilian structure of protection across industries (according to the WTO reports for Brazil, 2004 and 2009, tariff dispersion is relatively low during the analyzed period). Moreover, the MERCOSUR's Common External Tariff (CET) framework also restricts unilateral changes in tariffs for Brazil trade policy. The MERCOSUR Trade Commission is responsible for the application of common trade policy resolutions, which are mandatory for member countries (Brazil, Argentina, Paraguay, and Uruguay).

Finally, in the robustness section below (section 4.2) we estimate a specification controlling for exchange rates. We aim at checking if industry time-variant political economy factors may have a potential role in biasing estimated coefficients, as accounting for exchange rates may alleviate further concerns about time-variant political economy factors generating bias in estimation.

We now start our analysis of the effects of trade policy and trade status by using the simplest possible specification, where the only regressor that we include to explain productivity is output tariffs (T_O). This specification (Specification 1) has been widely used in the literature on trade liberalization and productivity:

$$tfp_{it} = \alpha + \alpha_i + \lambda_t + \gamma_1 T_O + u_{it} \qquad \text{(Specification 1)}$$

where α is a constant term and α_i is a firm fixed effect.

In this specification we expect γ_1 to be negative. Trade liberalization policies, implying a reduction of output tariffs, may increase competitive pressure from competing imported products and so force firms to use inputs more efficiently and, consequently, this should increase productivity. As the dependent variable is the log of TFP, the effect of a unit increase in output tariffs on TFP is computed from the estimated coefficient γ_1 as $100\left(\exp\left(\gamma_1\right)-1\right)$. This measure shows the percentage change on TFP when output tariffs increase by one unit. The estimate of γ_1 (see Table 3) shows that a decrease in output tariffs increases productivity, as expected. More specifically, as tariffs are in percentages in estimation, a fall in output tariffs of 10 percentage points increases TFP by 0.54 percent.[9]

[Insert Table 3 about here]

Next, in Specification 2, we consider simultaneously both output and input (T_I) tariffs:

$$tfp_{it} = \alpha + \alpha_i + \lambda_t + \gamma_1 T_O + \gamma_2 T_I + u_{it} \qquad \text{(Specification 2)}$$

This makes the output tariffs coefficient to slightly decrease, suggesting that a 10 percentage points fall in output tariffs increases TFP by 0.47 percent. Specification 2 considers a potential omitted variable bias in the estimation of the coefficient on output tariffs in Specification 1. The coefficient on input tariffs (γ_2) is higher, indicating that a 10 percentage points fall in input tariffs increases TFP by 0.59 percent.[10]

In Specification 3, we augment Specification 2 to consider: i) the direct effect of exporting on productivity and whether the effect of output tariffs on productivity is different for exporters and non-exporters; and, ii) the direct effect of importing inputs on productivity and whether the effect of input tariffs differs depending on whether the firm imports inputs. Therefore, in addition to the regressors included in Specification 2, we add a dummy that takes value one if the firm exports and zero otherwise (D_E), an interaction that results from multiplying D_E by output tariffs ($T_O \cdot D_E$), a dummy that takes value one if the firm imports and zero otherwise (D_I), and an interaction that results from multiplying D_I by input tariffs ($T_I \cdot D_I$). This allows analysing whether the effects of trading policy (as captured by inputs and output tariffs) are affected by firms' trade status.

$$tfp_{it} = \alpha + \alpha_i + \lambda_t + \gamma_1 T_O + \gamma_2 T_O \cdot D_E + \gamma_3 D_E + \gamma_4 T_I + \gamma_5 T_I \cdot D_I + \gamma_6 D_I + u_{it} \qquad \text{(Specification 3)}$$

[9] The weighted average of output tariffs for manufacturing and mining sectors in Brazil was 15.20 percent over the period analysed.

[10] The weighted average of input tariffs for manufacturing and mining sectors in Brazil was 8.49 percent over the period.

Our results from Specification 3 suggest that a 10 percentage points decrease in output tariffs increases productivity by 0.20 percent for non-exporters and by 0.35 percent for exporters (we get that both γ_1 and γ_2 are negative and statistically significant). These results may suggest that the potential productivity enhancing effects of product liberalization are larger for exporters than for non-exporters. This may result from two mechanisms that work in opposite direction: on the one hand, the reduction in output tariffs tightens competition in the domestic market and forces both exporters and non-exporters to increase efficiency; and, on the other hand, if trade liberalization reduces market shares in the domestic market, its impact could be larger in market shares for the less productive non-exporting firms (Cirera *et al.*, 2015, show that the self-selection mechanism fully works for Brazilian manufacturing firms), lessening their incentives to increase productivity. Additionally, our estimates show that exporting firms are 11.52 percent more productive on average than non-exporting firms. As already stated before, since we control for firm fixed effects in estimation, this finding is consistent with LBE.

Furthermore, our estimates for the coefficients on T_I and $T_I \cdot D_I$ (γ_4 and γ_5, respectively) suggest that a 10 percentage points decrease in input tariffs increases productivity by 0.62 percent both for importers and non-importers of inputs, with no significant differences in the potential productivity gains for importers and non-importers (the coefficient on the interactive term is negative as expected but not significant). The fact that reducing input tariffs results in productivity improvements for non-importers of inputs suggests the existence of positive spillovers from input importers to non-importers of inputs.[11] Domestic producers of inputs, when facing competition from foreign producers, are forced to increase the quality/variety of their products with a potential benefit

[11] Paz (2014) found the existence of inter-industry productivity spillovers for Brazil, using industry-level data, in the previous decade (1989-1998).

in the productivity of their domestic clients.[12] Moreover, our estimates suggest that the direct effect of importing inputs is increasing average firm productivity by 12.19 percent, providing evidence in favour of LBI.

4.2. Some robustness.

In this section we test the robustness of our results to alternative specifications. The aim of Specification 4 is to test whether two-way traders (firms that simultaneously export goods and import inputs) enjoy extra productivity gains in trade liberalization scenarios (reduction in output and/or input tariffs). For this purpose, we augment specification 3 with interactions of both input and output tariffs with the export and import dummies ($T_I \cdot D_E \cdot D_I$ and $T_O \cdot D_E \cdot D_I$):

$$\begin{aligned} tfp_{it} = {} & \alpha + \alpha_i + \lambda_t + \gamma_1 T_O + \gamma_2 T_O \cdot D_E + \gamma_3 D_E + \\ & \gamma_4 T_I + \gamma_5 T_I \cdot D_I + \gamma_6 D_I + \gamma_7 T_I \cdot D_E \cdot D_I + \gamma_8 T_O \cdot D_E \cdot D_I + u_{it} \end{aligned} \quad \text{(Specification 4)}$$

One way to interpret these interaction terms is to recognize that for two-way traders there can be some increasing returns (complementarity) in terms of productivity improvements when inputs or outputs tariffs decrease. If this occurs, an exporting (importing) firm will get a further increase in productivity when tariffs decrease if the firm adds importing (exporting) as a second trading activity. Hence, if γ_7 and γ_8 are negative and statistically significant it will mean that the marginal contribution to productivity improvements of tariffs reductions when adding a second trading activity is larger than the marginal contribution of adding that same activity when the firm does not perform the other one. However, we find that although the coefficients of these interactions

[12] According to Blalock and Veloso (2007), foreign suppliers encourage technology diffusion to domestic suppliers as a result of import competition.

(γ_7 and γ_8) are both negative, as expected, they are statistically non-significant and, therefore, we do not find evidence of the aforementioned increasing returns for two-way traders.

In Specification 5, we proxy trade policy using the effective rate of protection (ERP, hereafter) following an important strand of the traditional literature analysing the link between trade liberalization and productivity. According to this literature, a reduction in input tariffs that increases the ERP is interpreted as a rise in the degree of protection for domestic firms and, therefore, it is expected to diminish firms' pressure to increase their efficiency. However, the most recent literature on trade liberalization and productivity suggests using both input and output tariffs separately to measure trade policy. Within this approach the opposite argument arises relating input tariffs reductions and productivity. According to this argument, a decrease in input tariffs could result in domestic firms' productivity gains as it allows them to profit from: efficiency gains derived from the use of incorporated technology in imported inputs of higher quality and from the wider range of inputs available to domestic firms. Specification 5 is like Specification 3 but capturing the information on input and output tariffs in the synthetic measure ERP:

$$\begin{aligned} tfp_{it} = \alpha + \alpha_i + \lambda_t + \gamma_1 ERP + \gamma_2 ERP \cdot D_E + \gamma_3 D_E + \\ \gamma_4 ERP \cdot D_I + \gamma_5 D_I + u_{it} \end{aligned} \qquad \text{(Specification 5)}$$

The estimates of Specification 5 suggest that reductions in the ERP increase TFP for all firms, but more intensely for exporters and/or importers (the coefficients γ_1, γ_2 and γ_4 are negative and statistically significant). However, the effects of trade liberalization according to this synthetic measure of tariffs are much smaller in magnitude. These lower estimates result from the inability of the ERP measure to catch the increase in productivity produced from a reduction in input tariffs (as explained above).[13] In particular, we obtain that a 10 percentage points decrease in the ERP

[13] Recall that the input tariffs enter the ERP measure with a negative sign.

increases productivity by 0.04 percent for firms that do not export and do not import, by 0.07 percent for firms that only export or firms that only import, and by 0.10 percent for firms that both export and import.

Finally, in Specification 6 we augment Specification 3 to account for the possible effects that the appreciation of the real effective exchange rate (REER, hereafter)[14] experienced in Brazil during the period analysed on the relationship between trade status and productivity.[15] Hence, Specification 3 is extended to include as additional regressors the cross products of the REER with the export and import dummies. An appreciation makes imports cheaper, and so it has the potential to increase competition both for producers of final and intermediate goods. Therefore, it affects the incentives of domestic producers to increase productivity. To interpret the results from this specification one should bear in mind that an appreciation of the national currency means a decrease in the REER.

$$\begin{aligned} tfp_{it} &= \alpha + \alpha_i + \lambda_t + \gamma_1 T_O + \gamma_2 T_O \cdot D_E + \gamma_3 D_E + \gamma_4 T_I + \gamma_5 T_I \cdot D_I + \gamma_6 D_I + \\ &\quad \gamma_7 REER \cdot D_E + \gamma_8 REER \cdot D_I + u_{it} \end{aligned} \qquad \text{(Specification 6)}$$

The main results of our estimates can be summarized as follows. First, the direct effects of exporting and importing in productivity are larger when accounting for the REER, confirming the existence of both LBE and LBI processes (in Specification 6, the export and import productivity advantages are 15.37 percent and 16.48 percent, respectively; in Specification 3, they are 11.52 percent and 12.19 percent, respectively). Second, the estimates of the two interactions between

[14] REER is computed at CNAE 4 digits' sector (national/foreign currency).

[15] After a sharp depreciation of the REER at the end of 1998, the introduction of a floating exchange rate regime in early 1999 was followed by a relatively stable evolution in 2000. After this short period of relative stability, the Brazilian currency showed a trend towards depreciation in real terms until 2003, but since then and until 2008 showed a steady appreciation trend (Mourougane, 2012).

the REER and the importer and exporter dummies are negative and significant. Thus, a unit decrease in REER increases productivity by 6.08 percent and 7.66 percent for importers and exporters, respectively. This could be signalling that a real appreciation may also put pressure on exporters to increase productivity to offset the competitiveness loss generated by the appreciation of the national currency. Furthermore, it also lowers imported input prices, and so it might wide the access to imported inputs for importers, contributing to their increase in productivity. Third, the consideration of REER reduces the size (in absolute terms) of the estimates corresponding to output and input tariffs. Thus, whereas in Specification 3 a 10 percentage points reduction of output tariffs increases productivity of non-exporters and exporters by 0.20 percent and 0.35 percent, respectively, now the increase in productivity gets reduced to 0.16 percent both for exporters and non-exporters. For input tariffs a 10 percentage points fall increases productivity by 0.62 percent and 0.58 percent (both for importers and non-importers) according to Specifications 3 and 6, respectively.

Notice that the extra increase in productivity enjoyed by exporters (in comparison with non-exporters) in Specification 3 when output tariffs decrease, vanishes with the inclusion, in Specification 6, of the variable interacting REER with the export dummy. This finding suggests that the extra productivity improvement for exporters (*versus* non-exporters) associated to output tariffs reductions was really capturing the effects of higher competitive pressure to become more efficient in international markets due to the appreciation of the Brazilian *real*. Exporters needed to offset the competitiveness loss created by the simultaneous appreciation of the national currency as regards foreign currencies.

5. Conclusions.

The results from all specifications led us concluding that there was a positive impact of trade liberalization on firm-level productivity in Brazil, even during a period of slow liberalization. Specifically, we find evidence that trade liberalization impacted productivity across all firms, but through different channels and with positive but heterogeneous effects depending on the firms' trade status and the exchange rate.

The main findings of the paper can be summarized as follows. First, lower output tariffs (tariffs on imports of final goods) are associated with improvements in firm-level productivity, likely by increasing import competition which forces firms to improve efficiency. Second, lower input tariffs (tariffs on imports of intermediate inputs) are associated with firm-productivity improvements, possibly due to improvements in firms' access to a wider range of foreign inputs, to higher quality inputs, or to foreign technology embodied in imported inputs. Consequently, using effective rates of protection as the trade-policy variable that helps determine firm productivity dynamics, not only tends to mask the differential effects of changes in output and input tariffs, but also the separated identification of the effect of competition from the effect of better access to inputs. Third, we do not find that trade liberalization in the form of reducing input tariffs has a larger effect on the productivity of importing firms than on firms that do not import intermediate goods. This may indicate the existence of spillovers from foreign suppliers of inputs to domestic suppliers. Fourth, controlling for the effects of REER fluctuations on exporting and importing firms, the extra improvement on productivity find for exporters when output tariffs decrease vanishes, uncovering that it was in fact driven by the appreciation of the Brazilian currency. That is, the appreciation of the currency could have exerted additional pressure on exporting firms. Fifth, our findings indicate that the effects of tariffs in the economy in terms of firms' productivity spread among all firms, and do not only affect exporting or importing firms. These findings are consistent with the idea that knowledge produced by trade liberalization exerts competitive pressures on all firms, even those that are not directly involved in international transactions. Finally, we also find evidence of both learning-by-exporting and learning-by-importing effects on productivity, even after controlling for the effects of import tariffs.

From a policy point of view, a significant trade liberalization would expose the Brazilian industrial sector to a greater competition which would encourage firms' productivity improvements. Otherwise, Brazil has not yet benefited fully from the productivity gains associated to trade (including trade of intermediates).

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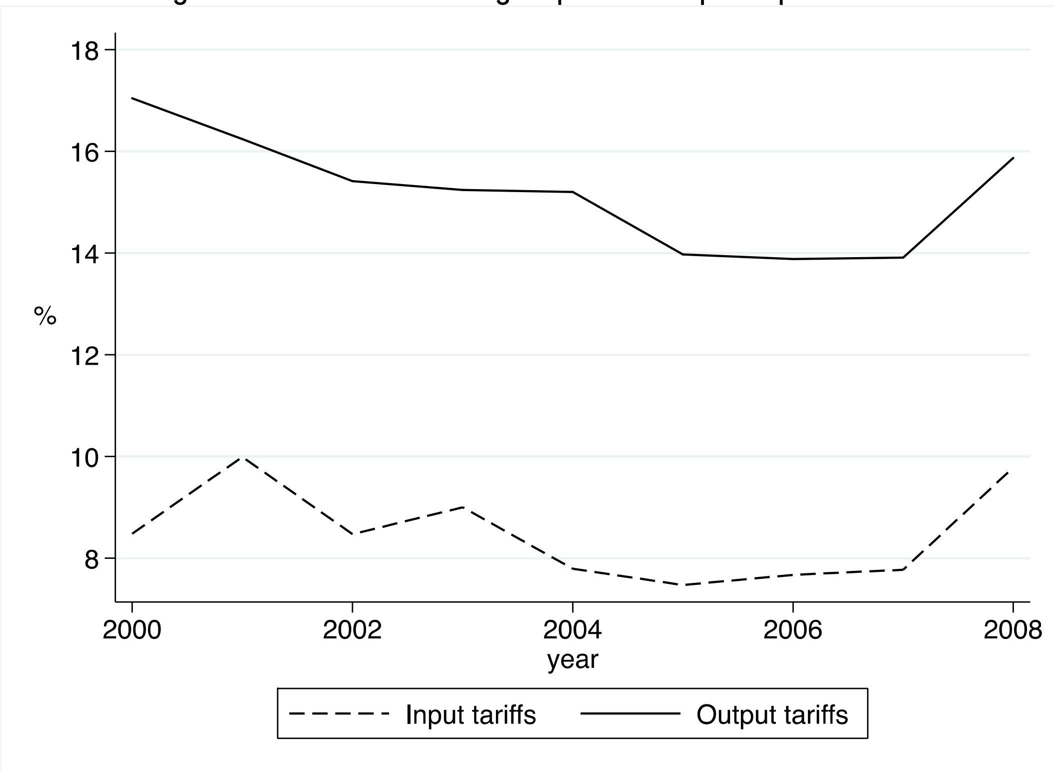
APPENDIX

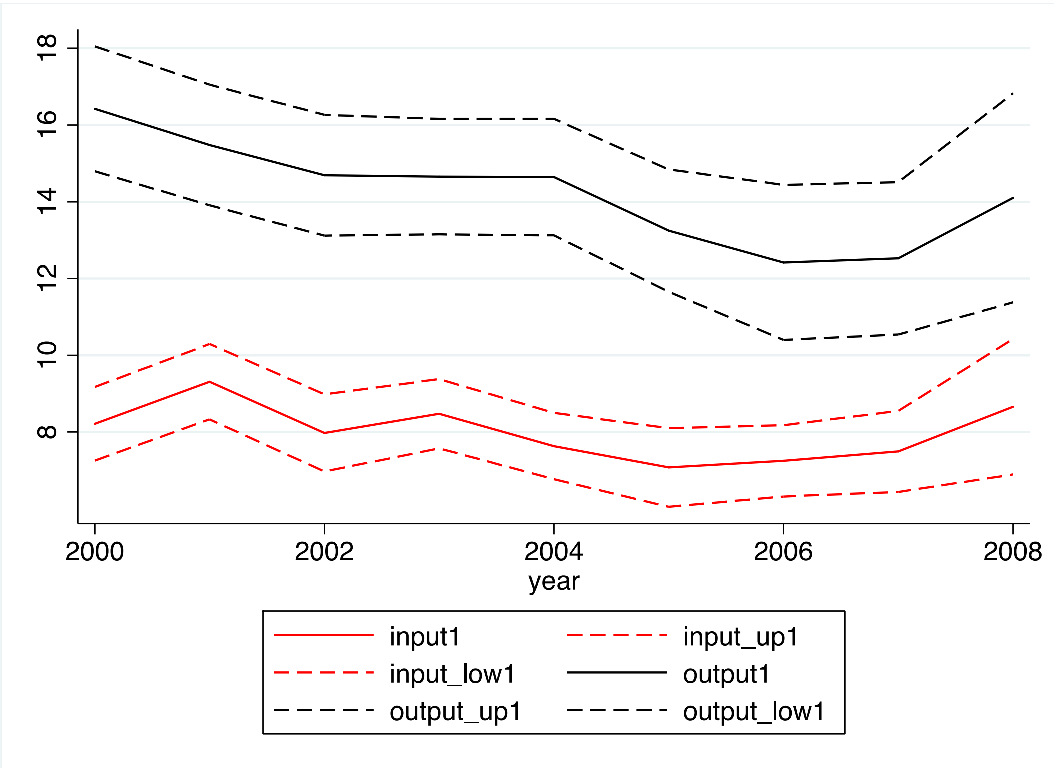
Table A.1. Variables description

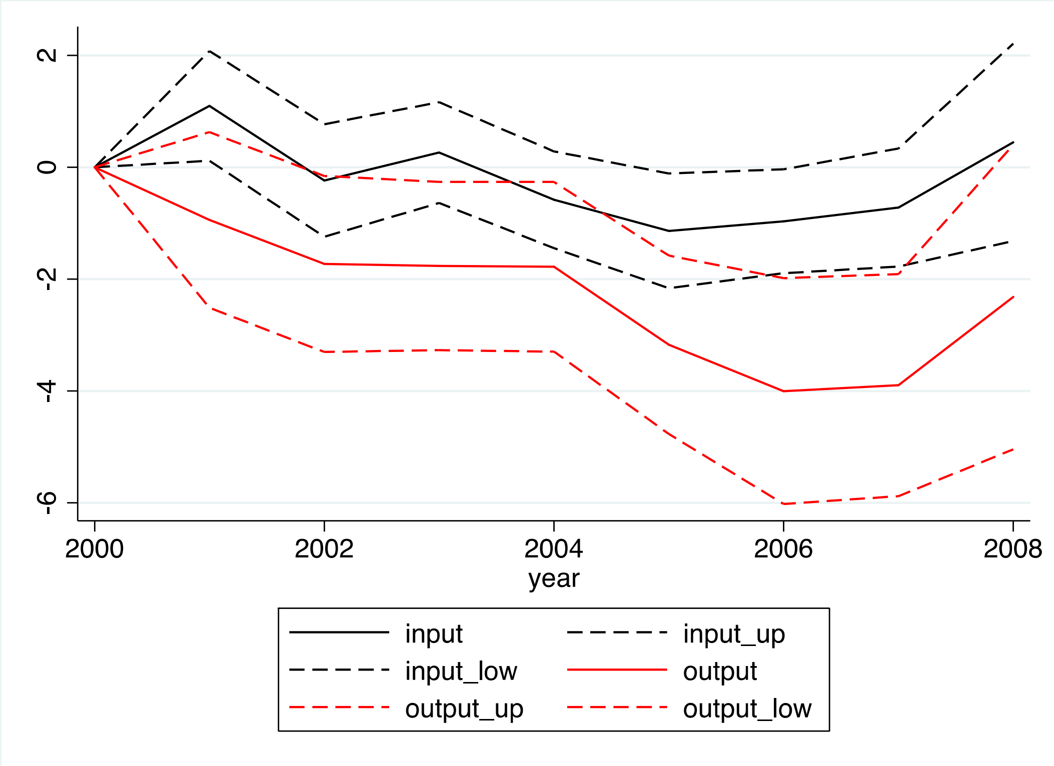
Production function variables	
Output	Deflated value of gross output
Labour	Number of employees
Capital	Value of assets deflated
Materials	Intermediate inputs, including electricity and energy, deflated
Trade policy variables	
Output tariffs	Average output tariffs at CNAE 4 digits sector (%)
Input tariffs	Average input tariffs at CNAE 4 digits sector using Input-Output tables (%)
Effective rate of protection	Difference between tariffs on outputs and inputs
Real effective exchange rate	Average real effective exchange rate at CNAE 4 digits sector (national/foreign currency)

Figure 1: Evolution of average input and output import tariffs



Note: Trade-weighted average input and output import tariffs





2
0
-2
-4
-6
2000
2002
2004
2006
2008
year
input
input_up
input_low
output
output_up
output_low

Table 1: Input and output import tariffs in Brazil, 2000-2008

Industry		Tariff	2000	2001	2002	2003	2004	2005	2006	2007	2008
10-14	Extractive industries	Input	5.82	5.96	4.79	5.93	4.11	4.94	4.58	4.62	5.16
		Output	7.22	7.27	6.47	6.50	6.29	3.90	3.85	3.88	3.62
15	Food	Input	6.62	8.84	6.49	7.51	8.02	6.47	9.01	6.94	7.69
		Output	16.46	16.01	15.24	15.22	15.17	13.39	13.39	13.49	13.49
17	Textile	Input	11.27	7.14	10.95	10.36	10.90	8.93	8.39	7.89	15.79
		Output	19.49	19.24	18.46	17.05	17.03	16.79	16.84	16.95	25.28
18	Apparel	Input	13.97	14.97	13.68	12.00	7.11	13.63	11.97	10.86	22.09
		Output	22.87	22.38	21.40	19.96	19.95	19.86	19.86	19.86	34.19
19	Leather	Input	12.94	13.07	13.55	13.41	13.37	11.92	7.98	13.93	14.33
		Output	21.05	20.79	19.44	19.25	19.31	17.81	20.27	20.40	21.15
20	Wood	Input	6.59	10.49	6.33	9.37	6.94	6.71	3.43	6.65	10.17
		Output	10.12	9.73	8.75	8.69	8.73	6.94	7.00	7.09	7.33
21	Paper	Input	4.81	10.53	9.06	8.35	8.96	4.73	7.13	7.08	8.18
		Output	15.60	15.02	14.26	14.28	14.25	12.73	12.76	12.59	13.15
22	Publishing	Input	7.69	8.44	6.35	7.49	7.32	4.09	7.56	6.74	5.86
		Output	10.46	10.06	9.65	12.44	12.76	11.64	9.01	8.98	11.20
23	Coal, petrol man.	Input	9.17	8.00	6.94	5.47	4.89	4.48	3.26	4.03	6.50
		Output	19.59	16.73	15.93	18.89	19.03	14.71	1.38	1.99	14.02
24	Chemical	Input	6.67	7.58	6.36	6.57	5.71	5.28	4.66	5.38	5.49
		Output	12.72	12.06	10.94	10.89	10.67	9.32	9.38	9.60	9.60
25	Rubber and plastic	Input	8.28	11.02	7.86	9.55	8.24	6.45	7.95	7.78	8.32
		Output	18.62	17.87	16.90	17.01	17.02	15.52	15.69	15.54	15.62
26	Non-metallic	Input	5.49	5.54	4.59	5.27	4.42	4.53	3.81	3.61	3.71
		Output	13.73	13.23	12.24	12.25	12.17	10.22	10.26	10.12	10.04
27	Metal processing	Input	6.00	7.00	5.53	5.80	5.56	4.32	5.26	4.96	4.74
		Output	13.13	12.61	11.25	10.92	10.82	9.55	9.53	9.65	9.22
28	Metal manufacturing	Input	7.51	10.61	9.28	9.26	7.48	5.96	7.91	7.08	8.94
		Output	17.96	17.11	16.06	15.72	15.55	15.09	14.47	14.44	14.76
29	Machinery	Input	9.15	10.41	9.34	9.32	8.43	7.14	8.49	7.97	9.43
		Output	17.16	14.02	13.59	13.72	13.64	13.01	12.89	12.94	12.80
30	Electrical machinery	Input	7.50	8.21	6.95	7.50	8.94	7.80	7.50	8.18	3.80
		Output	17.15	16.08	14.57	13.63	13.63	11.51	9.14	9.79	9.05
31	Office machinery	Input	8.74	9.57	7.26	8.32	8.11	7.12	8.21	7.30	8.52
		Output	18.73	17.64	16.81	16.82	16.70	15.29	14.86	14.99	14.95
32	Electronic	Input	7.52	7.88	6.26	7.18	7.86	7.49	7.63	7.28	6.76
		Output	16.57	15.54	14.29	12.91	13.02	12.18	11.20	12.07	11.13
33	Medical equipment	Input	9.71	9.60	8.68	8.98	8.69	6.90	8.78	7.55	7.60
		Output	14.80	13.24	13.47	12.92	12.94	12.17	11.50	11.32	9.71
34	Motor vehicles	Input	9.71	10.66	8.46	11.09	7.94	9.17	10.07	13.11	10.64
		Output	19.30	18.53	19.19	19.00	19.06	17.92	17.87	18.39	18.39
35	Other transport	Input	7.73	7.02	8.09	7.21	6.77	9.14	8.81	7.97	8.84
		Output	18.02	15.41	15.28	15.36	15.46	14.63	14.63	14.36	14.15
36	Furniture and misc.	Input	7.86	12.35	8.73	10.58	8.19	8.53	7.11	8.00	7.99
		Output	20.55	19.98	19.04	19.01	18.94	17.30	17.46	17.14	17.40

Figure 2: Evolution of the distribution of firms by trade statuses

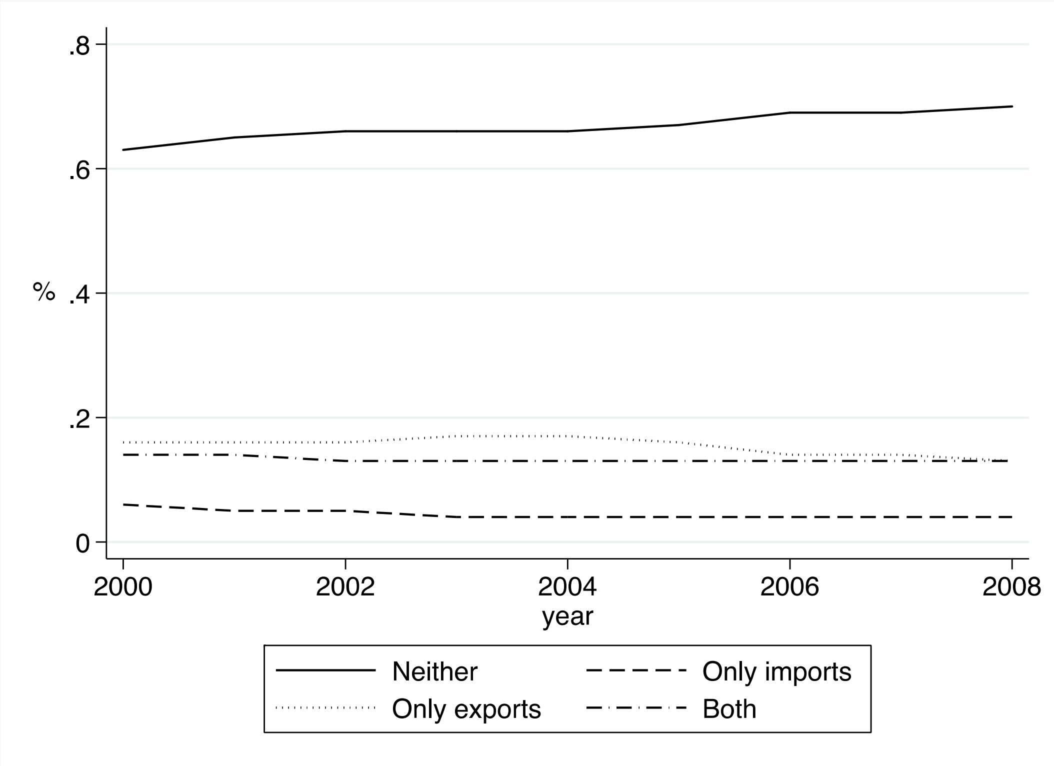


Table 2. Descriptive statistics (R$ million, labour as number of workers).

	Exporters & importers	Only exporters	Only importers	No traders
Production function variables				
Output	135.0	22.0	23.1	3.53
Labour	535.56	223.38	166.85	73.61
Capital	164.0	27.9	39.8	4.05
Materials	97.8	16.5	17.1	2.58

Table 3. Determinants of Firm TFP: Fixed effects regressions on trade policy and trade exposure

	Specification 1	Specification 2	Specification 3	Specification 4	Specification 5	Specification 6
T_O	-0.00054***	-0.00047***	-0.00020***	-0.00020***		-0.00016**
	(0.00005)	(0.00005)	(0.00007)	(0.00007)		(0.00007)
T_O*D_E			-0.00015*	-0.00013*		-0.00007
			(0.00009)	(0.00007)		(0.00008)
D_E			0.109***	0.113***	0.0979***	0.143***
			(0.0209)	(0.0217)	(0.0114)	(0.0250)
T_I		-0.00059***	-0.00062***	-0.00062***		-0.00058***
		(0.00011)	(0.00012)	(0.00012)		(0.00012)
T_I *D_I			-0.00018	-0.00003		0.00007
			(0.00025)	(0.00034)		(0.00021)
D_I			0.115***	0.116***	0.128***	0.137***
			(0.0196)	(0.0230)	(0.0124)	(0.0247)
T_I *D_E *D_I				-0.00016		
				(0.00033)		
T_O*D_E *D_I				-0.00003		
				(0.00013)		
ERP					-0.00004***	
					(0.00001)	
ERP*D_E					-0.00003**	
					(0.00001)	
ERP*D_I					-0.00003**	
					(0.00001)	
REER*D_I						-0.0608**
						(0.0265)
REER*D_E						-0.0766***
						(0.0238)
Constant	-3.534***	-3.511***	-3.579***	-3.580***	-3.653***	-3.591***
	(0.0126)	(0.0135)	(0.0180)	(0.0180)	(0.00705)	(0.0182)
Observations	132,218	132,218	132,218	132,218	132,218	132,218
Firms' number	31,000	31,000	31,000	31,000	31,000	31,000

Note: Robust standard errors in parentheses; ***, ** and * mean significance at 1, 5 and 10% level, respectively.