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EXPLORING THE RELATIONSHIP BETWEEN PRODUCTIVITY AND TRADE IN BRAZIL

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ABSTRACT

Beginning in the late 1980s, Brazil began the rapid implementation of trade liberalization. Tariffs fell drastically opening up previously protected sectors of the economy. This paper looks at the period directly following the reforms of the 1990s which also witnessed continued liberalization and increased trade. By examining firm-level data for 2001 and 2007 with fixed effect regression analysis, this paper investigates the relationship between productivity and trade. The results show that the effect of trade on firms' efficiency is generally insignificant.

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INTRODUCTION

As the world continues to march towards integration, a thorough understanding of the implications of globalization is in order. The effects of trade that could enhance welfare are of particular importance. Productivity growth does promise future benefit to the world, especially for developing nations. Differences in efficiency are a significant contributor to global inequality. Furthermore, unlike other factors of production which are generally fixed, productivity can rapidly change.

While the promises of productivity growth are great, the exact mechanisms that generate growth are difficult to identify. Recent theoretical and empirical work has acknowledged several possible mechanisms for productivity growth associated with trade. However, more statistical analysis is needed to further confirm or disprove existing theories.

This paper seeks to determine the relationship between productivity and trade in Brazil. I draw upon firm-level panel data for the years 2001 and 2007 to estimate, by Fixed Effect, the relationship between openness and productivity. To check the robustness of these results, I also perform a General Method of Moments regression and a Pooled OLS regression. My work updates the field by analyzing recent data and also adds to the larger debate of the role of openness in improving productivity growth. My results indicate that increased trade and interaction with foreign companies did not significantly affect productivity in Brazil.

ECONOMY OF BRAZIL

Brazil now has the largest economy in Latin America and a stable democracy; however, this was not always the case. After an initial struggle with democracy, the country entered a period of military rule that lasted from the 1960s through the early 1980s. In spite of the ruthless nature of the regime, the Brazilian economy achieved relative stability and considerable growth through technocratic policies. The petroleum crisis of 1973 and 1979 ended Brazil's economic miracle and ushered in the gradual transfer of power back to the civilian government (Wiarda, 2011).

Civilian government retuned in 1985, but the economy was plagued by volatility and outdated trade policies. During the period, prices rose at a dizzying pace sometimes with inflations rates higher than 700 percent (Wiarda, 2011). Numerous barriers to trade protected the economy from foreign goods. These measures included a ban on the importation of 1,300 different products, a regulation which required all firms to submit their annual importation plans in advance, and limitations on the importation of capital goods (Hay, 2001). Highly regulated special import areas represented most of Brazil's imports. By 1988, 70% of all non-oil imports came from these special trade zones (Hay, 2001).

A turning point in Brazilian trade policy occurred in 1988. Beginning under the presidency of José Sarney (1985-1990), trade regulation was consolidated and simplified in 1988 and 1989. The next president, Fernando Collor de Mello (1990-1992), made serious strides to open the economy. He eliminated many special import zones and the list of banned imports while lowering tariffs (Hay, 2001). By 1994, the average tariff rate reached 11.2%, a significant fall from 57.5% in 1987 (Cardoso, 2009).

President Fernando Henrique Cardoso (1995-2002) initially reversed some of these reforms. During his first three years in office, average tariff levels rose slightly because of greater protectionism in several selected industrial sectors (Muendler, 2004). In spite of this initial policy, Cardoso continued to liberalize the economy in the last term of his presidency. Cardoso especially focused on unilateral and multilateral trade negotiations with Brazil's traditional western trading partners. Throughout his term, trade negotiations with the European Union and the United States through the Free Trade Areas of the Americas (FTAA) were a top priority (Veiga, 2009).

Liberalization of trade continued during the presidency of Luiz Inácio Lula da Silva (2003-2010). Even though Lula was a former union leader and ran as a social reformer, the threat of a sudden stop of foreign investment forced Lula to continue to liberalize the economy and lower tariffs (Amaral, Kingstone, & Krieckhaus, 2008). The tariff reductions and heightened trade of Lula's presidency make the 2000s an interesting time to study Brazilian productivity. Between 2001 and 2007, the period of this study, the average Most Favored Nation (MFN) tariff rate fell from 14.63 to 12.24.[1] Furthermore, according to trade volume statistics, imports and exports rose by 49% and 77% respectively over those same years.[2]

REVIEW OF LITERATURE

The relationship between productivity and globalization has been the focus of numerous studies over the past several decades. Academic articles have explored the possible pass-through mechanisms that facilitate productivity growth. Many studies have focused on the effect of knowledge transfers between nations which could result from globalization.

Knowledge Transfers

Technological diffusion plays a large role in productivity growth. Wolfgang Keller writes that "for most countries, foreign sources of technology account for 90% or more of productivity growth" (Keller, 2004). There are three main channels for knowledge and technological diffusion: foreign direct investment, export, and import.

The most intuitive source of technological transfer is foreign direct investment (FDI).

[1] Data collected from the WTO's Tariff Analysis Online
[2] Based on Export and Import Volume Index retrieved from the World Banks Data Bank

FDI provides a linkage between technologically advanced firms and countries abundant in cheap labor but in need of technology. FDI could also lead to technological spillovers in the host country which would prompt productivity growth. Keller's review of economic literature concerning FDI and productivity noted that there were numerous studies with conflicting results about FDI spillovers (Keller, 2004). In spite of this, Keller concludes that "the evidence suggest that there can be FDI spillovers, but they do not occur everywhere to the same degree." This belief has been supported by recent empirical work (Blalock & Gertler, 2008).

There also appears to be a link between exporting and productivity growth; however, the causality is questionable. Several studies find that the correlation between exporting and efficiency depends on the self-selection of productive firms to enter the export market (Aw, Chung, & Roberts, 2000; Bernard & Jenson, 1999; Clerides, Lach, & Tybout, 1998). According to these studies, there was no significant difference between the productivity growth rates of non-exporting firms and comparable exporting firms. Bernard and Jenson state that "exporting does not confer the Midas touch." They go on to note that "most plant attributes, especially productivity, grow no faster, and even slower" when firms become exporters. However, several other studies disagree. Fernandes and Isgut (2005) found evidence that young firms do in fact learn by exporting. These firms attain greater productivity growth than comparable non-exporting young firms.

More recently, economists have begun to study the possibility of learning by importing. This could occur when a firm imports technologically advanced products to be incorporated in the production chain or when importation results in increased contact with foreign technology. Empirical results indicate that there is a linkage between importing and technology diffusion (Blalock & Veloso, 2007). However, the direction of causality remains uncertain.

Competition

Other studies find that increased international competition generates productivity growth. This could occur through two channels. First, the increased openness could result in greater competition from foreign firms which forces the least productive firms out of business. The exit of firms leads to a change in resource allocation as the most productive firms gain greater access to inputs (Melitz, 2003). Secondly, openness could allow firms to expand into new markets or new areas of production which will increase profit. However, since domestic resources, like labor are limited, only the most productive firms would be able to capitalize on this opportunity and in turn raise input cost on the least productive domestic firms (Melitz, 2003). Empirical research finds that the most productive domestic firms tend to enter and take advantage of the export markets (Aw et al., 2000). Also studies have found that the least productive firms tend to leave the market (Aw et al., 2000).

Competition can have internal effects on firms as well. Firms can cut slack, reduce cost, or lower markups. When faced with new competitive pressure, firms may also redirect their production from less productive goods to certain core goods. However, one empirical study indicates that other factors such as the reduction of input cost have a greater effect on productivity than heightened competition (Topalova & Khandelwal, 2010).

Inputs

Trade and globalization can significantly affect the cost of inputs and intermediate goods. For instance, a newly opened economy may be able to import inputs from abroad at a cheaper price than would be available at home. On the other hand, globalization could alter the cost of domestic inputs such at labor. A counterfactual experiment with a theoretical model found that a simulated 5 percent decrease in geographic distance between trade partners, which resulted in a

15 percent increase in world trade, caused productivity to rise by 4.7 percent. Importantly, they note that the main contributor to the productivity increase "is the gains within surviving plants driven by the decline in the price of intermediates as cheaper imports replace domestically produced inputs" (Bernard, Eaton, Jensen, & Kortum, 2003).

Productivity in Brazil

Several studies have focused on productivity in Brazil. These studies observe the rapid liberalization of the late 1980s and early 1990s which comes before the period examined by this thesis. Macr-Andreas Muendler (2004) found that trade liberalization caused productivity to rise in Brazilian firms. He claims that increased competitive pressure from abroad positively impacted firms while productivity gains associated with cheaper foreign inputs were negligible. He also writes that one of the main channels for growth was the exit of the least efficient firms from the market. Another study found that liberalization adversely effected profits pressuring firms to enhance their efficiency (Hay, 2001)

DATA

Survey Data

This study will rely on data from the World Bank collected by Enterprise Surveys.[3] While data exist for numerous countries around the world, this paper will focus on Brazil. The data is comprised of firm-level surveys collected over several months in two waves during 2002/2003 and again during 2008/2009. The data itself refers to 2001 for the first wave and 2007 for the second wave.

The figures come from survey questions which firms across Brazil were asked to answer. Each questionnaire was administered by a private contractor instead of a government agency to

[3] Data retrieved from Enterprise Surveys of The World Bank Group at https://www.enterprisesurveys.org/

avoid dishonesty and distortion of answers relating to corruption. However, the local agency originally hired in Brazil by Enterprise Surveys to conduct the interviews for the second wave was dismissed because of delays and “significant concerns about fieldwork quality” (Enterprise Surveys, 2009a). While Enterprise Surveys eventually replaced this agency, the delays caused the bulk of the surveying to be conducted during the Christmas and Carnival holiday seasons. The resulting absence of many firms’ top managers could impair the overall quality of the data for the 2007 panel. Additionally, firm closings during these holidays excluded some firms from the panel data set (Enterprise Surveys, 2009a).

In order to create data without a sampling bias, Enterprise Surveys generally relies upon stratified random sampling with replacement. In other words, the total data is separated into three different strata: firm size, business sector, and geographic region. Size breaks down into three categories: firms with 5-19 employees, 20-99 employees, and firms with more than 99 employees. Enterprise Surveys notes that they “oversample large firms since larger firms tend to be the engines of job creation.” The weighting for the remaining two strata depends upon geographic and sectorial intensities within Brazil. Through these manipulations, Enterprise Surveys “generates a sample representative of the whole non-agricultural private economy” (Enterprise Surveys, 2009b).

While the individual waves represent the overall economy, Enterprise Surveys limited the collection of longitudinal data to the industrial sector of Brazil. To identify a firm’s specific industry sector, Enterprise Surveys relied upon a two digit ISIC screener question, a four digit ISIC representation of the firm’s main product, and a written description of that product in either English or Portuguese. There are several instances where this screener code differs from the main product’s ISIC code. Because Enterprise Surveys states that the later “variable is probably the most accurate variable with which to classify establishments by activity" this paper will rely upon the four digit ISIC and written description of each firm's main product (Enterprise Surveys, 2009b).

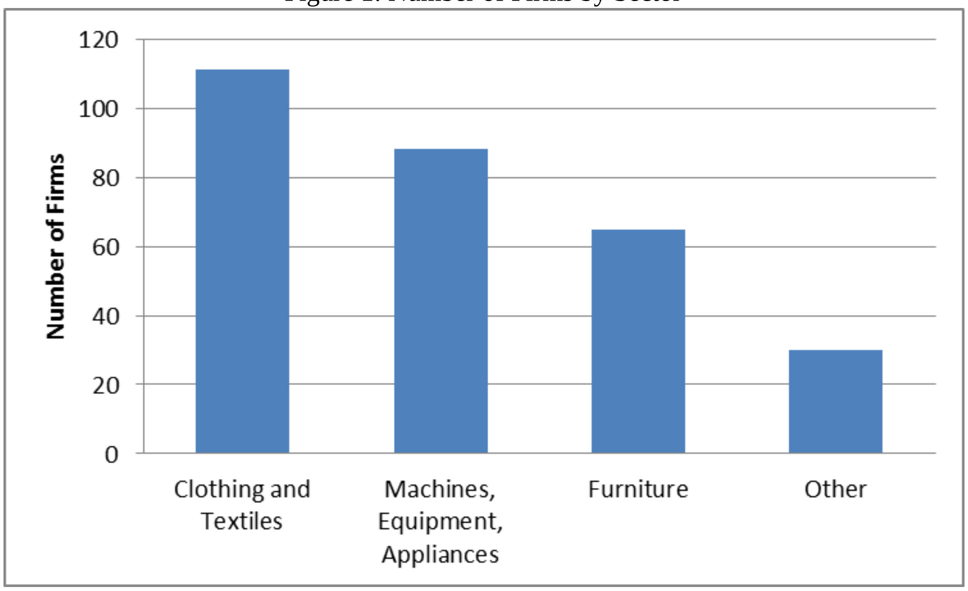
I extracted numerous variables for further analysis from these surveys. Most essential are the variables which pertain to input cost and revenue. The survey includes data on the total cost of labor, material inputs, electricity, in addition to the firm's net book capital value. Output is measured by the total annual sales. All monetary data are in terms of current Brazilian dollars. CPI data from the World Bank was used to deflate these values.[4] Besides these factor inputs, I also extracted variables on percentage of foreign ownership of the firm, a dummy variable for the use of licensed foreign technology, the number of power outages experienced in a year, and dummy variables for the direct importation of inputs and the direct exportation of output. Lastly, I collected data on governmental reliability measured by a numerical rating on a scale of one to four.

The nature of survey data itself creates certain problems that must be considered. First, the data is reported voluntarily. This means that there may be some inherent characteristics of the firms that participate which could bias the sample. Also, the information is not gathered directly from a firm's record. Instead, the representative of the firm serves as a filter between the true data records and the interviewer. Enterprise Surveys attempt to fix this problem by including a "Don't know/spontaneous answer" section which is meant to pick out false and extemporaneous answers. Since Enterprise Surveys is a relatively new operation, the company continuously makes slight alterations to the questions asked and the wording of the questions. This prevented me from including several other controls and variables which appeared in only one wave.

[4] Data retrieved from the World Bank's Databank at http://data.worldbank.org/data-catalog

Another problem was that many firms were missing entries essential to my regression analysis such as material input cost and net book value of capital. These firms had to be removed from the sample so that I could maintain a balanced panel. After all of the firms with missing observations had been removed, the sample contained data on 294 firms over two separate waves. I aggregated the firms into four main industry groups: furniture manufacturing, textiles and clothing manufacturing, the manufacture of machines and parts, and other manufacturing. This residual sector includes food and chemical manufacturing in addition to other firms which did not fit into the nomenclature.

Figure 1: Number of Firms by Sector



It should be noted that several of the aforementioned flaws could bias results. Foremost, in creating the panel data, Enterprise Surveys eliminated firms which had shut down, changed industry sector, or were unreachable. Intuitively, this could exclude those firms which were relatively less productive. For Brazil, this difficulty is compounded because of the problems encountered while conducting the 2007 survey. For example, it seems probable that firms which remain open during the holidays are more efficient than those that close. Similarly, those firms which did not record an approximation of material inputs or net book value of capital could have lacked proper record keeping or managerial skill. This could cause a regression model to overestimate productivity and bias results.

In spite of these flaws, Enterprise Surveys' data does offer considerable advantages. Primarily, firm-level data limits the aggregation and measurement bias which accompanies macro studies. Furthermore, the panel data allows for econometric modeling not available for cross sectional or time series datasets.

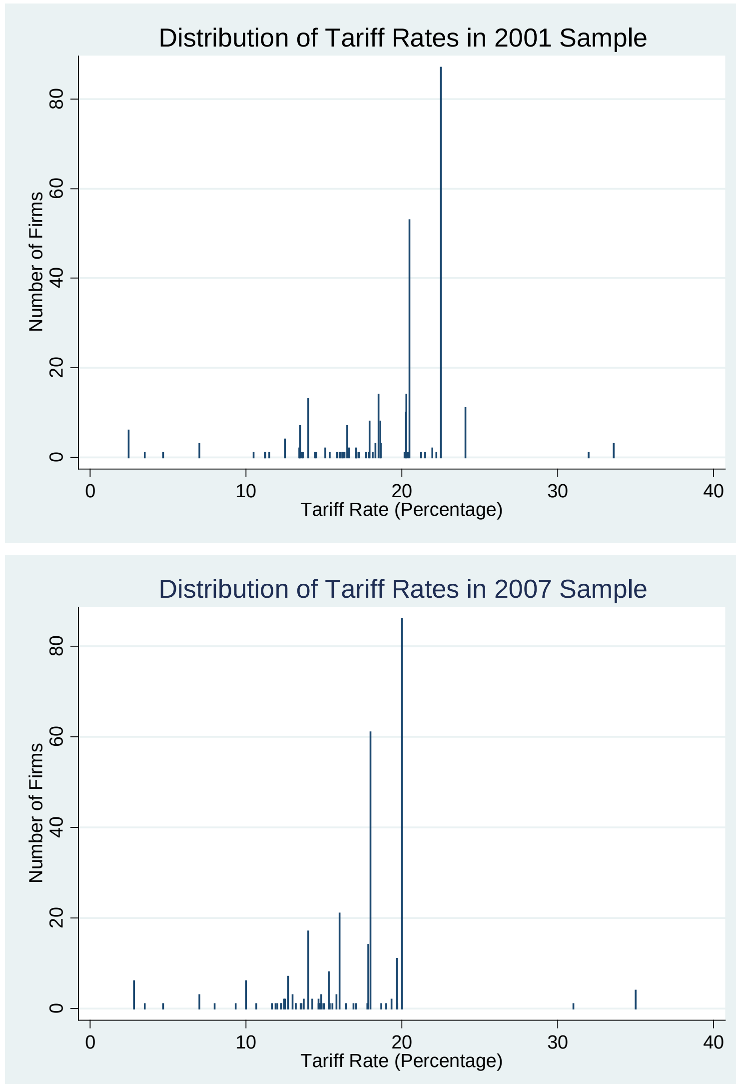
Tariffs and Imports

To measure the relative openness of an industry, this study will draw upon tariff rates collected from the World Trade Organization (WTO).[5] The data is described by Harmonized System (HS) up to the sixth digit. Since there is no simple conversion from the ISIC revision 3.1 used by Enterprise Surveys to the Harmonized System nomenclature, I translated the industry sector codes on a case by case basis. To facilitate this translation, I relied primarily upon the four-digit ISIC representation of the company's primary product and the literal description of the company's primary product.

The tariff data collected is based off of the country's Most Favored Nations (MFN) duties. In some instances, there was variation within the actual tariff lines. In such cases, the WTO provides an average which gives the best representation possible of the relative openness of that industry. A distribution of the tariffs of this data set for 2001 and 2007 is presented in Figure 2.

[5] Data retrieved from https://tariffanalysis.wto.org

Figure 2: Distribution of Tariffs in 2001 and 2007 Samples



Additionally, I collected data on total imports within an industry by HS classification from the United Nation's COMTRADE database.[6] This measure is used to construct a rough estimate of import penetration. Since I was unable to collect data on individual industry size, I instead used an aggregate industrial value added measure collected from the World Bank.[7] Both this statistic and those collected from COMTRADE are in terms of current US dollars. Dividing the industry imports by the aggregate industrial value added creates a unit free ratio. The log

[6] Data Retrieved from the World Bank's World Integrated Trade Solution (WITS) at http://wits.worldbank.org/wits/
[7] Data retrieved from the World Bank's Databank at http://data.worldbank.org/data-catalog

difference of this ratio can then be used as an admittedly rough measure of the change in import penetration across time. Essentially, the log difference of this ratio would measure the actual log difference of import penetration assuming that product specific inflation and sector growth was homogenous throughout the industrial economy. [8] While these assumptions are extreme they are unavoidable without more detailed price and output data. Furthermore, the inflation assumption is consistent with the use of the CPI as a universal deflator.

MODEL

Generally, there have been two types of models used to explore the relationship between productivity and trade. One model involves a two-step approach where productivity is first estimated and then regressed on by explanatory variables. The second approach is to directly regress trade policy on output.

Discussion of Possible Models

Because productivity cannot be directly measured, estimating its correlation with other variables can be problematic. The two-step approach solves this problem by first generating a productivity variable which is measured by the residual change in output not explained by a change in input. However, the residual of Cobb-Douglass equations can contain other unmeasured variables which are correlated with the independent variables. Without properly controlling for these omitted variables, the measurement of productivity will be biased. A basic log linearized Cobb-Douglass production function is seen below:

$$y_{it} = B_l l_{it} + B_k k_{it} + B_m m_{it} + a_{it}$$

where *y* represents output, *l* represents labor, *k* is capital, *m* is material inputs, and *a* is productivity. Intuitively, it would seem that managers can anticipate productivity growth and will

[8] See Appendix for proof

consequently alter inputs to match their expectations. If this is true, the *a* would be split into two separate variables, one which is known by managers and correlated with inputs and another which is exogenous, as represented by the following equation:

$$a_{it}= w_{it}(m_{it}) + u_{it}$$

Measuring *w* is problematic but several methods have been developed to correct this issue. For example, Ackerberg, Caves, and Frazer (2006) developed a model which allows "observed inputs to control for unobserved productivity shocks." In general, these methods require dynamic panel estimation which cannot be done with only two waves of data.

The two-step estimation approach can still be applied to two period panel sets but the technique is less rigorous. For example, Kapp and Sanchez (2011), who also use data from Enterprise Surveys, simply ignore the possibility for omitted variables in their initial estimation of productivity. They then run additional regressions to check the robustness of their original results. This theoretical framework would be biased if there is any correlation between productivity and the independent variables across time. Since this strict erogeneity assumption does not generally hold, I have rejected the two-step approach in favor of the one-step estimation approach.

One-Step Approach

The one-step approach avoids several statistical problems by simply regressing the relevant explanatory variables on total output. I begin with a Cobb-Douglas function:

$$Y_{it}= L^{B}{}_{it}M^{B}{}_{it}E^{B}{}_{it}\,K^{B}{}_{it}exp^{A+FE+}\delta$$

where *Y* is sales, *L* is labor, *M* is input materials, *E* is electricity, *K* is capital, and *exp* is the exponential function. The exponents on *exp* are *A*, the productivity measure, *FE*, the portion of the residual which is constant through time, and *δ* which is a dummy variable for 2007. Taking the log of each side yields the following equation where the lowercase letters represent the natural log of the variables:

$$y_{it} = \beta_l l_{it} + \beta_m m_{it} + \beta_e e_{it} + \beta_k k_{it} + a_{it} + fe_i + \delta_{2007}$$

Productivity is a function of explanatory variables which can be included within the initial model. I will include those variables which previous scholarly studies have found to be possible pass-through mechanism for productivity growth in addition to the tariff rate and import penetration which measure the relative openness of a specific industry. To represent the pass-through mechanisms, I will include dummy variables for the firm's status as an importer and exporter, and as recipient of FDI and licensed foreign technology. Additionally, I will control for nontrade related productivity gains by including dummy variables for government reliability and a proxy for infrastructure represented by power outages. This then leaves us with the following model:

$$a_{it} = \beta tar_{it} + \beta ip_{it} + \beta exp_{it} + \beta imp_{it} + \beta fdi_t + \beta ftech_{it} + \beta pow_{it} + \beta gov_{it} + \mu_{it} = \sum \beta\, x_{it} + \mu_{it}$$

$$y_{it} = \beta_l l_{it} + \beta_m m_{it} + \beta_e e_{it} + \beta_k k_{it} + fe_i + \delta_{2007} + \sum \beta\, x_{it} + \mu_{it}$$

To estimate these coefficients, I will use the Fixed Effect (FE) model.[9] Essentially, the FE model eliminates time invariant omitted variables by differencing across time. The model can be represented as follows:

$$y_{i2007} = \beta_l l_{i2007} + \beta_m m_{i2007} + \beta_e e_{i2007} + \beta_k k_{i2007} + fe_i + \delta_{2007} + \sum \beta\, x_{i2007} + \mu_{i2007}$$

$$y_{i2001} = \beta_l l_{i2001} + \beta_m m_{i2001} + \beta_e e_{i2001} + \beta_k k_{i2001} + fe_i + \sum \beta\, x_{i2001} + \mu_{i2001}$$

By subtracting the two models, I obtain the following equation which excludes all time invariant variables:

$$\Delta y_i = \delta_{2007} + \beta_l \Delta l_i + \beta_m \Delta m_i + \beta_e \Delta e_i + \beta_k \Delta k_i + \sum \beta \Delta\, x_i + \Delta \mu_i$$

[9] I heavily relied upon Jeffrey M. Wooldridge's textbook *Introductory Econometrics: A Modern Approach* to construct the Fixed Effect model in this paper.

The exclusion of these fixed effects makes the ceteris paribus condition more credible.

In spite of this benefit, FE estimation and differencing across time can have negative consequences. In particular, differencing can reduce the overall variation in the data. Generally, such problems are solved by expanding the years between each difference. Unfortunately, in spite of the five year separation between the two waves of data, some of the differenced dummy variables suffer from this problem. Lack of variation could lead the model to overestimate the standard errors of these variables.

To estimate the coefficients, I will use an Ordinary Least Squares (OLS) regression. For the model to generate unbiased estimates, the usual assumptions of OLS regressions must apply. Specifically, the error term must be uncorrelated with the explanatory variables. Differencing does not eliminate the possibility of endogeneity with the error term. To check the robustness of the OLS estimation, I will also perform as General Method of Moments (GMM) regression. This regression will use the non-differenced log transformed variables from both panel waves as instrumental variables to the log differenced equation. Since the GMM estimation does not rely upon the same assumptions as the OLS, this result will help to determine if the errors are truly exogenous.[10]

Fixed Effect estimation also assumes that the independent variables' coefficients are constant across time. To examine this assumption, I will include the results of a pooled OLS estimation. If the two periods have similar coefficients then this further adds to the robustness of the FE model.

The results of the pooled OLS regression also shed light on the type of model which best matches the data. Instead of the FE model, the Random Effect (RE) model could also be used to estimate the coefficients of a panel data set if certain assumptions are met. The major difference

[10] I would like to thank Dr. Herman Bierens for his suggestion to run the GMM regression as a robustness check.

in assumptions between the two models is that the RE model assumes that the time constant fe_i is not correlated with the explanatory variables. Since the pooled OLS includes fe_i in the error term, any correlation between fe_i and the independent variables would bias the OLS estimates. Therefore, if the pooled OLS estimates closely match the estimates of the FE model, fe_i should be uncorrelated with the explanatory variables. This would indicate that a RE or Mixed Effects estimator may be more appropriate. While the FE estimator is still unbiased for RE models, it is less efficient than a RE estimator (Wooldridge, 2009).

RESULTS

In general, the regressions show that there is not a significant relationship between productivity and trade. Furthermore, the results from the GMM and the pooled regression support the overall robustness of the FE model but also indicate that some specific variables could be estimated incorrectly. The results provide an interesting view of productivity that challenges several theoretical trade pass-through mechanisms advanced by previous papers. [11]

Fixed Effect

The FE approach found little relationship between trade and productivity. The results are presented in Table 1. Because the Breusch–Pagan test rejected homoskedasticity, heteroskedasticity corrected standard errors and t-values are displayed. Most of the variables were found to be insignificant. However, several of the trade related variables were found to be significant and negative. For example, the model found a strong negative relationship between a firm gaining foreign direct investment and productivity.

Beside the trade related variables, the model did find other significant correlations. All of

[11] All the analysis, interpretations, and conclusions drawn from the data are entirely my own and do not reflect the opinions of the organizations that supplied the data.

the factor inputs which served as controls to isolate productivity were strongly significant. Also, the FE model found a strong relationship between the power outage dummies and productivity. Lastly and contrary to intuition, the model found a negative relationship between governmental reliability and productivity.

Table 1: OLS FE Results

Variable	Coefficient	Standard Error	T-value
ΔLn(labor cost)	0.366895	0.05811	6.314
ΔLn(Material cost)	0.3314347	0.06173	5.369
ΔLn(Electricity Cost)	0.104499	0.0377	2.772
ΔLn (Value of Capital)	0.1269136	0.03745	3.389
ΔLn Import Penetration	0.4547306	0.30898	1.472
ΔTariff	0.0648428	0.04186	1.549
Stopped Having Power Outages	0.2426609	0.16506	1.47
Started Having Power Outages	-0.3864238	0.13684	-2.824
Stop Using Foreign Licensed Tech	0.3202417	0.29933	1.07
Started Using Foreign Licensed Tech	-0.1172664	0.13673	-0.858
Began to Directly Import Inputs	0.0376096	0.14831	0.254
Stopped Direct Importation of inputs	-0.1664387	0.33241	-0.501
Began Direct Export	0.2679891	0.206	1.301
Stopped Direct Exportation	-0.2110531	0.19593	-1.077
Gained Foreign Ownership(FDI)	-0.7647524	0.19985	-3.827
Lost Foreign Ownership (FDI)	0.2645692	0.82093	0.322
Reliability Of Government Improved	-0.3360329	0.17017	-1.975
Reliability Of Government Decreased	0.0000041	0.17584	0
Furniture Dummy	-0.0000078	0.24976	0
Appliances, Machine Dummy	0.135545	0.24637	0.55
Textiles Dummy	-0.0703477	0.29579	-0.238
Constant	0.5319756	0.28544	1.864

Robustness Checks

The GMM regression estimates have positive implications for the robustness of the OLS estimates of the FE model. Before running the GMM model, I performed a joint Wald test on the original FE results to exclude dummy variables which were not significant at the level of 5%. Table 2 provides the results of the GMM model and the revised FE model for comparison. For the factor inputs, the results are very similar supporting the FE estimation. Additionally, both models estimate similar coefficients for the effect of tariff reduction and import penetration on productivity. While the coefficients on power grid, FDI, and Government, have different estimated magnitudes for the FE and GMM models, the signs remain the same reinforcing the results of the FE model.

Table 2: Comparison between GMM and FE Results

Variable	Coefficient (GMM)	T-value (GMM)	Coefficient (FE)	T-value (FE)
ΔLn(labor cost)	0.36864	7.75	0.363953	6.284
ΔLn(Material cost)	0.32881	7.53	0.3309238	5.199
ΔLn(Electricity Cost)	0.10743	3.44	0.1073138	2.803
ΔLn (Value of Capital)	0.13224	4.48	0.1282334	3.497
ΔLn Import Penetration	0.2693	1.33	0.3180939	1.352
ΔTariff	0.08296	1.94	0.0807245	1.819
Worse Power Grid	-0.81019	-2.95	-0.4608963	-3.639
Begin FDI	-0.77872	-1.64	-0.6656899	-3.88
Reliability Of Government Improved	-0.19998	-0.98	-0.3423226	-2.841
Constant	0.61859	3.97	0.6487779	3.896

The pooled OLS also holds implications for the FE's results. The results of this regression are provided in Table 3. In general, the coefficients on the 2007 dummy interaction terms were insignificant. This supports the assumption that the betas are the same across time. However, the estimates for material and electrical inputs are not the same across time. Also, the estimates of the Pooled OLS differ from those found by the FE and GMM model. This suggests that the data contains fixed effects as opposed to random effects.

Table 3: Pooled OLS Results

Variable	Coefficient	T-value	Coefficient (2007 Dummy)	T-value (2007 Dummy)
Ln(labor cost)	0.4055074	9.313	-0.0333814	-0.382
Ln(Material cost)	0.4861088	12.687	-0.1996043	-2.382
Ln(Electricity Cost)	0.0189561	1.086	0.1923385	3.415
Ln (Value of Capital)	0.0689103	3.296	0.0150386	0.246
Tariff	-0.0063421	-0.736	-0.0173164	-0.969
Power Outage Dummy	-0.0432049	-0.714	-0.1212953	-0.948
Foreign Tech Dummy	0.109376	0.852	-0.1925568	-1.134
Direct Export Dummy	0.0623226	0.89	0.1779107	1.258
Direct Import Dummy	0.2768144	3.028	0.0072938	0.047
Government Reliability Dummy	0.0318127	0.541	-0.0565821	-0.45
FDI Dummy	-0.020996	-0.125	-0.2434821	-0.932
Furniture	-0.2259171	-1.733	0.0944405	0.372
Machines, Appliances	-0.0945556	-0.83	0.2312569	0.887
Textiles	-0.0792286	-0.598	0.1267672	0.493
Constant	1.4390701	2.345	1.9589395	6.742

INTERPRETATION

In general, the results of this paper support the robustness of the FE model which found an insignificant and sometimes negative relationship between openness and productivity. This does not mean that there was no productivity growth over the period. The presence of a positive, nearly significant time constant in the FE model suggest that firms in 2007 could generate higher sales than firms in 2001, all else being equal.

Furthermore, the results seem to reject several of the specific pass-through mechanisms argued for by other economists. For example, the negative relationship between the FDI dummy and sales challenges foreign interaction as a source of technological diffusion and productivity growth. Additionally, if foreign competition were to play a major role in productivity growth, import penetration would be significantly correlated to productivity. While the relationship between the two is positive in the FE and GMM models, it is not significantly different from zero.

Instead of trade, the FE model indicates that productivity gains occur mostly through improvements to infrastructure. This is consistent with results found in other studies of Brazil. For example, a recent literature review of papers on macro productivity found that infrastructure is widely agreed upon to be one of the main inhibitors of productivity growth in Brazil (Alston, Mueller, Melo, & Pereira, 2010). This could indicate that productivity stimulants are country specific.

The other explanatory variable which was borderline significant was reliability of government. The FE regression estimates suggest that there is a negative relationship between governmental reliability and productivity. Contrary to this result, intuition would suggest that advances in the quality of government should allow for greater efficiency at the firm level. The reason for the strange results of the FE regression could be attributed to the subjective nature of the variable which is based on managers' rankings of governmental reliability on a scale of 1 to 4.

Because the variable is based on a person's opinion, other factors such as the ideological leanings of the managers could influence the data. This problem is enlarged because the time period of this study corresponds with a presidential regime change from Cardoso to Lula. The perceived ideological differences between these two presidents could influence the data. Therefore, this variable may measure change in ideology of the president as opposed to a real change in governmental reliability. For instance, if less productive or failing firms preferred Lula—who is perceived to be a leftist—over Cardoso, the negative relationship between governmental reliability and productivity would make sense.

CONCLUSION

The period of this study was both a time of economic growth and increased openness. This fact is borne out by both macro level stylized facts presented at the beginning of this paper and the firm level data collected by Enterprise Surveys. While other academic papers have found a relationship between productivity growth and openness, my paper rejects that connection.

In spite of this, it appears that individual firms did become more efficient over the period. My results show a significant correlation between change in the amount of power outages and productivity, which could indicate that productivity growth is driven by improvements to infrastructure.

Even though my robustness checks largely supported the findings of the FE model, several data issues could have biased my results. The nonrandom sampling of the panel firms could have affected my results by excluding firms which tended to be less productive. Additionally, the diversity of industries found in my sample could affect my findings. While the FE approach helps to mitigate industry effects, it is unable to account for industry-specific production functions with different input elasticicities. Such sector variations would lead to biased estimations. The use of sales as a proxy for output is even more problematic. Without industry-specific prices to deflate this variable, changes in markup could adversely affect my results. For instance, if firms lowered their markups in the face of increased competition from abroad, my model could incorrectly identify the subsequent decrease in sales per unit of inputs as a reduction in productivity.

More work should be done to determine if productivity growth really stems from openness or from other factors like improved infrastructure. However, to accomplish this, better datasets need to be made available. Many of the potential biases of this paper resulted from data deficiencies. More accurate and complete data would allow for a more thorough analysis which is less constrained by some of the assumptions that I made. Hopefully, with detailed data, future researchers will be able to discover if there exists a causal relationship between productivity and trade and also find the exact mechanisms that instigate productivity growth. Additionally, future researchers should ask if there are any country-specific traits which either augment or mitigated the effect of openness on productivity. Answering these questions will allow policymakers to implement more effective reforms that promise great benefit to the world.

Appendix

Import Penetration (IP) = ln $\frac{Imp_i^{2007} * P_i^{2007}}{Size_i^{2007} * P_i^{2007}}$ $-$ln $\frac{Imp_i^{2001} * P_i^{2001}}{Size_i^{2001} * P_i^{2001}}$

= ln($Imp_i^{2007} * P_i^{2007}$) $-$ ln($Size_i^{2007} * P_i^{2007}$) $-$ln($Imp_i^{2001} * P_i^{2001}$) + ln($Size_i^{2001} * P_i^{2001}$)

=lnImp_i^{2007}+ lnP_i^{2007} $-$ ln $Size_i^{2007}$ – ln P_i^{2007} $-$lnImp_i^{2001} $-$ lnP_i^{2001} + ln$Size_i^{2001}$ + lnP_i^{2001}

=ln($Imp_i^{2007}/Imp_i^{2001}$) $-$ ln($Size_i^{2007}/Size_i^{2001}$) + ln($P_i^{2007}/P_i^{2001}$) $-$ln(P_i^{2007}/P_i^{2001})

If: ln($Size_i^{2007}/Size_i^{2001}$) = ln($Size^{2007}\big/Size^{2001}$) and ln($P_i^{2007}/P_i^{2001}$)= ln($P^{2007}\big/P^{2001}$)

Then:

IP = ln($Imp_i^{2007}/Imp_i^{2001}$) $-$ ln($Size^{2007}\big/Size^{2001}$) + ln($P_i^{2007}/P_i^{2001}$) $-$ ln($P^{2007}\big/P^{2001}$)

=lnImp_i^{2007}+ lnP_i^{2007} $-$ln $Size^{2007}$ – ln P^{2007} $-$ lnImp_i^{2001} $-$ lnP_i^{2001} + ln$Size^{2001}$ + lnP^{2001}

= ln($Imp_i^{2007} * P_i^{2007}$) $-$ ln ($Size^{2007} * P^{2007}$) $-$ ln($Imp_i^{2001} * P_i^{2001}$) + ln($Size^{2001} * P^{2001}$)

=ln $\frac{Imp_i^{2007} * P_i^{2007}}{Size^{2007} * P^{2007}}$ $-$ln $\frac{Imp_i^{2001} * P_i^{2001}}{Size^{2001} * P^{2001}}$

Therefore,

ln $\frac{Imp_i^{2007} * P_i^{2007}}{Size_i^{2007} * P_i^{2007}}$ $-$ ln $\frac{Imp_i^{2001} * P_i^{2001}}{Size_i^{2001} * P_i^{2001}}$ =ln $\frac{Imp_i^{2007} * P_i^{2007}}{Size^{2007} * P^{2007}}$ $-$ ln $\frac{Imp_i^{2001} * P_i^{2001}}{Size^{2001} * P^{2001}}$

if ln$Size_i^{2007}/Size_i^{2001}$ = ln$Size^{2007}\big/Size^{2001}$ and lnP_i^{2007}/P_i^{2001}= ln$P^{2007}\big/P^{2001}$

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