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Trade Barriers and Productivity Growth: Cross-Industry Evidence.[*]

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Abstract

This article investigates the impact of trade protection on the evolution of labor productivity and total factor productivity (TFP) of the Brazilian manufacturing sector. An annual panel-dataset of 16 industries for the years 1985 through 1997, a period that includes a major trade liberalization, was used. The regressions reported here are robust to openness indicator (nominal tariffs and effective protection rate were used), control variables and time period and suggest that barriers to trade negatively affects productivity growth at industry level: those sectors with lower barriers experienced higher growth. We were also able to link the observed increase of industry productivity growth after 1991 to the widespread reduction on effective protection experienced in the country in the nineties.

Very Preliminary Draft (August 1999)

1 Introduction

Import substitution was the foundation of development policy in Latin America and a large number of Third World countries after the Second World War. One of its main assumptions was the idea that growth could only be achieved by fast industrialization and by the reduction of the relative importance of agriculture. However, according to this doctrine, fast growth would not be achieved under free trade. On the one hand, making use of a static argument, not entirely clear or logical, under this regime the comparative advantage of poor countries would stay forever in the production of primary goods. On the other hand, more sophisticated reasonings would justify trade restriction based on infant industry

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and scale or learning factors. Moreover, in the early stages of development, importation of heavy machinery and other capital goods would be an essential part of the process so that, given the relative scarcity of foreign exchanges (due to a supposed decline in terms of trade, among other reasons), capital °ow controls would have to be imposed.

These arguments echoed loud among policy makers in the region, so that by the early ¯fties almost all the countries in Latin America had adopted one form or another of trade barriers. In some countries, Brazil for one, what was supposed to be a temporary policy became permanent. Instead of identifying those sectors where protection would make sense, there was widespread imposition of tari®s and quantitative controls (import ban, in many cases) to stimulate the domestic production of formerly imported goods. In most cases, these controls lasted until the beginning of the nineties. In Brazil, for instance, the so-called "lei do similar nacional" ("law of similar domestic production") would grant market shares for Brazilian ¯rms or impose extremely high tari®s in any sector where domestic production was present, with no phase-out timetable or incentives to reduce cost.

There is now evidence, however, at least for country-level data, that the imposition of trade barriers hurt rather than helped growth in the long run, and that for many countries the large degree of protectionism bears a good part of the blame for their disappointing macroeconomic performance. For instance, evidence regarding the positive relationship between open trade policy and growth rates at cross-country level has been documented recently by Edwards (1997), Frankel, Romer and Cyrus (1996), Harrison (1995), Lee (1993), Sachs and Warner(1965) and Taylor (1996), using various types of data samples and techniques[1]. Perhaps a more anecdotal but also indicative piece of evidence comes from picking some representative countries. Consider, for example, the four \dragons" of South East Asia: Singapore, Taiwan, Hong Kong and Korea. According to Lee's (1993) own-import weighted tari® rates on intermediate inputs and capital goods data, their average tari® rates are, respectively, 2%, 7%, 0% and 14%. Consider now the following, much less successful, list of countries: Argentina, Peru, Uruguay, India and Bangladesh. The numbers are: 29%, 41%, 21%, 132% and 41%.

In this paper we test the link of trade barriers and productivity growth at the industry level. We construct an annual panel dataset for 16 Brazilian industries at a level that roughly corresponds to 2-digit level in the classi¯cation adopted in the United States. We use labor productivity data and two (estimated) series of total factor productivity (one of them includes a rough measure of human capital). Most of our regressions use two alternative measures of trade protection, average nominal tari®s and e®ective rate of protection, to test for its impact on labor productivity and total factor productivity (TFP) growth[2]. We

[1] See also Edwards(1993) for a survey of empirical results on this subject and Krueger(1997) for a historical and theoretical discussion.

[2] In a recent paper, Rodr¶guez and Rodik(1999) critique part of the empirical literature

do not have data on quantitative restrictions, but this is not a serious problem in the present case because in the period of study - 1985 to 1997 - tari®s were the main policy instruments and most quantitative barriers were already abandoned, although some important exceptions remained.

There are few recent studies at micro level of the impact of trade policy on productivity growth, Lee(1996) being an exception. He used Korean industry data to estimate the impact of public policies - credit and trade policies, among them - on the growth of value-added, total factor productivity and capital stock growth and ¯nds that the impact of trade policy (nominal tari® and non-tari® barriers in this case) is negative and signi¯cant.

One of the main advantages of using this type of data is to control better for institutional and country-speci¯c factors that have been found important in previous growth studies. At cross-country level, the studies by Douglas North:(e.g., North[1981] and North[1990]) have stressed the importance of institutions and institutional changes (e.g., respect to contracts and property rights) as a major factor explaining growth. More recently, Hall and Jones(1998) shows that a qualitative index of "institutional infrastructure" composed of measures of bureaucratic e±ciency, degree of respect to contracts and rule of law, explains a large part of labor productivity dispersion across countries.

With a cross-industry panel dataset, institutional factors are basically the same for all cross-section observations, and institutional changes in the time-series dimension in general will a®ect industries in the same way so that the structure of incentives is similar across industries[3]. Moreover, valuable information is not lost as in aggregate data and, therefore, there is no aggregation bias. Finally, given that the decision units in theoretical models are individuals and ¯rms, the more disaggregate the regression the closer we are to theory. Of course, ¯rm-level data would be ideal, but there are no reliable data available and, in this case, industry-level data are less likely to have serious problems of measurement error.

This paper is organized in 3 sections, in addition to this introduction. The next section discusses the data used and presents the main stylized facts. Just to anticipate some of those, by 1990 the country experienced a major commercial liberalization, when average nominal tari®s to the industry felt from 105% to 14% while the e®ective rate of protection experienced an average reduction of 75%. At the same time, productivity growth rates, negative for most industries before 1990, reached extremely high levels after this year. Section three tests the statistical signi¯cance of this relationship while at the same time estimating

linking poor growth performance and trade policy. His criticism is centered on the estimation techniques and mainly on the data used in these studies, e.g. black-market premium, that might not be measuring trade barriers accurately. This is not the case in the present study, both series used - nominal tari® and e®ective protection rate - are traditional measures of commercial restrictions.

[3] They may di®er, however, in the degree of monopoly power and concentration. And this can partly explain policy (e.g. tari®s) across industries.

productivity elasticity with respect to measures of trade protection. Section four concludes.

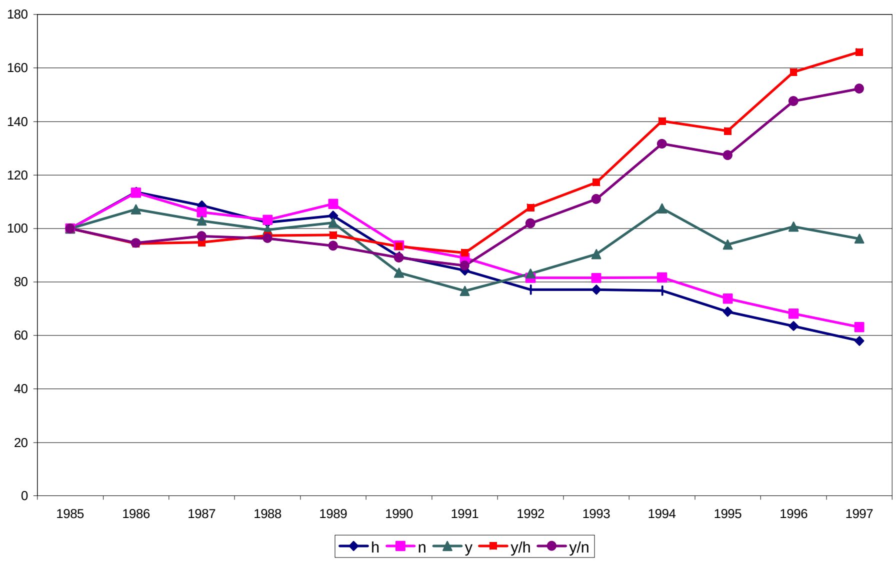
2 Productivity growth and trade policy in Brazil

2.1 Labor productivity

Labor productivity and output series were constructed using information obtained in the "Pesquisas Industrial Mensal - Produção Física" (Monthly Industry Survey - Physical Production) and "Pesquisas Industrial Mensal-Dados Gerais" (Monthly Industry Survey - General Data), both from IBGE. We constructed two measures of productivity: one used total hours worked and the other "total labor force employed in production"[4].There is no information on value-added by industry, so that we used physical output as a proxy. This of course can be a problem. Bonneli and Fonseca (1997), however, show that for the industry aggregate there is no significant effect. Moreover, at industry level, this would only be a relevant issue if the input-output relation within each sector changed considerably in the period, or if inputs that were previously produced in the sector started to be acquired outside it. Both facts are not true in the present case[5]. Figure one below presents the evolution of average productivity, average hours, average employment and average output of the 16 Brazilian manufacturing industries for which there are data available for the entire period (1985 to 1997).

[4] This series does not include administrative workers and services such as security or cleanning, so that the corresponding productivity measure is not affected by the observed trend of sub-contracting some of these services.

[5] It is interesting to note that, in a study for 19th century U.S., Engermen and Sokoloff (1986) finds that the growth rates of labor productivity and total factor productivity for 15 industries are very similar either using value added or gross output.



Labor Productivity (Industry Average, 1985-1997)

In the picture above, h stands for hours, n for labor force and y for output. These 13 years can be divided in 3 sub-periods: 1985-1989, 1990-1993 and 1994-1997. In the ¯rst one, labor productivity declined at an annual rate of -1.61% or -0.57%, in the output/labor or in the output/hours concepts, respectively. In this period output and employment increased, but the latter more than the former. Between 1990 and 1993, coinciding with the beginning of trade liberalization, average productivity increased at an annual rate of 5,11% (when using hours) or 4,80% (when using the employment concept). In this period the country was experiencing a recession but output reduction was more then compensated by employment reduction. Finally, the 1994-1997 period is one of very fast productivity growth (above 8.5% in both concepts). Employment kept its negative trend but in this case output increased in all industries. All in all, the two productivity measures have the same trend for the entire period.

Behavior by industry is similar. For instance, in the 1994-1997 period all the 16 sectors experienced fast productivity growth, with the "plastic material" (12.46% annual growth rate) and "rubber products" (12.81% annual growth rate) industries leading. On the other hand, in the ¯rst sub-period most industries had negative productivity growth, textiles with the worst record (-3.31% annual growth). In the second sub-period, on the other hand, only two industries experienced negative productivity growth: plastic material (-1.42%) and pharmaceutical (-1.64%).

2.2 Total Factor Productivity

Total factor productivity is measured in the standard way. Assume Cobb-Douglas production function:

$$Y_{it} = A_{it}.K_{it}^{\alpha}.H_{it}^{\beta}.L_{it}^{\gamma}; \quad i = 1; ...; N; \quad t = 1; ...; T; \tag{1}$$

where Y_{it} denotes output of sector i at time t; and K; H and L stand for physical capital, human capital and raw labor, respectively. Hence, in this formulation the residual A is equivalent to the TFP. Applying logarithm and differentiating with respect to time we obtain the expression below:

$$\frac{\dot{Y}_{it}}{Y_{it}} = \frac{T\dot{F}P_{it}}{TFP_{it}} + \alpha.\frac{\dot{K}_{it}}{K_{it}} + \beta.\frac{\dot{H}_{it}}{H_{it}} + \gamma.\frac{\dot{L}_{it}}{L_{it}} \tag{2}$$

The capital series were constructed from investment data obtained in the "Pesquisa Industrial Anual ("Annual Industry Survey") of the IBGE. We used the perpetual inventory method, assuming a constant annual depreciation rate of 5% per year and investment values were deflated by the gross capital deflator calculated in the national account. In order to remove possible effects of business cycle fluctuations on TFP, the stock of capital obtained was multiplied by the rate of utilization of sector capacity to obtain the fraction of physical capital effectively used in production.

As for human capital, there is no detailed information at the industry level, only aggregated information of average schooling years of the labor force for two main groups, "modern" and "traditional" industries, surveyed by the IBGE. The first group includes the following sectors: transportation equipment, electronic and communication equipment, mechanical machinery, plastic products and metalworking, the remaining sectors being classified as traditional. Consequently, most of the variation is in the time-series dimension, given that for each year there are only two observations of the human capital stock. Instead of discarding this incomplete information, we opted to perform two sets of estimations of the TFP, one without human capital:

$$\frac{\dot{Y}_{it}}{Y_{it}} = \frac{T\dot{F}P_{it}}{TFP_{it}} + \alpha.\frac{\dot{K}_{it}}{K_{it}} + \gamma.\frac{\dot{L}_{it}}{L_{it}} \tag{3}$$

and the other using the above-mentioned series as human capital stock for each industry, so that we obtain exactly equation (2)[6].

Our data consist of a panel of 16 industries for 13 years (from 1985 to 1997). There are basically two main techniques for panel estimation. One is the

[6] We could also perform a Mincer transformation in the schooling series. However, given that there is not much variation in years of education across industries - in 1985, for instance, the average years of scholling in the modern industries was 4.15 years while in the traditional industries it was 3.84 years - this transformation would not make any difference.

¯xed-e®ects method which is essentially an OLS regression with cross-section dummies. The other is the random-e®ects method in which the intercept is considered a random variable and the generalized least square method is used. According to Hsiao (1993) the former is the proper procedure when estimating regressions with a speci¯c number of sectors of ¯rms and the inference is restricted to the behavior of this set. On the other hand, if the study is concerned with a large number of individuals or ¯rms, so that they could be viewed as a random sample of a larger population, the latter method is recommended. We ran the Hausmann speci¯cation test, shown in the appendix, in order to decide between those two methods and the result favored the ¯xed-e®ects method, which we therefore used in all regressions[7].

After testing for endogeneity of output growth rates, and rejecting the OLS method being consistent, we estimated factor shares using instrumental methods. In the present case the method chosen was the Weighted 2 Stages Least Squares, which also corrects for cross-section heteroskedasticity. In this case, lagged variables were used as instruments. Moreover, constant returns of scale were imposed. Estimated factor shares, from regressions of equation (3), are presented in Table 1 below. Both labor measures were used.

Table 1: Factor Shares Estimation

Independent Variable	Labor Variable	
	n	h
Physical Capital	0:46	0:36
	(7:16)	(5:47)
Labor	0:54	0:64
number of observations	192	192

note: t-statistic in parenthesis, method:w2sls

Results are slightly sensitive to the labor series used, as the estimated labor share is 0.10 points higher when we used hours (h) instead of labor force (n). In any case, the values found are not far from international evidence and national account estimates. For our purposes these small di®erences are not important as they did not change the behavior of the estimated TFP series, which is our ¯nal objective here.

In both cases, TFP growth rate has the following behavior: between 1985 and 1989 it declined in almost all industries, in certain cases at annual rates above 3%. From 1990 to 1993 this trend is reverted, as we observe positive but small growth in all but one industry. The average growth rate jumps from minus 1% in the previous period to 2%. In the ¯nal period, again all but one industry (sector 10, "perfumes, soap and candles") had positive TFP annual growth, but the rates now are considerably higher as the average growth more

[7] Hence, we are implicitly associating TFP growth to the country-speci¯c ¯xed e®ect and a disturbance term.

than doubled. In exactly half the sectors, annual growth rates are above 5%, an impressive performance. Note also that the evolution of labor productivity in the period is very similar, although magnitudes vary. Table 2 below displays TFP annual growth rates by industry in the 3 sub-periods, for the case were hours where used as labor variable[8]:

Table 2: TFP Annual Growth Rates

industry	Period		
	1985-1989	1990-1993	1994-1997
1	-0,49%	1,66%	5,58%
2	1,30%	2,77%	6,71%
3	3,02%	2,96%	4,41%
4	-0,31%	5,41%	5,32%
5	-6,53%	1,15%	5,54%
6	-1,84%	1,35%	4,40%
7	-1,67%	2,13%	4,60%
8	-4,57%	1,61%	8,10%
9	-0,56%	0,22%	0,36%
10	6,17%	4,78%	-0,54%
11	-1,71%	-2,88%	5,89%
12	-1,61%	4,30%	2,67%
13	-4,48%	1,11%	1,23%
14	-0,88%	3,21%	4,66%
15	-0,52%	4,65%	6,68%
16	1,59%	0,82%	6,43%
Mean	-1,03%	2,00%	4,29%

note: TFP estimated by W2SLS.

2.3 Trade Policy and Tari®s

Import substitution and protection to infant industry were the foundation of industrial policy and development strategy in Brazil until the end of the eighties. Up to 1979, quantitative controls, reserved market shares and outright import bans were the dominant policy instruments. The so-called "lei do similar nacional" ("law of similar domestic production") banned the importing of or imposed prohibitive tari®s on any industrial product competing with domestic production. After 1979, tari®s were re-established as the main instrument of trade policy and quantitative controls were gradually abandoned, but some remained. However, to compensate for the decrease in industry protection, nominal tari®s were raised to levels well above international standards. In 1988

[8] Numbers, instead of the names of the industries, are used to save space. In the appendix the corresponding industries are presented.

there began a process of trade liberalization. First timidly with the elimination of redundant tari®s, but after 1990 the pace of the reform accelerated. All quantitative controls were de¯nitely eliminated and a timetable established for tari® reduction. As a result, tari®s and exchange rates have since become the main instruments of trade policy in the country.

Table 4 below displays the average nominal tari® for the 16 industries between 1985 and 1997. On average, tari®s in the ¯rst period were almost eight times larger than in the 94-97 period. The highest tari®s in the ¯rst ¯ve years were observed in consumption industries such as tobacco (industry number 16), beverages (industry 15), clothing, fabric products and footwear (industry 13), perfumes, soap and candles (industry 10) and textiles (industry 12). The lowest tari®s were those on intermediate industries such as chemistry (industry 8) and machinery (industry 3).

Table 4: Average Nominal Tari®s

Industry	Period		
	1985-1988	1989-1993	1994-1997
1	87.70	18.97	7.18
2	65.15	21.33	12.41
3	58.88	31.59	16.76
4	91.73	34.69	18.31
5	105.53	40.65	24.69
6	75.80	17.34	10.48
7	95.58	37.12	12.63
8	32.48	16.70	6.63
9	43.28	22.92	8.58
10	158.83	44.40	8.58
11	142.93	34.79	16.38
12	142.03	39.54	15.18
13	166.55	45.31	19.55
14	77.50	23.51	12.53
15	159.50	54.66	13.93
16	176.10	60.55	10.16
mean	104.97	34.00	13.37

Sources: Pinheiro e Almeida (1994), Kume(1996). Data for 1997 were based on the Mercosul common tari®s.

It is interesting to note that although the fall in nominal tari®s after trade liberalization is widespread across sectors, the ordering is more or less the same as before, and consumption industries still have more protection than intermediate and capital-goods industries. The highest average tari® is found in the transportation industry (industry 5) due to exceptions obtained in the Mercosul Treaties by the automobile industry. Average nominal tari® in this case is almost twice as large than the overall average for the 16 sectors.

The study of e®ective protection rate behavior rather than nominal tari®s behavior is pehaps more important to understand the impact of trade policy on productivity growth. This is so because that measure takes into account not only the price of ¯nal product but also that of the inputs used in its production. If we de¯ne e®ective protection rate as the percent increase in domestic value-added due to (tari® and non-tari®) protection relative to free trade value-added, we have:

$$g_j = (V_{ad} - V_{alc})/V_{aLc}$$

where g_j is e®ective protection to industry j; V_{ad} is value-added at domestic price in industry j and V_{alc} is free trade value-added (i.e., at international prices). The expression above is equivalent to:

$$g_j = (t_j - \sum a^{lc}_{ij}.t_i)/(1 - \sum a^{lc}_{ij})$$

where $a^{lc}_{ij} = a^{d}_{ij}.(1 + t_j)/(1 + t_i)$ is the free trade technical coe±cient, measuring input i participation in ¯nal price of industry j (both at international prices); a^{d}_{ij} is the distortionary technical coe±cient, measuring input i participation in ¯nal price of industry j; at domestic prices; t_j is the nominal tari® in industry j and t_i is the nominal tari® of input i: Hence, e®ective protection is a better measure of barriers to trade as it takes into account the incentives a®ecting ¯nal product but also a®ecting inputs. For instance, an industry with high nominal tari®s on ¯nal price (high t_j) and low nominal tari®s on its inputs (low t_i) has high e®ective protection, while one with low t_j but high nominal tari®s on its inputs has low e®ective protection. Table 5 below displays e®ective protection rates calculated for the 1985-1997 period.

Table 5: E®ective Protection Rates

Industry	Period		
	1985-1988	1989-1993	1994-1997
1	35.65	27.52	13.63
2	57.24	27.03	16.68
3	26.38	32.74	18.96
4	95.24	41.27	22.75
5	60.96	122.47	75.66
6	30.88	14.92	10.66
7	108.13	46.12	14.81
8	56.92	17.11	7.84
9	52.38	26.13	7.96
10	96.10	59.07	26.10
11	339.85	40.55	23.20
12	61.30	49.05	21.96
13	203.68	57.61	22.48
14	34.47	25.02	15.59
15	18.90	70.44	21.98
16	-3.96	6.85	10.80
Mean	79.63	41.49	20.69

Sources: Pinheiro e Almeida (1994), Kume(1996). Data for 1997 were based on the Mercosul common tari®s.

On average, e®ective protection rates are today one fourth of the 1985 values. The decrease, however, is not uniform, and at least in the transportation industry the e®ective protection rate is still high. As a matter of fact, it is now above the ¯gure of ten years ago. The largest reductions were observed in the industries of plastic products (sector 11) and "clothing, fabric products and footwear" (industry 13). In the ¯rst case the current rate is less then 7% of its 85-89 average. Note also that there is a decrease in the tari®s dispersion: the standard error to average ratio fell from 1.05 to 0.76 in the period.

More important for us here is to notice that the observed increase in the growth rate of total factor productivity and labor productivity across industries in the period coincides with the reduction of nominal tari®s and of e®ective rate of protection. According to table 2, cross-industry annual TFP growth rate was -1.03% in the 85-89 period and jumped to 4.29% between 1994 and 1997. As said before, average nominal tari®s in the last sub-period was less than 13% of ¯rst period tari®s and e®ective protection rate was one fourth. In the next section we investigate this relationship econometrically.

3 Estimations

Following the same procedure as is section 2.2 we performed Haussman speci¯-cation tests and the results once again favored the ¯xed-e®ects method, which we therefore used in all regressions. We also ran the same diagnosis test to test for the endogeneity of trade variables. It could be the case that lower productivity sectors, being less able to compete with imports, received higher protection. It is shown in the appendix that the OLS test is consistent, so we did not use any instrumental method to test for the links between productivity growth and trade policy. We started regressing either nominal tari®s (NT) or e®ective protection rates (EPR) on labor productivity or TFP growth rates. We then included other variables that previous empirical or theoretical studies found relevant to explain productivity growth. In addition to testing their signi¯cance for the present case, this would also test the robustness of our results. If the inclusion or exclusion of variables changed dramatically the magnitude, sign or signi¯cance of NT or EPR estimates, the results would be considered fragile and we would reject the link between them (or openness) and productivity growth.

We basically tested 3 additional variables: import ratio,export ratio and in°ation. The trade ratio variables are industry-speci¯c indexes. They may be considered direct measures of openness but also, especially in the case of imports, indirect measures of technological adoption (see, for instance, Coe, D.T., E. Helpman, A.Ho®maister(1995) and Holmes and Schmitz (1995)). Other channel of imports a®ecting growth would be increasing returns {as in Romer and Rivera-Batiz (1991) or Grossman and Helpman (1991). The negative impact of in°ation on growth is well documented (e.g., Fischer(1993)). One possible channel would be the increase in uncertainty brought about by higher price volatility (Ramey and Ramey (1996)). For our regressions, 16 industry sector in°ation rates were constructed from industry prices indexes. Export ratios may also be used to test export led growth arguments.

In what follows we present three sets of regressions, with di®erent independent variables: labor productivity, TFP constructed without human capital and TFP with human capital. We used the following equation in all estimations:

$$\dot{Y}_{it} = \beta_i + \phi . Z_{it} + \varepsilon_{it}; \qquad i = 1, ..., 16; \quad t = 1985, ..., 1997 \qquad (4)$$

where $\dot{Y}_{it}$ is the growth rate of productivity (either labor productivity or TFP), Z_{it} is a vector of independent variables that always contain one of the two openness indicators, β_i is the country-speci¯c ¯xed e®ect, and ε is the error term.

3.1 Labor productivity

Given the high correlation (0.95) between the two labor productivity measures constructed, we opted to present only the results of the estimations that used "labor force used on production" as the labor variable. Just to be sure, we ran a set of regressions with the other productivity measure and the results as expected were very similar. Table 6 below presents the results.

Table 6: Labor Productivity Growth Regressions

Model	Independent Variable		
	NT	EPR	M
1	-0.041 (-7.96)		
2		-0.048 (-7.18)	
3	-0.045 (-7.35)		0.001 (1.29)
4		-0.037 (-5.42)	0.033 (3.17)

note: t-statistic in parenthesis, NT: log of nominal tariffs, EPR: log of effective protection rate, M: log of industry-import ratio. 192 observations. Method: WLS

The results reported above confirm the negative relationship between labor productivity and barriers to trade. They are also robust to changes in the set of control variables. In models 2 and 4 it can be seen that a 20% reduction in the effective protection rate implies an increase between 1% and 1.2% in the growth rate of labor productivity. The inclusion of import ratio, inflation and/or export ratio (not reported here) did not change the results, although the estimated coefficients were smaller in general. Remember that in certain cases (see table 3) effective protection dropped from more than 200% to less than 25% and that, on the average, it fell from 75% to 20%. Hence, the present results would imply, for instance, that the 70% mean reduction in effective protection rate could explain a 3% to 4% increase in the labor productivity growth rate. Remember also that prior to trade liberalization labor productivity was falling at an annual rate of -1% and that in the last 4 years, it increased 8% per year on average.

The results of the regressions with nominal tariffs (models 1 and 3) are also significant and robust to changes in controls. They also show that increases in protection imply slower productivity growth and the estimated elasticities are in the same order of magnitude as in models 2 and 4. A 20% reduction of the average nominal tariff of any industry would induce increases around 1% of its productivity growth rate. We have seen that the average tariff reduction in the period was around 85%, so that, according to the estimations above, this brought abound a 6% increase in the productivity growth rate.

With respect to the other control variables, the impact of the inflation rate was either estimated as negligible or non-significant. This result holds also for

TFP regressions. Uncertainty or own price increases do not seem to be an issue for industry productivity determination. The estimated coefficient of import ratio had the expected sign and was significant in some cases. Higher sector imports seem to be mildly correlated to increases in labor productivity. On the other hand, exports ratios were not robust and not significant in almost all regressions[9].

3.2 Total Factor Productivity

Table 7 below presents the results of the estimations of equation (4) with TFP growth rate as the dependent variable.

Table 7: TFP Growth Regressions(w/o Human Capital)

Model	Independent Variable		
	NT	EPR	M
1	-0.031 (-6.23)		
2		-0.040 (-6.10)	
3	-0.030 (-5.55)		2.30 (0.66)
4		-0.038 (-5.41)	1.75 (0.44)

note:t-stat. in parenthesis, NT: log of nominal tariffs,
EPR: log of effective protection rate,
M log of industry import ratio.Method:WLS

Results are similar to those obtained with labor productivity. Wheter trade barriers are measured by effective protection rate or nominal tariffs, its estimated effect on total factor productivity growth is negative, robust to control variables and always significant. The estimated coefficients are slightly smaller, but of relevant magnitude in any event: -0.03 in the regressions with nominal tariffs, and -0.04 in the regressions with effective protection rate. This is somewhat expected as now we are subtracting the effect of capital stock; moreover, TFP growth rates are on average considerably smaller than labor productivity growth rates. Still, trade liberalization in the country can explain a large part of TFP growth: the decrease in the effective rate of protection observed in the period implies, according to our estimations, an increase of 3% of the TFP growth rate. If we use nominal tariffs the estimated impact is even larger, as tariff reduction was more dramatic than the drop in the effective protection rate

[9] Note that the above table and the next two do not present all regressions used to test robustness. The total number is much larger as it includes not only exports, but combinations of exports, imports and inflation. The resulting estimations, however, are very similar.

and the estimated elasticity is also higher in absolute value. Results for import ratio, export ratio and in°ation follow exactly those of the labor productivity case. For instance: the estimate e®ect of in°ation is not signi¯cant at the usual con¯dence interval.

Table 8 below presents regression results of the case when TFP was constructed considering human capital[10]. They follow closely the results of the previous table. Estimates of the TFP growth elasticity with respect to the effective protection rate are smaller than corresponding estimates using nominal tari®s . According to the present results, increases of 20% in the latter variable would decrease TFP growth rate by 0.6% and increases of the same order of magnitude in the e®ective protection rate would reduce TFP growth rate by 0.5%. Although these values are small, it is still the case that they are not only robust and very signi¯cant, but when we take into account the magnitude of the trade liberalization and tari®s reduction in the country, the estimated e®ect is still very relevant. For the plastics industry, for instance, where the e®ective rate of protection dropped by more than 90%, the estimated increase in TFP growth rates is above 2.3%.

Table 8: TFP Growth Regressions(w/ H. Capital)

Model	Independent Variable		
	NT	EPR	M
1.1	-0.031 (-3.38)		
1.2		-0.026 (-2.77)	
1.3	-0.029 (-2.94)		10.135 (2.64)
1.4		-0.021 (-2.50)	11.904 (3.15)

Note: t-stat. in parenthesis. See Table 7 for variables.
Method: WLS

3.3 Alternative Frameworks

One potential problem in using annual data to run TFP regressions is that business cycle °uctuations that a®ect the behavior of output and factors may also a®ect the productivity measurement, although those °uctuations have no long run impact on the productivity trend. This is the case if labor hoarding is a relevant fact or if capital services is measured by the stock of capital and not by the stock of capital e®ectively used in production. In this case, during

[10] The results of Table 8 are extremely preliminary as we have no con¯dence in the TFP regressions with human capital and we did not run all the necessary diagnostic tests.

a recession, for instance, while output reduces, input levels are kept constant; consequently, measured TFP would also reduce. The opposite would occur during a recovery. In the present study the capital series used to construct TFP was already corrected by the capacity utilization rate . However, we may have a problem in the labor series, especially with the "labor force used in production" series. To check for this fact, we run a series of regressions with 3-year averages, in order to reduce potential problems caused by business °uctuations. Table 9 below presents a sample of the results.

Table 9: TFP Growth Regressions
(Correcting Cyclical E®ects).

Model	Independent Variable	
	NT	EPR
1.1	-0.053 (-6.52)	
1.2		-0.042 (-3.12)

note: t-statistic in parenthesis; method: wls.
observations are 3-year averages.

The above regressions used the WLS method and results are robust to the inclusion or exclusion of control variables. The TFP series used does not employ human capital. The comparison with table 7 shows that the results are similar. The estimated coe±cients of the e®ective rate of protection are almost the same in the two tables and those of nominal tari®s are close to each other, while in table 9 it is slightly higher. This similarity can be explained either because we had already taken into account business cycle and short term °uctuations when constructing the productivity series or because cyclical e®ects do not have a relevant e®ect on the correlation between trade protection and growth in the present context.

Another potential problem here is that when we ¯rst estimate the TFP and then the e®ect of trade barriers on it, the errors of the two sets of regressions might compound on each other. The ¯nal estimated elasticity, hence, might be estimated less precisely than if we just estimate a production function directly, substituting in the trade variable. In other words, we have been assuming the following relationship between productivity growth and, for instance, nominal tari®s:

$$\frac{\dot{TFP}_{it}}{TFP_{it}} = \beta_i + \phi NT_i + \varepsilon_{it}$$

where β_i is the country-speci¯c ¯xed e®ect and ε_{it} is the disturbance term. So we could plug the above expression in (3) and obtain:

$$\frac{\dot{Y}_{it}}{Y_{it}} = \beta_i + \phi NT_i + \alpha.\frac{\dot{K}_{it}}{K_{it}} + \gamma.\frac{\dot{L}_{it}}{L_{it}} + \varepsilon_{it} \qquad (5)$$

This type of model was used, for instance, in Harrison(1995) for a panel data of developing countries. In the present case, the effect of trade barriers on output growth when directly controlling for factors growth is estimated. Table 10 below presents the results of the estimation of equation (5) using our panel of Brazilian industries:

Table 10: Output Growth Regressions

Model	Independent Variable				
	Dk	Dn	Dh	LPE	NT
1	0.47	0.53		−0.067	
	(6.94)	-		(−6.98)	
2	0.50	0.50			−0.063
	(6.50)	-			(−7.74)
3	0.43		0.57	−0.063	
	(6.36)		-	(−6.49)	
4	0.47		0.53		−0.060
	(6.16)		-		(−7.62)

note: t-statistic in parenthesis. NT:log of nominal tariffs, EPR: log of effective protection rate. Dk, Dn and Dh: growth rate of physical capital, labor force and hours, respectively.

After testing, we used the w2sls method with lag variables serving as instruments for factors of production but no instruments for the trade variables. We ran regressions using both hours and labor force as the labor variable. As can be seen from the four regressions above, the estimated effect of trade restriction measures on output growth is significant and has the expected sign in all regressions. Moreover, the estimated coefficients are considerably higher, being in the case of nominal tariffs, more than twice as big as those in table 7. In model 2, for instance, it is −0.063, whereas in table 7 it was at most −0.031. The sequential estimation (first the TFP, then trade barriers on TFP), if anything, hurt the case of negative growth effects of trade barriers as it can be biasing downward its true magnitude.

4 Concluding Remarks

The estimated measures of productivity growth for the 16 Brazilian industries studied in this article all display a common patter of behavior in the years between 1985 and 1997: first they fall, then increase after 1990. In the same period, the country moved to liberalize its international trade, reducing tariffs, eliminating import quotas and reserved market shares and consequently decreasing the protection of domestic production. Estimations in this article allow us to conclude that there is a signi¯cant and robust relation between these two facts so that the higher the barriers to trade, the lower the growth rate of total factor productivity and labor productivity.

These results question the import substitution model as a long-run development policy. If it is true that Brazil experienced high growth rates after the war, our evidence says that this could be mainly due to accumulation of factors and that it occurred under low productivity growth. Import quotas and/or bans and punitive tari®s gave no incentive for domestic ¯rms to invest in technology adoption, while increasing the price and restricting the set of intermediate inputs available to production. Consequently, the low productivity level of domestic industries end up hurting these industries in the long run, especially after trade protection reduction and increased competition from import products. In other words: trade barriers implied slow or even negative productivity growth, with slow technical progress, and had a negative impact on the country's long run prospects.

The present results also show that, as the country moved to adopt a less restrictive comercial policy, the response was strong and impressive, and productivity growth rates changed from negative or negligible to positive and high. This is an optimistic result not only for Brazil but for Latin America, where most countries are now following similar trade liberalization policies.

The question left to be answered and that we intend to investigate in future research is why some industries had tari®s and e®ective protection so much higher than others. One possible answer is monopoly power: the more concentrated the sector, the higher its political leverage and the greater its chance to obtain advantages in the form of tari® protection, tax breaks and subsidy.

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A table of industries

Table A.1: Industry Classi¯cation

Number	Industry
1	Nonmetal mineral products
2	Metalworking
3	Machinery
4	Electronic and communication equipment
5	Transportation and motor vehicles
6	Paper and paper products
7	Rubber products
8	Chemicals
9	Pharmaceutical
10	Perfumes, soap and candles
11	Plastic products
12	Textiles
13	Clothing, fabric products and footwear
14	Food
15	Beverages
16	Tobacco products