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Input Trade and Service Industry Productivity Growth[*]

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ABSTRACT

In this paper, I address two questions: (1) Does reducing tariffs for manufacturing inputs affect productivity in service industries? (2) Does the effect of input trade liberalization differ for importers in service and manufacturing industries? To answer these questions, I used an establishment-level survey of Uruguayan service industries from 1998 to 2005, a period in which the country reduced its tariffs on manufactured products. I found that service establishments that import inputs from abroad experience a larger increase in productivity relative to non-importers when input tariffs are reduced. Furthermore, the effects of trade liberalization are as significant in the service industries as in manufacturing.

KEY WORDS Input Trade; Productivity; Service Industry; Uruguay

A well-established channel on how international trade affects productivity is the idea of technology diffusion. Theoretical approaches such as those of Ethier (1982), Markusen (1989), Grossman and Helpman (1991), Rivera-Batiz and Romer (1991), and Eaton and Kortum (2002) suggest that when a country lowers its barriers to trade, the variety and the quality of inputs it uses will improve as a result of specialization.[1] The basic idea behind this channel is that when a domestic firm purchases a manufactured product to use as an input (hereby referred as *manufacturing input*), any technology embodied in the input can be "spread" to different countries. Furthermore, the technology embodied in these inputs is nonrival; any firm can access the same technology by buying the identical input. Input trade therefore allows developing countries that do not have a comparative advantage in research and development

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(R&D) to move closer to the global technology frontier through input trade, allowing them to access the embedded technology without paying the R&D cost to acquire it.

This paper addresses two questions: (1) Does reducing tariffs for manufacturing inputs affect productivity in service industries? (2) Does the effect of input trade liberalization differ for importers in the service and manufacturing industries? The paper aims to fill the gap in current empirical evidence on the technology-diffusion hypothesis by focusing on the productivity gains from input trade for service industries. So far, the empirical evidence on productivity gains from input trade focuses on the impact for manufacturing firms,[2] although service industries may also benefit from input trade liberalization through their usage of foreign manufacturing inputs. Imported inputs account for a non-negligible percentage of all inputs used by service industries. For example, World Bank's enterprise survey found that among 87 developing countries, the average level of imported inputs equals 37 percent.[3] Furthermore, while service industries are growing in importance relative to manufacturing in most developing nations, the impacts of trade liberalization on service industries is relatively unknown. To obtain a complete picture of the consequences of trade policies, it is therefore crucial to evaluate the effects on service industries.

Two things motivate this paper: (1) the attempts that have been made to liberalize trade in Uruguay and (2) the importance of service industries to Uruguay's economy. Since the late 1980s, Uruguay has gone through a series of reforms that have reduced tariffs on imported products. In 1998, the country joined the trading bloc MERCOSUR, which aims to create a customs union in South America. As a member of MERCOSUR, Uruguay adhered to the convergence scheme in the union and began the process to reduce its common external tariff (CET) to the level of other MERCOSUR countries. The result was that by 2005, 86 percent of all items imported to Uruguay from non-MERCOSUR countries was subject to CET (Vaillant 2005), higher than the average of all MERCOSUR countries. Service industries accounted for the majority of Uruguay's production and employment. For example, from 1998 to 2005, the service industry's value added on average accounted for 61.7 percent of the country's GDP and for 66.8 percent of the country's total employment (World Bank 2021a, 2021b). The country's accession to MERCOSUR and the importance of its service industry justify the understanding of how trade liberalization contributes to productivity growth in its service industries.

To answer both research questions, this paper uses a firm-level panel survey for Uruguay provided by the National Statistics Institute (INE) from 1998 to 2005 that contains information on importing status, value of production, and usage of inputs for firms in both manufacturing and service industries and adopts a fixed-effect estimation strategy to test the technology-diffusion channel among firms in the service industry. To be consistent with the channel, the effects of input-tariff reduction should be amplified by the share of imported intermediate input. In other words, firms that import more should grow productivity by a larger amount than others. Given the availability of data, however, this paper uses the share of capital inputs imported from abroad (hereby referred to as *imported capital share*) as a proxy for the share of imported intermediate inputs (hereby referred to as *imported input share*). Although imported capital share is not a perfect measure for imported input share, it is an adequate proxy for the latter, as both shares are somewhat correlated.[4] Furthermore, using imported capital share is still consistent with the technology-diffusion story, as imported capital itself also embeds production technology from abroad.[5]

The main result is that for firms in service industries, higher imported capital share magnifies the productivity gains from input tariff reduction. The effects are robust to alternative measures of productivity, the addition of country-sector-year varying controls, and alternative econometric specifications. Another result suggests that the effects of input trade liberalization for importers are as strong in service industries as in manufacturing industries.

These results support the idea that international trade promotes technology diffusion. As in Eaton and Kortum (2001), the gains from input trade follow a simple Ricardian idea: when all countries in the world specialize based on their respective comparative advantages, countries without a comparative advantage in research and development can import inputs incorporating R&D efforts from abroad. The results also highlight another potential benefit for enabling developing countries to integrate themselves into global supply chains as users of intermediate inputs. Whereas traditional trade theory focuses on the consumption gains (i.e., the welfare effects) from trade, the technology-diffusion channel highlights the *production* gains from trade. For developing countries, the integration implies increased access to the R&D efforts from other countries in the form of higher quality input. This allows developing countries to achieve the productivity gains necessary for further gains in employment and wages, which are among the most important objectives under the United Nations' Sustainable Development Goals.

The results in this paper are consistent with studies investigating the liberalization of trade in manufacturing goods on productivity in the service sectors. Dehejia and Panagariya (2016) look at how trade liberalization in Indian manufacturing sectors contribute to labor productivity growth in the service sectors and the spillover effects of such productivity growth on the Indian manufacturing sectors. Malchow-Moller, Munch, and Skaksen (2015) study the effects of manufacturing inputs and service inputs in the productivity for Danish manufacturing and service industries using firm-level data. Both papers find that reduced tariffs and increased imports in manufacturing inputs can positively affect the productivity of the service industry. In addition, this paper complements the macroeconomic-level studies on input trade restrictions and productivity growth such as those by Coe and Helpman (1995) and Estevadeordal and Taylor (2013) by examining and comparing the growth effects between firms in both the service and manufacturing industries.

The next section of this paper explains the empirical strategy. The paper then introduces the data used and presents the results before concluding.

ESTIMATION STRATEGY

Measuring Productivity

Following the standard assumption in studies on productivity growth, all firms have the following Cobb–Douglas production function:

$$Y_{eit} = A_{eit} K_{eit}^{\beta_{1i}} L_{eit}^{\beta_{2i}}, \tag{1}$$

where the value added (*Y*) for firm *e* in industry *i* at time *t* is a function of capital (*K*) and labor (*L*). Equation (1) suggests that within all service industries, the elasticities of capital and labor with respect to output (β_1 and β_2) are identical across firms and remain constant over time, although the elasticities can be different from those in manufacturing industries. The productivity measure in this paper is total factor productivity (TFP), which is the unobserved factor that represents how efficiently the firm uses its production factors *K* and *L*. TFP is represented by A_{eit} in Equation 1. A rise in TFP implies that production factors *K* and *L* are used more efficiently in the production process, as the same amount of *K* and *L* result in higher production *Y*.

TFP for each firm is constructed as the residual from running a regression based on Equation 1.[6] In particular, TFP for each firm is equal to the following:

$$tfp_{et} = y_{et} - \hat{\beta}_1 k_{et} - \hat{\beta}_2 l_{et} \tag{2}$$

One concern with this estimate is that the decision to employ capital and labor is endogenous to productivity shocks. In this case, the coefficients in Equation 2 are biased because they capture the effects of the shocks. To address this potential issue, this paper follows the Levinsohn and Petrin (2003) estimation method to control for the simultaneity problem in which the input choice of a surviving firm depends on its productivity level. This method addresses the issue by using other intermediate inputs to act as proxies for the shocks. The identifying assumption behind the method is that firms increase their use of certain inputs following a positive shock to productivity and as a result, the unobserved shocks can be estimated with the observed usage of inputs. Once the unobserved shocks are proxied, the estimated coefficients in Equation 2, and thus the TFP measure, should be consistent. This paper uses the consumption of materials deflated by the producer price for intermediate goods as the proxy.

Table 1 presents the regression results from estimating Equation 2 using both OLS and Levinsohn–Petrin methods. The coefficients for capital and labor in Equation 2 in the Levinsohn–Petrin method are smaller as compared with OLS, although they remain statistically significant.

There are a few issues remaining with respect to the TFP measure. One issue is that measured productivity may capture the differences in markups across firms rather than capturing actual efficiency. To address the issue, this paper uses the measures of output, capital, and spending using industry-level prices because firm-level prices are not

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available. As De Loecker et al. (2016) argued, however, trade liberalization may allow the firm that trades to gain market power over time relative to others in the same industry. As long as the industry is not perfectly competitive, the firm can charge a higher markup for its output than the industry average, which increases its measured TFP even when its efficiency does not improve.

Table 1. Estimating TFP

	(1)	(2)	(3)	(4)
Method	OLS	OLS	Levinsohn–Petrin	Levinsohn–Petrin
Sector	Services	Manufacturing	Services	Manufacturing
	0.221***	0.269***	0.091*	0.040
Log capital	(0.005)	(0.008)	(0.055)	(0.039)
	0.734***	0.835***	0.682***	0.564***
Log labor	(0.009)	(0.017)	(0.027)	(0.045)
Number of observations	12393	4900	5197	4787

Notes: TFP=total factor productivity.

Dependent variable is value added. The first column uses the OLS method to estimate TFP, the second column uses Levinsohn and Petrin method to estimate TFP. Standard errors are shown in parentheses.

*$p < .10$ **$p < .05$ ***$p < .01$

In addition, because there is no data on the composition of workers, the TFP estimates may also capture the changes in human capital stock rather than the overall efficiency. To address issues related to unmeasured inputs such as human capital, this paper also uses labor productivity (defined as value added per worker) as an alternative measure of productivity. Although the measure captures the efficiency of workers rather than the efficiency of all inputs, the advantage of labor productivity is that it is not sensitive to the aforementioned measurement issues.

As another robustness check, this paper also follows Amiti and Konings (2007) by controlling for industrial concentration to serve as proxy for unobserved markups. The rationale is that if some firms are charging higher markups after trade liberalization, their sales should expand relative to those of other competitors; hence, an increase in the concentration of sales within an industry implies an increase in the markups.

Uruguay's Trade Policy

Uruguay's ascension to the MERCOSUR implies that the nation's trade policies have to (1) liberalize trade between members of the trading bloc and (2) converge to a common trade policy for trade with nonmembers. For goods that do not meet the rule-of-origin requirement (i.e., nonnative products), a CET will be applied. Although the goal of MERCOSUR is to create a customs union that jointly sets and enforces CET, the members were allowed to include a national exception list in which the convergence to CET could be delayed (Vaillant 2005). All countries in MERCOSUR negotiated an exception list, which results in differences in applied CET across countries. For example, the average applied CET for all products in MERCOSUR was 10 percent in 2004, while in Uruguay it was 9.1 percent (Vaillant 2005).

While it is possible that less-productive manufacturing industries may have more incentive to lobby for their goods to be put on the exception list in order to reduce foreign competition, this paper assumes the tariffs on manufacturing inputs are exogenous to any particular firm's productivity. The first reason is that the service firms, especially the ones that import inputs, actually have incentives to lobby *against* higher CET, which may potentially offset the manufacturing industries' lobbying effort. Also, Uruguay actually outperformed its MERCOSUR counterparts in applying CET, as 86 percent of all imported items from non-MERCOSUR countries are subject to CET rather than on the exception list. Furthermore, although MERCOSUR members began negotiations to liberalize service trade, no major policy actions took place in the sampled period. Besides an increase in private participation in the service sector, there were no other simultaneous service trade-liberalization policies in Uruguay.[7] These support the hypothesis that Uruguay's tariff rates on manufacturing inputs are not directly affected by firm productivity in service industries.

Another feature of Uruguay's trade policy is the temporary admission regime for exporters, which allows tariff-free importing of certain materials and manufactured inputs, provided the final good is re-exported (Terra 2006). The regime may affect exporting and non-exporting firms differently; however, as noted in Terra (2006), the beneficiaries of this policy are primarily firms producing manufactured final goods rather than services. This paper will control for the effect of such a regime on particular industries and the overall economy through industry and time fixed effects while assuming that the regime's effect did not vary across firms within the same industry, given that the beneficiaries of this policy were not from service industries.

Input Trade and Productivity

This paper estimates the following equation to test the relationship between input tariffs and productivity:

$$tfp_{eit} = \gamma_0 + \gamma_1 tfp_{ei,t-1} + \gamma_2 T_{it} + \gamma_3 imp_{eit} + \gamma_4 T_{it} imp_{eit} + \alpha_i + \alpha_t + \epsilon_{eit}, \qquad (3)$$

where T_{it} is the tariff of imported inputs faced by industry i in year t, and imp_{eit} is a time-varying measure of the importing status of establishment e. Given the data availability, imported capital share is used as a proxy for the share of inputs imported from abroad.[8] The assumption is that imported capital share is positively correlated with imported input share; that is, the more capital a firm imports, the more intermediate inputs it will also import. The equation also controls for lagged TFP ($tfp_{ei,t-1}$), as suggested by the Levinsohn and Petrin (2003) method, as well as for unobserved time-invariant characteristics of each industry (α_i) and common time trends that affect all firms within the country (α_t).

This paper employs a fixed-effect estimation strategy to estimate Equation 3. Under this strategy, the coefficient γ_2 captures the average effect of input tariff on all firms within the same industry. A negative estimate of γ_2 suggests that removing restrictions on trading inputs has a positive effect on average productivity growth among all firms. In addition, γ_3 in Equation 3 captures any fundamental differences in productivity explained by import shares, and γ_4 is the coefficient of interest. Given the estimation strategy, the coefficient should be interpreted as the additional contribution of import shares on the productivity gains from input trade liberalization. A negative estimate of γ_4 is therefore consistent with the technology-diffusion hypothesis: when firms import more capital (and therefore more intermediate inputs) from abroad, they receive larger productivity gains following a reduction in input tariffs.

The biggest macroeconomic shock for Uruguay occurred from 2002 to 2003, when the country suffered from massive recession and sharp currency depreciation. Although the inclusion of the common time trends controls for macroeconomic fluctuations that affect all firms in any given year, the effects of these shocks can affect firms of different types and sectors heterogeneously; for example, firms that relied more on domestic sales or incurred more foreign-currency-denominated trade credit would be disproportionately worse off. The survey data do not suggest a big change in the intensive and extensive margin among service providers, as the percentages of imported capital inputs and of firms that imported these inputs are comparable before and during the recession of 2002–2003.[9] This paper also estimates Equation 3 separately for years 1998–2001 and 2002–2005, however, and compares the effects as a robustness check to account for differential effects during the recession years.

Other underlying assumptions in Equation 3 are that (1) imported inputs improve importers' productivity as soon as the inputs are utilized and (2) all other simultaneous shocks that affect productivity and importing decisions are addressed by the fixed effects. These assumptions are based on the observation that firms in developing countries face technological constraints due to inadequate access of inputs, so when the restrictions on imported inputs are loosened, firms will respond immediately to the new policy. A well-established finding in the trade literature, however, is that firms may select themselves to import inputs, and the input importing status may hence be endogenous to tariffs.[10]

Although the industry and country fixed effects control for industry-wide factors and macroeconomic shocks that may affect importing decisions, tariffs, and productivity simultaneously, they do not fully address the endogeneity of input importing status arising from firm-level characteristics. This paper therefore employs two alternative strategies to address issues with assumptions 1 and 2. The first is to lag all the independent variables in Equation 3 by one period. The idea is that firm productivity in the current period (t) should not have a direct impact on the firm's importing decisions in the *past* ($t-1$). This addresses the reverse causality issue and at the same time allows the possibility that the full effect of policy shock on productivity may take longer to be realized. Another alternative strategy is to replace time-varying importing status (imp_{eit}) with a time-invariant importing status that is equal to the firm's importing status in its first year in the sample (imp_{ei0}). This strategy addresses the possible dynamic relationship between trading decisions and productivity[11] by eliminating the endogenous variation in importing status over time.

DATA

Tariff data on manufacturing products come from the United Nations' Conference on Trade and Development (UNCTAD) database obtained from the World Bank (2018). Tariff rates are available on an annual basis for all types of manufacturing goods at the six-digit Harmonized System industry level, the most detailed industrial classification possible.[12] The tariff rates are then aggregated to the two-digit Global Trade Analysis Project (GTAP) industry level, with the weights equal to the share of imports for each six-digit good in the total imports for the corresponding two-digit good. The reason to aggregate is that the input-output tables used in this paper, which details the usage of domestic and foreign inputs, are available for only the two-digit manufacturing and service industries.

This paper follows the method by Amiti and Konings (2007) on computing the imported input tariff that each industry faced as the weighted average of tariff rates on manufactured goods:

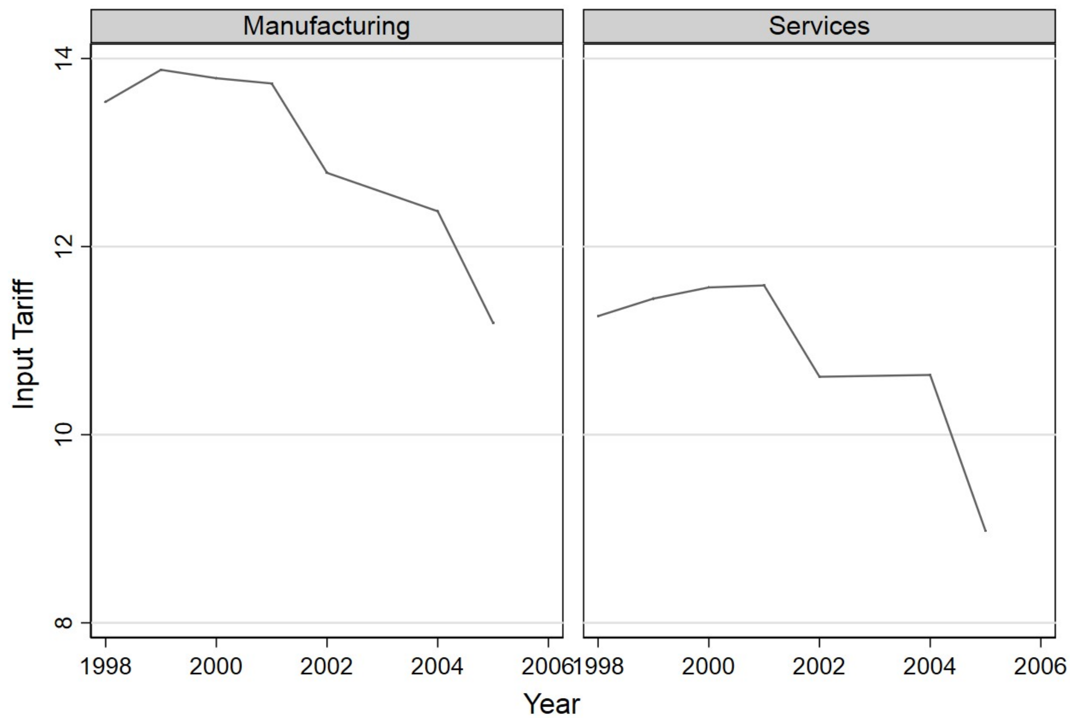
$$T_{it} = \sum_j s_{ij} t_{jt} \quad , \qquad (4)$$

where T_{it} is the tariff on manufacturing inputs faced by industry i in period t, t_{jt} is the tariff on manufacturing goods produced by industry j in period t, and the weight (s_{ij}) is industry i's spending on input j as a percentage of industry i's total spending on manufacturing inputs. In other words, T_{it} is a weighted average of tariffs on manufacturing inputs used by industry i. For example, if the transportation sector allocates 55 percent of total input spending to motor vehicle inputs, then tariffs on vehicles should account for 55 percent of the overall input tariff for the transportation sector.

The weights vary at the industry level rather than at the firm level. As Amiti and Konings (2007) argue, using the weights at the firm level may cause additional issues if input-importing firms are able to purchase inputs at lower prices from abroad and are thus able to achieve higher measured productivity than are the others. Because the survey does not provide firm-level details on the type of inputs used, this paper uses the input-output table from the seventh version of the GTAP from Purdue University to compute the weights.[13] This paper fixes the weights over time because variation in input spending over time may be driven by productivity growth.[14]

Figure 1 shows the changes in average input tariffs over time for manufacturing and services. Input tariffs fell by slightly more than two percentage points on average for both manufacturing and service industries from 1998 to 2005, while service industries faced lower input tariffs, on average, during this period than did manufacturing industries. Table 2 details the rate of input tariffs for each two-digit service and manufacturing industry.

Figure 1. Input Tariffs for Manufacturing and Services



Note: Input tariffs for manufacturing and services are the simple averages of input tariffs in all manufacturing industries and all service industries.

The main takeaway is that input tariffs fell by different proportions for the sectors depending on each sector's import usage. For example, tariffs for air transportation fell by only 1.5 percentage points from 1998 to 2005, but tariffs for wholesale and retail trade fell by 2.3 percentage points. This implies that the tariffs for manufacturing inputs that were used more heavily in air transportation industries fell by a smaller amount relative to the tariffs for other inputs.

Productivity data come from the Encuesta Anual de Actividad Económica (Economic Activity Survey) compiled by the INE of Uruguay for 1998 to 2005.[15] For the Uruguayan survey, all firms in the manufacturing and service industries with more than 50 employees were included, and some with fewer than 50 employees were randomly selected. The same firms were surveyed annually. In place of firms that ceased doing business, the INE added new ones into the sample to replace them. This paper uses 1998 as the starting year because it is the first year for which survey data are available. The final year is 2005 because a major revision to survey methodology and firms sampled occurred in 2006 and it was not possible to uniquely identify the firms included in both the pre- and post-2005 surveys.

Table 2. Input Tariffs by Industry

Sector	1998 Tariff (%)	2005 Tariff (%)
Services		
Gas distribution	11.28	8.86
Water	11.84	9.47
Wholesale and retail trade	13.54	11.21
Other transport	7.32	6.38
Water transport	11.67	9.70
Air transport	9.29	7.80
Post and telecommunications	8.28	5.57
Other business services	10.45	7.64
Other services	12.06	9.70
Manufacturing		
Meat processing	12.86	10.23
Vegetable oil	12.81	11.23
Milk	13.44	10.90
Other food	13.72	11.46
Beverage and tobacco	14.54	11.89
Textiles	15.01	12.30
Wearing apparel	19.25	16.01
Leather	15.38	12.03
Lumber	15.51	12.42
Paper & paper products	13.86	11.30
Petroleum & coke	12.34	9.87
Chemical rubber products	12.27	10.00
Nonmetallic minerals	13.44	10.51
Iron & steel	12.34	10.51
Fabricated metal products	12.71	10.69
Motor vehicles and parts	13.85	12.03
Other transport equipment	18.73	15.17
Electronic equipment	10.36	7.86
Other machinery & equipment	11.67	9.39
Other manufacturing	12.78	10.66

The variables used in this paper include value added, number of workers, value of capital stock, value of materials used, and industry of each firm. Aggregated country-level GDP deflator as well as material and capital prices are used to deflate revenue, material, and capital inputs, given that no firm-level price indexes were available in the survey.[16] Price indexes were obtained from Banco Central de Uruguay (2018). The measures for value added and labor input are straightforward to compute. For capital stock, this paper uses the perpetual inventory method to calculate capital stock because of data availability, assuming a constant depreciation rate over time for all firms in the same sector.[17] The data comprise an unbalanced panel of firms in 19 manufacturing and 9 service industries. Appendix Tables A1 and A2 list the number of firms included in the sample for each year and the number of observations among firms in the sample, and Appendix Tables A3 and A4 present the summary statistics for all firms and for firms in the service and manufacturing industries.

RESULTS

Do Service Firms Benefit from Input Trade Liberalization?

Table 3 presents the baseline results. The first column shows the average effect of input tariff on TFP calculated by the Levinson–Petrin method. Column 1 estimates the average effects from input tariff reduction, and column 2 shows the regression results from estimating Equation 3 for both manufacturing and service-industry firms. The coefficients for input tariff and import share all display expected signs, suggesting that input-tariff reductions are positively associated with TFP growth, while firms with a higher share of imported inputs also have higher productivity. The coefficient for the interaction term is negative, suggesting that the productivity gains from input tariff reduction is magnified by the firms' usage of imported inputs. To put the estimates in perspective, a one-standard-deviation increase in import share increases the effect of a one-standard-deviation decline in input tariff on TFP by 0.28 percent.

Columns 3 and 4 of Table 3 estimate Equation 3 for service firms and manufacturing firms separately. Similar to the main results in column 2, results in column 3 suggest that import share further increases the productivity gains from input tariff reduction for firms in the service industry. The coefficient suggests that among service firms, raising the share of imported inputs by one standard deviation magnifies the increase in TFP from a one-standard-deviation decline in input tariff by 0.29 percent. Column 4 shows that among manufacturing firms, the same pattern also holds, although the effects are less statistically significant. The results from the final two columns suggest that a reduction in tariffs on manufacturing inputs affects not only the manufacturing sector but also the productivity of firms in the service sector, and the effect is stronger when firms increase their use of imported inputs.

Table 3. Baseline Results Using TFP Estimated by Levinsohn–Petrin Method

Industry	(1) All	(2) All	(3) Services	(4) Manufacturing
	Dependent variable: Log(TFP)$_{eit}$			
TFPt−1	0.387**	0.387**	0.201*	0.673***
	(0.183)	(0.182)	(0.106)	(0.134)
Input tariff	–0.523	–0.470	–0.732	–0.660
	(0.435)	(0.417)	(0.625)	(0.508)
Import share		1.971**	2.138***	1.251
		(0.814)	(0.687)	(0.892)
Input tariff × Import share		–0.744**	–0.873***	–0.431
		(0.334)	(0.265)	(0.359)
R^2	0.25	0.25	0.13	0.48
Number of observations	14102	14102	10193	3909

Notes: TFP=total factor productivity.

All regressions include sector and year dummies. Sector-clustered standard errors are shown in parentheses.

*p < .10 **p < .05 ***p < .01

The evidence from Table 3 supports the hypothesis that international trade contributes to international technology diffusion through intermediate inputs. Furthermore, the results for service firms are similar to the findings for manufacturing firms and plants. As firms in service sectors may use inputs from manufacturing sectors, liberalizing manufacturing trade may also have additional benefits in service sectors, and vice versa. The results are also robust to alternative definitions of productivity. For example, Table 4 reestimates the same equations as in Table 3, with output per worker as the productivity measure. The coefficients from Table 4 are consistent with those from the main results, suggesting that the results are not sensitive to productivity measures.

One issue with the main results is that the amount of imported inputs may be endogenously determined. For example, a well-established finding in the trade literature is that firms with higher productivity are more likely to participate in international trade. To control for the possibility, this paper uses two alternative import-status measures: an import dummy equal to 1 as long as the firm imports in a given period, and an initial import dummy equal to 1 if the firm imports in the first year of observation. Both measures eliminate the endogenous variations in the intensive margin of imports, and for the initial import dummy, the time variations in importing status are entirely removed. Columns 1 and 2 of Table 5 present the results for service firms. The interaction terms are similar in magnitude to the main results, indicating that firms' self-selection into imports does not entirely drive the productivity gains from importing inputs.

Table 4. Baseline Results Using Labor Productivity

Industry	(1) All	(2) All	(3) Services	(4) Manufacturing
	Dependent variable: Log(VA/L)$_{eit}$			
(VA/L)$_{t-1}$	0.002	0.002	–0.000	–0.018
	(0.017)	(0.017)	(0.020)	(0.032)
Input tariff	–0.120	–0.091	0.001	–0.690
	(0.200)	(0.200)	(0.227)	(0.533)
Import share		1.223***	1.093***	2.673*
		(0.321)	(0.276)	(1.282)
Input tariff × Import share		–0.482***	–0.435***	–1.037*
		(0.128)	(0.112)	(0.501)
R^2	0.10	0.10	0.09	0.12
Number of observations	19908	19908	14822	5086

Notes: All regressions include sector and year dummies. Dependent variable is value added per worker. Sector-clustered standard errors are shown in parentheses.

**p* < .10 ***p* < .05 ****p* < .01

Column 3 in Table 5 addresses other possible explanations for the main results by including an exit dummy that equals 1 if the firm is no longer included in the subsequent surveys after year *t*,[18] as well as the competitiveness of the industry, measured by the Herfindahl index constructed at the two-digit industry level. The rationale behind including these variables is that (1) the main results may capture survival bias and may overestimate the true effects of tariff reduction on importers, and (2) if less-productive firms leave the market, the productivity gains from importing inputs may instead be capturing increasing market power by remaining firms. The coefficient for the interaction term in column 3 is comparable to those coefficients in Table 3, implying that the main results are still robust after controlling for these variables.

Another set of robustness checks deals with simultaneity issues among productivity, contemporaneous import decisions, and input-tariff rates, as well as the significant macroeconomic shocks during the sample period. Table 6 addresses these issues by estimating Equation 3 with lagged independent variables. Using lagged independent variables also accountst for the possibility that more time may be required to realize the effect of input-tariff reduction. The coefficients for the interaction terms remain negative and statistically significant for firms in the overall economy and within service industries, implying that input tariff reduction has a stronger effect on *subsequent* productivity growth for firms importing a larger amount of inputs. Table 7 reestimates Equation 3 for service firms in two subperiods—1998–2002 (column 1) and 2003–2005 (column 2)—to test whether the results remain robust after the major economic recession of 2002–2004. The recession may have affected import decisions and productivity differently across firms, which may in turn have affected the impact of import shares on the trade-growth relationship after recession if only the more productive firms survived the macroeconomic shock. The results from Table 7, however, suggest that there are no differential impacts before and after recessions, although the coefficients for the interaction terms become less statistically significant.

Table 5. Alternative Import Definition and Adding Control Variables

	(1)	(2)	(3)
Dependent variable: Log(TFP)$_{eit}$			
TFP$t-1$	0.201* (0.106)	0.202* (0.106)	0.201* (0.106)
Input tariff	–0.701 (0.612)	–0.722 (0.651)	–0.742 (0.625)
Import dummy	1.751*** (0.606)		
Import dummy × Input tariff	–0.699*** (0.230)		
Initial import dummy = 1 × Input tariff		–0.538* (0.290)	
Import share			2.140*** (0.684)
Input tariff × Import share			–0.873*** (0.264)
Herfindahl index[a]			0.227 (0.376)
Exit dummy[b]			–0.063 (0.095)
R^2	0.13	0.13	0.13
Number of observations	10193	10193	10193

Notes: TFP=total factor productivity.
[a] Calculated at the two-digit industry level.
[b] Exit dummy=1 if firm is not in the sample in period $t + 1$.
All regressions include sector and year dummies. TFP is estimated using Levinsohn–Petrin method. Sector-clustered standard errors are shown in parentheses.
*$p < .10$ **$p < .05$ ***$p < .01$

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Table 6. Alternative Specifications: Lagged Independent Variables

Industry	(1) All	(2) Services
Dependent Variable: Log(TFP)$_{eit}$		
TFP$t-1$	0.387**	0.203*
	(0.183)	(0.108)
Input tariff$_{t-1}$	0.515	0.640
	(0.407)	(0.498)
Import share$_{t-1}$	2.007***	1.846***
	(0.587)	(0.516)
Input tariff$_{t-1}$ × Import share$_{t-1}$	–0.748***	–0.661***
	(0.227)	(0.200)
R^2	0.25	0.13
Number of observations	14103	10193

Notes: TFP=total factor productivity.

All regressions include sector and year dummies. TFP estimated using Levinsohn–Petrin method. Sector-clustered standard errors are shown in parentheses.

**p* < .10 ***p* < .05 ****p* < .01

Table 7. Alternative Specifications: Different Time Periods

Period	(1) 1998–2002	(2) 2003–2005
Dependent variable: Log(TFP)$_{eit}$		
TFP$t-1$	–0.083	0.129***
	(0.182)	(0.002)
Input tariff	–1.437	–0.112
	(1.170)	(0.224)
Import share	2.574	1.592
	(1.752)	(0.999)
Input tariff × Import share	–1.042	–0.651
	(0.686)	(0.399)
R^2	0.04	0.22
Number of observations	5081	5112

Notes: TFP=total factor productivity.

All regressions include sector and year dummies. TFP estimated using Levinsohn–Petrin method. Sector-clustered standard errors are shown in parentheses.

**p* < .10 ***p* < .05 ****p* < .01

The final set of robustness tests (Table 8) looks at alternative econometric specifications to test whether the results are sensitive to these specifications. Columns 1 and 2 use two-year averages (year *t* and the prior year) for dependent and independent variables, and columns 3 and 4 use the two-year growth rates. The reason for using two-year rates instead of longer periods is to maximize the number of observations, because the sample period from 1998 to 2005 is only seven years. The primary result—that input trade disproportionately benefits firms with higher imports—remains statistically significant. Overall, these results further verify that the productivity growth from manufacturing-trade liberalization was stronger for service firms that used more foreign inputs. The effect is robust to alternative econometric specifications that control for potential endogeneity issues, as well as to alternative definitions of importing status.

Table 8. Alternative Specifications: Average Tariffs and Tariff Growth Rates

Industry	(1) All	(2) Services	(3) All	(4) Services
Dependent variable: ΔLog(TFP)$_{ei(t,t-2)}$				
Import share	5.334**	4.891**	–0.032	0.338*
	(2.015)	(2.289)	(0.138)	(0.189)
Average tariff[a]	2.950	4.122		
	(3.025)	(4.639)		
Average tariff × Import share	–2.075**	–1.890*		
	(0.791)	(0.927)		
Tariff growth[b]			–0.842	–1.046
			(0.706)	(0.831)
Tariff growth × Import share			–9.754***	–5.615**
			(2.634)	(2.413)
R^2	0.03	0.04	0.04	0.04
Number of observations	5504	3968	5504	3968

Notes: TFP=total factor productivity.

All regressions include sector and year dummies. TFP estimated using Levinsohn–Petrin method. Sector-clustered standard errors are shown in parentheses.

[a] Two-year average of input tariffs (in logs).

[b] Two-year growth rate of input tariffs.

*$p < .10$ **$p < .05$ ***$p < .01$

A couple of potential explanations cannot be tested because of limitations of the data. One potential direction for future research is for understanding the dynamic effects of technology diffusion through alternative channels. For example, Keller (2004) argued that international economic activities such as trade also lead to additional contacts with

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foreign firms and individuals who may possess advanced technological knowledge. This increased interaction may contribute to technology diffusion through (1) domestic firms learning the foreign technology through foreign firms and individuals, (2) imitation of this technology by domestic firms, and (3) original innovation by domestic firms, in addition to adoption of the technology embodied in the intermediate good itself. Given the time span of the survey, the dynamic effects from learning foreign technology cannot be isolated from the contemporaneous gains from input trade, as the latter mechanism tends to take more time to realize the effects. Furthermore, MERCOSUR also provided Uruguayan firms access to larger markets through exports, which can also directly affect the firms' productivity. This hypothesis cannot be isolated, however, because of a lack of information in the survey about the intensive and extensive margin of exports, although the time-specific dummies would capture the economy-wide effects of wider access to the export market.

Does Trade Liberalization Have Larger Effects on Service Sectors than on Manufacturing Sectors?

Because reductions in input tariffs also increase the productivity of service firms that import, this paper tests whether the marginal effects from importing inputs on the trade-growth relationship are different for service and manufacturing firms. The test is motivated by the possible differences in the mechanisms for how input tariffs may affect manufacturing and service industries. The effects may also differ based on the differences in the input-output structure between the two importers. For example, if the quality of certain inputs contributes to the measured productivity of manufacturing firms more than it contributes to that of service firms, importing such inputs with higher quality should increase productivity more in manufacturing relative to services.

To answer this question, the following equation is estimated:

$$\begin{aligned} tfp_{eit} = \beta_0 + \gamma_0 tfp_{ei,t-1} + \gamma_1 T_{it} + \gamma_2 imp_{eit} + \gamma_3 serv_i + \\ \gamma_4 T_{it} imp_{eit} + \gamma_5 T_{it} serv_i + \gamma_6 imp_{eit} serv_i + \\ \gamma_7 T_{it} imp_{eit} serv_i + \alpha_e + \alpha_t + \epsilon_{eit}, \end{aligned} \quad (5)$$

where $serv_i$ is a dummy that equals 1 if the firm is in one of the service industries. Other variables in Equation 5 are the same as those in Equation 3.

In Equation 5, γ_7 is the main coefficient of interest. It captures the difference between service and manufacturing firms on the differential impact of import shares (imp_{eit}) on the productivity gains from input tariff reduction. A negative γ_7 implies that the marginal effect of import share on the productivity gains from input tariff reduction is stronger for service firms than for manufacturing firms, whereas a positive γ_7 suggests otherwise. Other terms capture the fundamental differences in productivity between different types of firms. For example, γ_3 captures the fundamental differences in productivity between service and manufacturing firms, γ_4 captures the average effect of import share among all firms, γ_5 captures the differences in the average effect of tariffs for manufacturing and service firms, and γ_6 captures the average differences in import share on productivity between service and manufacturing industries.

Table 9. Triple-Difference Results

	(1)	(2)	(3)	(4)
Period	1998–2005	1998–2005	1998–2002	2003–2005
TFP_{t-1}	0.387**	0.387**	–0.305*	0.106***
	(0.182)	(0.182)	(0.151)	(0.028)
Input tariff	–0.639	–0.647	–0.593	–0.170
	(0.489)	(0.486)	(1.221)	(0.328)
Import share	3.629**	3.634**	3.778	0.144
	(1.735)	(1.741)	(5.169)	(1.677)
Service dummy	–0.807	–0.816	–0.904	–0.285
	(0.705)	(0.697)	(3.823)	(0.757)
Input tariff × Import share	–1.335**	–1.337**	–1.293	–0.071
	(0.631)	(0.633)	(1.823)	(0.685)
Service × input tariff	0.205	0.211	0.181	–0.018
	(0.295)	(0.293)	(1.421)	(0.315)
Service × Import share	–1.332	–1.336	–3.952	1.586
	(1.949)	(1.953)	(5.190)	(2.008)
Service × Input tariff × Import share	0.381	0.383	1.299	–0.654
	(0.727)	(0.728)	(1.830)	(0.823)
Herfindahl index		0.072		
		(0.260)		
Exit dummy		0.029		
		(0.281)		
R^2	0.25	0.25	0.12	0.07
Number of observations	14102	14102	4967	7070

Notes: TFP=total factor productivity.

All regressions include sector and year dummies. Sector-clustered standard errors are shown in parentheses.

$^*p < .10$ $^{**}p < .05$ $^{***}p < .01$

Table 9 presents the results from estimating Equation 5. Column 1 suggests that, similar to the main results, the impact of input tariff reduction on productivity is enhanced by the share of imported inputs. The coefficient for the triple interaction term is not significantly different from zero, however, suggesting that importers in service industries enjoyed additional benefits from tariff reduction similar to those enjoyed by their manufacturing counterparts. Column 2 controls for the possibility of exit and industry concentration. Similar to column 1, controlling for these additional variables does not affect the results significantly. Columns 3 and 4 look at the subperiods 1998–2002 and 2003–2005 and also find no evidence indicating a stronger impact of productivity growth differences between service and manufacturing industries.

To summarize, not enough evidence exists to support the supposition that the effects of tariff reductions on importers versus nonimporters differ between service and manufacturing firms. Although both service and manufacturing importers were affected by tariff reductions, the evidence suggests that any additional mechanisms by which tariffs affect manufacturing importers were not significant enough to generate any differential effects between the importers in the different sectors.

CONCLUSION

This paper looked at how input tariff reduction affected productivity for service and manufacturing firms in Uruguay. This is one of the first studies to estimate the effects of input trade on service industries and to compare the effects between service and manufacturing firms. The results showed that input tariff reduction disproportionately benefits importers; in particular, the more manufactured inputs a service firm imports from abroad, the bigger the increase in the service firm's productivity. The effects are robust to alternative measures of productivity, the addition of country-sector-year varying controls, and alternative econometric specifications. Furthermore, the effects of tariff reductions on importers are similar between service and manufacturing industries.

The results support the theoretical possibility that input trade is crucial for productivity gains by allowing production technology to spread across international borders. They also highlight the service industry's contributions to overall productivity growth from trade-liberalization policies. One possible direction for future research is in further understanding the technology-diffusion channel—in particular, isolating the contribution of immediate technology acquisition through imported inputs from other potential channels, as in Keller (2004). Another possible direction is in testing the complementarity between input trade liberalization and other policy reforms. For example, Halpern, Koren, and Szeidl (2015) find that the productivity benefits from importing foreign inputs are larger for foreign-owned manufacturing firms than for domestic ones, as the former have more information about foreign markets and therefore have more knowledge about matching the suitable input supplies with demand. Testing whether the complementarity also applies for service industries is crucial, as these industries account for an increasing share of production in developing nations.

ENDNOTES

1. Also see Keller (2004) for a summary of studies related to technology diffusion.

2. For some examples of input trade and productivity growth among manufacturing firms, see Pavcnik (2002), Bernard et al. (2003), Amiti and Konings (2007), Kasahara and Rodrigue (2008), Goldberg et al. (2010), Topalova and Khandelwal (2011), and Halpern, Koren, and Szeidl (2015).
3. See Amin, Islam, and Wong (2014) for more information.
4. For example, Caselli (2018) finds that among Mexican manufacturing industries, those with higher shares of plants importing intermediate inputs also have higher shares of plants importing capital inputs.
5. Empirical evidence from Caselli (2018), Bempong Nyantakyi and Munemo (2017), and Estevadeordal and Taylor (2013) suggests that imported capital inputs have a relatively larger impact on productivity than do material inputs.
6. As a check of robustness, this paper also estimates TFP by assuming that both service and manufacturing industries have identical elasticities. This assumption does not change the results.
7. See World Trade Organization (1998) for a detailed description about the trade-liberalization policies.
8. As a robustness check, this paper also uses an indicator dummy equal to 1 if the firm imports any amount of its capital goods, and the results are similar.
9. For all firms included in the sample for 2001–2003, the share of firms importing from abroad fell from 5.5 to 3.5 percent, but the share of imported inputs fell from 8.7 percent to only 8.5 percent.
10. See Bernard et al. (2003), Vogel and Wagner (2010), and Kasahara and Lapham (2013) for evidence regarding productivity differences between trading and nontrading firms.
11. As Aw, Roberts, and Xu (2011) find, given the trade costs, as companies become more productive, they are more likely to engage in international trade.
12. The UNCTAD data do not include tariff rates for 2003. This paper therefore uses tariff data from the World Trade Organization (WTO) to compute tariff rates in 2003. The tariff rates from the WTO data are comparable to UNCTAD's data at the six-digit industry level.
13. This paper chooses 2004 as the base year to compute the input-output table.
14. For example, suppose that as productivity in the transportation sector grows, the sector may spend relatively more on automobiles and/or other transportation equipment and relatively less on other inputs. In this case, productivity growth affects input spending and the weights for input tariffs.
15. Refer to National Statistics Institute of Uruguay (2005) for details on the methodology.
16. An aggregate price deflator is subject to the markup argument as discussed in De Loecker (2011), in that the measured productivity increase may capture the higher markups rather than true productivity growth in industries where the degree of competition declines. This paper attempts to address the issue by controlling for industrial concentration, as outlined in the estimation strategy section, but acknowledges that this issue cannot be fully controlled, given the available data.

17. Capital stock data are available only for years 2004 and 2005, whereas data on gross capital formation are available for all years. Although estimating capital stock retrospectively with the perpetual-inventory method is subject to survival bias, no alternative measures of capital stock are available in the data.
18. According to the INE of Uruguay, firms not included in the surveys were not necessarily out of business; they may not have been included in subsequent surveys because they failed to respond to earlier surveys or because they were no longer included in the random sample selected by the INE. The exit dummy is therefore not a perfect indicator of whether a firm was out of business; it only suggests that the firm was not included in subsequent surveys.

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APPENDIX

Table A1. Panel Data Summary: Observations per Year

Year	Observations
1999	1149
2000	1177
2001	1239
2002	1516
2003	1696
2004	1709
2005	1707
Total	10193

Table A2. Panel Data Summary: Observations per Firm

Total Observations	Firms
1	114
2	228
3	681
4	1176
5	460
6	408
7	7126
Total	10193

Table A3. Summary Statistics for Uruguay

Sector	Mean	SD
Value added in millions, 1997 pesos	18.95	100.92
Value added per worker	0.27	0.96
Capital stock	56.10	378.69
Number of workers	88.43	299.32
Import dummy[a]	0.10	0.30
Import share[b]	0.05	0.19
Input tariff	12.32	2.28

Notes: Number of observations = 14102.
[a] Import dummy = 1 if the firm directly imports any of its capital inputs from abroad.
[b] Import share = spending on imported capital inputs / spending on capital inputs.

Table A4. Summary Statistics for Uruguay: Manufacturing vs. Service Firms

Manufacturing	Mean	SD	Observations
Value added in millions, 1997 pesos	25.13	82.87	3909
Value added per worker	0.28	1.10	3909
Capital stock	81.11	305.92	3909
Number of workers	90.49	154.86	3909
Import dummy[a]	0.24	0.43	3909
Import share[b]	0.11	0.26	3909
Input tariff	13.17	1.83	3909
Services	Mean	SD	Observations
Value added in millions, 1997 pesos	16.58	106.94	10193
Value added per worker	0.26	0.89	10193
Capital stock	46.51	402.73	10193
Number of workers	87.63	338.75	10193
Import dummy[a]	0.05	0.22	10193
Import share[b]	0.03	0.14	10193
Input tariff	12.00	2.36	10193

[a] Direct import dummy = 1 if the firm directly imports capital goods from abroad.
[b] Import share = spending on imported capital goods / spending on capital goods.