

Input-quality upgrading from trade liberalization: Evidence on firm product scope and employment effects

Maria Bas* Caroline Paunov**

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Does input-trade liberalization, through quality upgrading, foster firm product innovation and their employment size? Using detailed firm-product level data for Ecuador, we exploit the unilateral trade liberalization episode when the country entered the World Trade Organisation in 1996 to identify the causal effect of exogenous input tariff changes on the product scope and employment size of importing firms. We show that it is access to high-quality important inputs that led importers to expand the number of products. The producers of new products and importers foreign inputs also increase their employment size. Our findings also show that input-trade liberalization, through the quality-upgrading channel, results in skilled-biased production processes.

Keywords: Input-trade liberalization, product innovation, product scope, employment, quality of foreign inputs, firm-product-level data, Ecuador

JEL Codes: F16, O30, D22, O12, O54, L6

* Maria Bas, University of Paris 1, Centre d'Economie de la Sorbonne (CES). E-mail: maria.bas@univ-paris1.fr. Postal address: Maison des Sciences Economiques, 106-112 Bd de l'Hôpital, 75647 Paris, France.

**Caroline Paunov, OECD, Directorate for Science, Technology and Innovation, 2, rue André Pascal, 75 775 Paris Cedex 16, France. Email: caroline.paunov@oecd.org and caroline.paunov@gmail.com. Phone: 00 33 (0) 1 45 24 90 40.

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1. Introduction

Job creation is at the top of most governments' agendas. Well-known arguments in favor of trade protectionism point to potentially negative effects of free trade on employment. Few protectionists are unhappy about facilitating exports since successful exports are expected to create rather than destroy jobs. It is the penetration of imports into national markets that opponents of free trade regard as the negative downside to bilateral trade liberalization policies since foreign competition might threaten local businesses and, therefore, employment. However, imports also constitute one of the most valuable channels to access advanced technologies and know-how. Particularly in countries in which the technology gap with leading economies is large, the adoption of imported foreign embodied know-how in production processes can stimulate firms to produce new products and expand.¹ Trade liberalization, through the access to high quality and technological inputs, is therefore expected to boost firms' growth (Amiti and Konings, 2007; Topalova and Khandelwal, 2011; Goldberg et al., 2010).

The aim of this paper is to provide evidence on the impacts of input-trade liberalization on Ecuadorian firms' product scope and their employment size. The theoretical mechanisms motivating our empirical analysis are the following: input-trade liberalization reduces the costs of access to higher quality imported intermediate inputs allowing firms to become more efficient by decreasing their marginal costs and increasing their profitability. In the presence of fixed cost of product innovation, input tariff reductions allow firms to upgrade the quality of foreign inputs to produce new products. Product innovation requires both high-quality intermediate inputs and skilled labor to produce new products. Thereby, firms importing inputs and selling new products in the market also expand their employment of skilled labor.

These implications are tested using a detailed and unique linked firm-product-level dataset for Ecuador over the 1997-2007 period. This dataset provides information on production, employment and firm-product information on the values and quantities produced and on the values and quantities of intermediate goods used in the

¹ The endogenous-growth literature has provided theoretical arguments for the role of foreign intermediate inputs in enhancing economic growth and productivity gains (Ethier, 1979,1982;Grossman and Helpman,1991; Rivera-Batiz and Romer,1991).

production process. Our empirical analysis relies on the unilateral trade reform that took place in Ecuador when the country joined the WTO in 1996. Exploiting exogenous changes in input tariffs across industries, we establish a causal link between the availability of imported intermediate goods and firms' product and employment growth.²

The findings show that Ecuadorian firms have upgraded the quality of the inputs sourced from abroad thanks to input tariff reductions. Following the methodology developed by Khandelwal et al. (2013) we estimate the quality of imported inputs as a residual of a demand function estimation. We show that a 10 percentage point reduction in input tariffs increase the quality of firms' intermediate inputs by 22%.

Then we investigate the effect of input tariff reductions on firms' ability to introduce more final goods products in the market. Our results show that firms sourcing their inputs from abroad in industries with larger input tariff cuts expanded the number of final good products in response. Moreover, we find that imported inputs quality upgrading boosts the product scope of those firms that import high-quality inputs. Our results suggest that a 10 percentage point fall in input tariffs leads to 3.5 % increase in the number of products for the firms that import intermediate goods and upgrade the quality of foreign inputs.

As a final step, we explore if input-trade liberalization has positive effects on employment of those firms selling new additional products and importing high quality inputs. Our results show that a 10 percentage point fall in input tariffs leads to 10% increase in their employment size, pointing to comparative gains for these firms that resulted in job creation. We also show that input-trade liberalization, through the quality-upgrading channel, results in skilled-biased production processes.

These results are robust to specifications that control for firm initial size trend, firm and industry-year fixed effects that take into account other time-varying industry characteristics that could be related to tariff cuts and might change over time. We also

² We show that input and output tariffs changes over the period are uncorrelated with initial industry or firm characteristics. Moreover, pre-reform trends in firms' performance did not play a role when deciding to reduce tariffs. The reforms are discussed in section 4.1.

look at an alternative proxy for the quality of foreign inputs relying on the product differentiation measure developed by Rauch. The rationale for using this measure is that only those firms relying on differentiated intermediate inputs, that have a larger scope for quality upgrading, are affected by input tariff cuts to have access to high quality inputs. We also take into account other possible explanations related to the incentives of firms to introduce new products and expand employment. We show that our results remain robust when we explicitly control for foreign demand shocks (export-channel) and the currency crisis that took place in 1999-2000.

The main contribution to the existent literature on the impact of input-trade liberalization on firm performance is to investigate whether quality upgrading of foreign inputs affects firms' product innovation and employment. Our findings show that input tariff cuts improve firms' product scope for firms that are able to upgrade the quality of imported inputs. We also show that those firms increase their employment size in response and their skilled labor demand. Moreover, we provide evidence for a developing country that has been little analyzed to date, Ecuador, and contribute to identifying trends that apply to Ecuador to the same extent as they apply to other countries.

These findings contribute to the literature on trade liberalization and its impacts on firms' performance. Most of the literature focuses on the effect on within-firm productivity and investigates the impact of a decrease in tariffs on firms' total factor productivity (TFP) (e.g., Pavcnik, 2002; Schor, 2004; Fernandes, 2007; Amiti and Konings, 2007; Topalova and Khandelwal, 2011; Brandt et al., 2012). The main findings are that there is a positive pro-competitive effect of output tariff reductions on firm productivity and an even stronger impact from a decrease in input tariffs. Other studies relate imported inputs and firms' TFP but do not consider trade liberalization (e.g., Kasahara and Rodrigue, 2008; Halpern et al., 2015). More recent studies explore the effect of trade liberalization on the other attributes of the firms. Goldberg et al. (2010), for instance, demonstrate that input-tariff cuts in India account on average for 31% of the new products introduced by domestic firms. Moreover, using firm-level data from Argentina, Bas (2012) finds that firms producing in industries with larger input-tariff cuts have a greater probability to enter the export market. Bas and Strauss-Kahn (2015) show that Chinese firms that benefited from

input tariff cuts bought more expensive inputs and raised their export prices. These findings suggest that input-trade liberalization induces firms to upgrade their inputs at low cost to upgrade the quality of their exported products. Few papers empirically study the relationship between trade, prices (quality) and markups. Those that do focus on the pro-competitive effect (i.e., Fernandes and Paunov, 2013; Amiti and Khandelwal, 2013) or examine output prices and markups (i.e., De Loecker et al., 2012).

Our work complement these findings by showing that input-trade liberalization allowed firms to sell new products because they accessed higher quality inputs and that this expansion allowed them to gain in their employment size and their skilled labor demand compared to other firms.

The next section describes the theoretical motivation that rationalizes the mechanisms through which input-trade liberalization affects firms' product scope and employment. Section 3 presents a first glance at the data. Section 4 describes the trade liberalization reforms in Ecuador. Section 5 introduces the estimation strategy of the quality of intermediate inputs and looks at the effect of tariff cuts on firms' imported inputs quality upgrading. Section 6 introduces the baseline specification and the main results on the effects of input trade liberalization, through quality upgrading, on firms' product scope and employment. Section 7 looks at alternative explanations and robustness tests. The last section concludes.

2. Theoretical motivation

The aim of this section is to motivate our empirical analysis by introducing a simple framework that rationalizes the relationship between input-trade liberalization, input quality upgrading, product scope and employment.

Firms can produce several products paying fixed costs of product innovation. The rational is that product design incurs fixed costs paid in units of total labor. Firms combine intermediate inputs (X) and labor (l) to produce each final product (k). The production function for product k of firm i is given by a Cobb-Douglas technology

with factor shares η and $1-\eta$: $q(ki) = X^\eta l^{1-\eta}$. The firm i maximizes profits to choose inputs optimally and produce product k if the variable profits are greater than or equal to the fixed cost of production.

There variable and fixed costs of importing foreign varieties of intermediate goods (F_{mv}). Only the more profitable firms will be able to source inputs from abroad. Firms that produce using both domestic X_d and imported X_m input varieties combined those inputs in a CES function with an elasticity of substitution between the two types of inputs equal to $\theta = \frac{1}{1-\alpha}$:

$$X(ki) = (X_d^\alpha + (X_m)^\alpha)^{\frac{1}{\alpha}},$$

$$\text{with } X_m = \left(\int (\gamma_{iv} x_{miv})^{\frac{\sigma-1}{\sigma}} d \right)^{\frac{\sigma}{1-\sigma}}$$

The parameter γ_{iv} represents the quality of foreign input varieties relative to domestic ones. Assuming that imported varieties are of a higher quality than domestic ones we have $\gamma_{iv} > 1$. The high value of this factor is only available to firms that pay the fixed cost of importing foreign varieties. This fixed cost of importing inputs represents an investment in a new and more advanced technology of a higher quality that reduces marginal costs of production and it is variety specific.

Final good producers are price-takers in intermediate-input markets. The price of imported inputs takes into account the input tariff (τ_m). The price of domestic intermediate inputs is equal to the wage which is used as a numeraire, the cost index for firms relying only on domestic inputs (index by d) and importing firms (index by m) can be expressed as a function of the imported inputs quality and input tariffs:

$$c_d = 1, \quad c_m = \left(1 + \left(\frac{\tau_m}{\gamma_{iv}} \right)^{\frac{\alpha}{\alpha-1}} \right)^{\frac{(\alpha-1)\eta}{\alpha}}$$

Importing firms pay a fixed cost that allows them to reduce their marginal cost by increasing their efficiency through access to high-quality imported inputs. The relative cost is an increasing function of input tariffs ($c_m/c_d = c_m$). Partially differentiating c_m with respect to the input tariffs: $\frac{\partial c_m}{\partial \tau_m} > 0$. The lower the input tariffs the lower the relative unit costs of importing firms vis-a-vis non-importing firms.

Under this simple framework with fixed costs of producing additional products and fixed costs of importing varieties, it is straightforward to analyse how input tariff cuts affect firms' decision to import high-quality inputs to increase product scope and employment.

First, input tariffs reductions lowers the relative cost of using high-quality imported varieties of inputs increasing variable profits allowing firms to import more varieties and upgrade the quality of inputs. Second, firms upgrading the quality of inputs will increase even more their variable profits due to the high efficiency of foreign varieties in the production process. They will be able pay the fixed cost of production to introduce new varieties of final goods. Finally, producing new products requires additional labor increasing firms' labor demand. We consequently have the following testable implications:

Testable implication 1: Input-trade liberalization increases the number of final good products for firms importing intermediate goods through a quality-upgrading channel.

Testable implication 2: Input-trade liberalization has a positive effect on employment for firms adding new products and importing intermediate goods.

Note that if one assumes that fixed costs of introducing new products are skilled intensive, under this framework input tariff reductions will have a positive effect on skilled labor demand. This is a third implication that we will test in the next sections.

3. A first glance at the data

3.1 Firm-product level data

We use a Census panel dataset collected by the Ecuadorian Institute of Statistics (INEC) of formal manufacturing plants (corresponding to ISIC Rev. 3 category D) with 10 or more employees for the period 1997 - 2007.³ The full baseline manufacturing dataset contains 16,678 manufacturing plant- year observations and

³ The dataset collects information at the plant level. For convenience we refer to the terms plant and firm interchangeably.

provides information on plants overall sales and value-added, employment, capital investments as well as expenditures on production as provided in most firm census data.

The distinctive feature of our data is that we can link this information to two additional datasets, which contain information on plants intermediate inputs and on plants output products, respectively. The first dataset gives annual plant-level information on primary materials, auxiliary materials, replacements and accessories, packing materials used for production. For each intermediate input plants provide information on the purchasing price and quantity separately for national and foreign supplies. The second dataset provides information for each plant's final products.

We implement several data cleaning procedures and check the quality of our dataset following Bernard et al. (2010), Kugler and Verhoogen (2011) and Goldberg et al. (2010). The Appendix provides a detailed description of the dataset and cleaning procedures. We test the quality of our products data by identifying firms with irregular output product drops (i.e. products that disappear from production and then reappear again) and firms with product jumps (i.e. products that are produced only once in the intermediate years of firm presence in the sample). These tests, which follow Bernard et al. (2010), are satisfactory in that product drops and jumps are relatively infrequent.

We find similarities between a series of statistics based on our product level data and those obtained based on comparable data for other countries. Ecuadorian firms core products represent 77%, 50% and 43% for plants that produce 2, 6 and 8 products respectively as reported in Table A.1. This compares to the evidence by Bernard et al. (2010) for the United States and Goldberg et al. (2010) for India. Single-product firms represent, on average across 1997-2007, about 32% of overall output sales, a lower share compared to the numbers for India and the United States. Based on our inputs dataset we find a similar concentration for firm intermediate inputs (Table A.2). The number of inputs used in production is however less skewed than for outputs reflecting the multiple set of inputs needed for output production.⁴

⁴ We also compare the standard deviations of purged unit values for 2-digit ISIC Rev. 3 industries with the same standard deviations obtained for a Colombian products dataset by Kugler and Verhoogen

To identify the impact of input-trade liberalization on firms' domestic product growth and employment size, we use input tariffs at the 4-digit ISIC rev.3 industry level. Tariffs data is provided by WITS (World Bank) and corresponds to Ecuador's effectively applied most favourite nation (MFN) import tariffs with respect to the rest of the world at HS6 product level. We link the tariff data to our data on Ecuadorian firms by establishing a product correspondence to the 11-digit ISIC-Rev. 3 categories of Ecuadorian firms' input products.

3.2. Characteristics of importers and their imports

We have also replicated the analysis Kugler and Verhoogen (2009), referenced as KV hereafter, conduct for a sample of Colombian firms on the characteristics of importers and their imported input prices for Ecuadorian firms.

First, we study the relationship of importer status and plant-level performance using the log of real gross output and controlling for region, industry and year effects in columns (1) and (2) and for plant and year effects in columns (3) and (4) of Table 1. Results of column (1) in Panels A indicate a positive relationship between firms importer status and firm size measure including when their exporter status is taken into account (column 2). The gross output effect is maintained for the within-plant comparisons as indicated in columns (3) and (4). This lends support to the importance of firm self-selection into importing.

Second, focusing on intermediate inputs and their unit values, results of panel B of Table 1 show that whether within industries (reported in columns 1 and 2) or within firms (shown in columns 3 and 4) importing has a positive impact on the number of input categories. This suggests that imports facilitate firms access to input varieties.

Kugler and Verhoogen (2011). Purged unit values are the residuals from regressions of log unit values on product fixed effects or from regressions of log unit values on product-year fixed effects. Our standard deviations are somewhat larger than theirs but are sufficiently within bounds to be explained by the fact that we consider more aggregate industry categories and a country with a distinct profile of manufacturing production.

As for the unit values of inputs, computed as the expenditure in inputs over their quantity, Panel C looks at their relationship with importing. The analysis is at the input-product-firm-year level and therefore includes product-year fixed effects so as to exclude effects of differences across products, different units of measurement and different product-specific demand shocks on prices. The regressions reported in column (1) of Panel C include industry and region effects only, whereas columns (2), (3) and (4) incorporate plant, plant-product and plant-year effects respectively. The coefficient indicates that imported products are on average more expensive than domestic inputs.

Panel D treats imported and domestic prices as separate for those observations where firms purchase both from national and foreign producers by using a modified imports measure to indicate whether the price corresponds to the imported product or not. We find a confirmation that firms pay higher prices for products they import from abroad. Note that due to the limited number of observations on inputs that are both imported and purchased domestically we cannot include plant-product-year effects to exploit variation within those products as in KV. Finally, Panel E analyses whether domestic prices for imported inputs are higher for the importers of inputs. We find no evidence that this is indeed the case for our sample of firms.

In conclusion, KV interpret their findings as suggesting that Colombian plants purchase higher-quality inputs on the import market than on the domestic market. We find similar evidence for our dataset on Ecuadorian manufacturing firms from 1997-2007 and explore the quality of inputs further in our study. The consistency of our findings with theirs also provides additional confidence in using this novel dataset for empirical analysis.

Table 1: Replication of Kugler and Verhoogen (2009)

	(1)	(2)	(3)	(4)
Panel A: Dependent variable: log real gross output				
Importer	1.461*** (0.078)	1.106*** (0.069)	0.101** (0.041)	0.098** (0.041)
Exporter		1.566*** (0.072)		0.175*** (0.034)
R^2	0.45	0.55	0.93	0.93
Panel B: Dependent variable: number of inputs				
Importer	1.257*** -0.161	1.180*** -0.159	0.879*** -0.132	0.875*** -0.132
Exporter		0.338** -0.154		0.215** -0.084
R^2	0.401	0.402	0.861	0.861
Region effects	Yes	Yes	No	No
Industry effects	Yes	Yes	No	No
Plant effects	No	No	Yes	Yes
Year effects	Yes	Yes	Yes	Yes
N (plant-year observations)	13,037	13,037	13,037	13,037
N (distinct plants)	1501	1501	1501	1501
Panel C: Dependent variable: log real input price				
Importer (of relevant input)	0.138*** (0.032)	0.284*** (0.030)	0.172*** (0.020)	0.302*** (0.030)
Observations (plant-product-year)	81309	81309	81309	81309
R^2	0.83	0.86	0.95	0.89
Panel D: Dependent variable: log real (domestic or imported) input price				
Imported product	0.206*** (0.030)	0.327*** (0.022)	0.261*** (0.031)	0.339*** (0.028)
Observations (plant-product-year-origin)	86417	86417	86417	86417
R^2	0.82	0.85	0.94	0.88
Panel E: Dependent variable: log real domestic input price				
Importer (of relevant input)	-0.079 (0.051)	0.049 (0.041)	0.049 (0.042)	0.043 (0.052)
Observations (plant-product-year)	64062	64062	64062	64062
R^2	0.84	0.87	0.95	0.90
Region, industry effects	Yes	No	No	No
Product-year effects	Yes	Yes	Yes	Yes
Plant effects	No	Yes	No	No
Plant-product effects	No	No	Yes	No
Plant-year effects	No	No	No	Yes
Plant-product-year effects	No	No	No	No

Notes: Robust standard errors clustered at the plant level in parenthesis. ***, ** and percentage level. Only plant-year observations with information on the number of input Panel A and B. In Panels C to E, Column 2-4 were calculated using Stata a2reg procedure (from Amine Ouazad) with bootstrapped standard errors, using 50 replications with draws on distinct cross-sectional units (plants). Plant-year observations in Panels A and B are 13037. Plant-product-year observations in Panels C and D are 81309 and in Panel E 64062.

4. Trade liberalization in Ecuador

4.1. Ecuador's accession to the WTO

The main feature of trade reform in Ecuador was the substantial trade-integration process following its accession to the WTO in mid 1990s. In this section, we describe Ecuador's trade liberalization process and the trade-policy instruments that were applied.

Ecuador's trade policy during the 1970s and 1980s was characterized by trade protection policies focusing import substitution as in other Latin American and Caribbean countries during this period. Trade was consequently very restricted, with high levels of nominal tariffs and import licenses in almost all sectors. This protectionist trade regime in the 1980s shielded many industries (e.g. household appliances, metal manufacture, petrochemicals and textiles) from foreign competition and foreign technology transfers.

A unilateral trade-reform plan was launched in the mid 1990s when Ecuador started implementing Uruguay Round commitments that were completed in 2007. Right before Ecuador's accession to the World Trade Organization (WTO) in 1996, the authorities undertook a series of steps to open the economy to international trade.

Unilateral trade liberalization consisted in tariff reform, reductions to import restrictions, modernization of trade institutions (customs procedures and simplification of steps for trade procedures), multilateral trade integration, reinforcing trade preferences that Ecuador receives from the U.S. within the ATPA (Andean Trade Promotion Act). Several laws promoting free trade were signed by mid 1990s, among them the most important are the "Law of Export Facilitation and Maritime Transport" and the "Customs Law". The latter aimed at reducing and simplifying customs procedures from 18 steps to only 3.

After Ecuador enters WTO, the government signed the "Foreign Trade Law" (1997). This law resulted in the creation of an institution, Ministry of Foreign Trade, which replaces the Ministry of Industries, Integration and Fishing. The aim of this new Ministry is to promote export diversification and foreign technology transfer through

imports of inputs and capital goods. During the period 1997-2000 multilateral negotiations within WTO took place on specific accession commitments of Ecuador. These negotiations are characterized by tariff reductions and elimination of licenses in specific sectors such as automobile and food.⁵

In 1999-2000 took place an important economic and financial crisis that resulted in the adoption of the US dollar as Ecuador's official currency in 2000. We dealt specifically with this issue in Section 7.1. and show that our results are not affected by this currency crisis.

With tariff reductions the highest initial input tariffs experiencing the biggest reduction over the period. Figure A1 in Appendix 1 shows the variation in industry level input tariffs between 1996 and 2007. Average input tariffs declined by 5 percentage points during the period. The maximum level of reduction of input tariffs is 25 percentage points for the 4-digit industry 3150 (manufacture of electric lamps and lighting equipment) from an input tariff of 30% in 1996 to 5% in 2007. The minimum input tariffs of almost zero in 2007 correspond to the 4-digit industry 3691 (manufacture of jewellery).

This unilateral process of trade liberalization resulted in a significant growth of imports. Ecuador's total imports more than doubled in ten years between 1994 and 2004. During that period, the annual average growth rate of imports was of 14 percent. We exploit the changes in input-tariffs across industries over the period in our empirical analysis to first look at the effect of input-trade liberalization on firms' quality upgrading of imported inputs and then on firms' product scope and employment. The next section shows that those changes in input tariffs across sectors are exogenous to firms and industries initial characteristics.

4.2 Exogenous input tariffs variations

In our framework we make use of this sectoral difference in input tariff reductions to capture the impact of input-trade liberalization in Ecuador on domestic product scope

⁵ See for more details the description of these negotiations at https://www.wto.org/english/thewto_e/acc_e/a1_ecuador_e.htm

and employment. For this approach to be valid potential reverse causality between tariff changes and firm performance needs to be excludable. As such, it seems unlikely that firms producing in industries with greater input-tariff cuts were able to lobby for these lower tariffs.

We test whether tariff changes are exogenous to initial industry and firm characteristics. Following previous works on trade liberalization, such as e.g. Topalova and Khandelwal (2010), we regress first changes in input and output tariffs on a number of industry characteristics computed as the size-weighted average of firms' characteristics in the initial year of our sample. Table 2 shows the coefficients on the change in input and output tariffs (1996-2007) on industry level regressions of initial industry characteristics (sales, number of products, employment and number of firms importing of intermediate goods) on these tariff changes. The estimates confirm that input and output tariff changes between 2007 and 1996 were uncorrelated with initial industry-level outcomes.

Next, following the analysis of Goldberg et al. (2010) we provide additional evidence that input tariff changes between 1996 and 2007 were uncorrelated with initial firm performance measures that we are considering in this analysis. Table 3 shows estimates from regressing firm characteristics in the initial year of the sample such as the importer of inputs status, the logarithm of the number of products produced in the domestic market, employment and total production on the variation in input tariffs across industries between 1996 and 2007. Had the government targeted specific firms/industries during trade liberalization, we would expect tariff changes to be correlated with initial firm performance. However, the correlation is insignificant.

This evidence suggests that the government did not take into account pre-reform trends in firm performance measures when deciding to reduce tariff starting in 1996.

Table 2: Tariff reductions between 1996 and 2007 and pre-reform industrial characteristics

Panel A Dependent variable: change in input tariffs between 1996-2007				
	(1)	(2)	(3)	(4)
Sales(s)	0.003 (0.002)			
N products(s)		-0.001 (0.003)		
Employment(s)			0.001 (0.003)	
N importing inputs firms(s)				0.001 (0.004)
Observations	143	149	149	119
R-squared	0.512	0.492	0.493	0.503

Panel B Dependent variable: change in output tariffs between 1996-2007				
	(1)	(2)	(3)	(4)
Sales(s)	-0.001 (0.002)			
N products(s)		0.001 (0.004)		
Employment(s)			-0.004 (0.002)	
N importing inputs firms(s)				-0.004 (0.005)
Observations	144	151	151	120
R-squared	0.543	0.567	0.577	0.531

Notes: The dependent variable is the changes in input or output tariffs between 1996 and 2007. The table shows regressions at the 4-digit industry level of changes in input tariffs on different industry level characteristics. All industry-level variables are expressed in logarithms. Heteroskedasticity-robust standards errors are reported in parentheses.

Table 3: Initial firm characteristics in 1989 and input tariff changes between 1989-1997

	(1)	(2)	(3)	(4)
	Importer inputs	N products	Employment	Production
Change output tariffs(s,07,96)	-0.913 (1.628)	1.499 (0.999)	-0.727 (1.594)	-0.359 (3.400)
Change input tariffs(s,07,96)	2.279 (2.978)	0.437 (0.567)	2.473 (2.435)	4.410 (3.995)
Observations	503	504	504	494
R-squared	0.376	0.211	0.218	0.301

Notes: The dependent variables in each column are the initial firm-level outcomes in the initial year of the sample. The table shows the coefficients on changes in input tariffs between 1996 and 2007 from firm-level regressions of initial firm characteristics on output and input tariff changes and 2 digit industry fixed effects. Firm-level variables are expressed in logarithms except for the importer of inputs dummy. Heteroskedasticity-robust standards errors are reported in parentheses. Errors are corrected for clustering at the 4-digit industry level.

5. Trade liberalization and input-quality upgrading

5.1. Input-quality estimation

The main contribution of this work to the existent literature is to explore the imported input-quality upgrading mechanism. In order to test this channel, we first estimate a measure of imported inputs quality following the methodology proposed by Khandelwal et al. (2013) (KSW hereafter).

KSW show how under certain assumptions the quality for each firm-product-year observation can be estimated. They demonstrate that assuming a CES utility function where product quality acts as a demand shifter, the quality of each product can be estimated using information on quantities, unit values and the elasticity of substitution across products. Quality is then represented as any product attribute that imply a shift in the demand curve reflecting Sutton's (1991) pioneering idea. Inferring product quality from demand functions implies that conditional on prices a product with a higher market share or a higher demand (quantity) is assigned a higher quality.

They estimate quality as a demand shifter that correspond to the residual of an OLS estimation of the quantity and price (unit value) on country-time fixed effects -that control for price index and income at destination-, and product fixed effects that control for variation across products -since prices and quantities are not necessarily comparable across products-. The estimated quality depends on the residual of such estimation and the elasticity of substitution between products. They estimate product quality at the firm level using Chinese firm-product disaggregated at the HS6 level and country of destination level customs data for the textile sector. This methodology requires an assumption on the elasticity of substitution across products. Since Khandelwal, Schott and Wei (2013) are interested in quality estimates for one specific sector (textile), they rely on the median elasticity across textile products of Broda, Greenfield and Weinstein (2006).⁶

⁶ Other alternative empirical methodologies disentangle price and quality using trade values and quantities to obtain a quality-adjusted measure of unit values. Hallak and Schott (2011) develop a methodology that decomposes countries observed export prices into quality and quality-adjusted components using information of their trade balances from the demand side. Khandelwal (2010) proposes a measure of quality that accounts for both product prices and market shares. He uses unit value and quantity information for imports of the US to infer quality from the estimation of a nested logit demand system. This methodology provides quality estimates at the

We adapt KSW's estimation to the import side and to our data to estimate the quality of imported inputs by firms in Ecuador. Note that we have information at the 11 product code on the inputs use by firms and their origin (domestic or foreign), but we do not know the country of origin of imported inputs. The quality of imported inputs corresponds to the residual of an OLS estimation of the following regression:

$$x_{ikt} + \sigma p_{ikt} = \alpha_k + \alpha_t + \eta_{ikt} \quad (I)$$

where x_{ikt} and p_{ikt} denote the natural logs of the quantity and price of product k imported by firm i in year t . The product fixed effect α_k controls for unobservable characteristics across products since prices and quantities are not necessarily comparable across products. The estimated log quality, λ_{ikt} , depends on the residual of that estimation η_{ikt} and the elasticity of substitution σ : $\lambda_{ikt} = \eta_{ikt}/(\sigma - 1)$.

We estimate quality following this method for each HS2 sector using our database. We rely on the elasticity of substitution at the HS3 digit estimated by Broda, Greenfield and Weinstein (2006) for Ecuador. We also present a robustness test relying on the average elasticity of substitution equal to 5 for the US estimated by Broda and Weinstein (2006). The indicator of input quality derived from this estimation implies that conditional on input price, a foreign variety with a higher import quantity (demand by domestic firms) is assigned a higher quality.

5.2. Input-trade liberalization and imported inputs quality upgrading

In this section, we look at the relationship between import tariff cuts and changes in the quality of imported inputs. We use the estimated quality at the firm-product-year level, λ_{ikt} , as the dependent variable and regress it on import tariffs applied by Ecuador at the HS 6 digit level, including firm, product and industry-year fixed effects as well as firm initial size trend (where the initial size of firm i is defined by the logarithm of total production of the firm).

product level in which imported products with higher market shares are assigned higher quality after controlling for price differences and country size.

Columns (1) and (2) of Table 4 present the results. The coefficient of interest on import tariffs at the product level is negative and significant indicating that input-trade liberalization allowed firms to upgrade the quality of their imported inputs. The estimated coefficient suggests that for a 10 percentage point reduction of input tariffs, importing firm have increase the quality of their intermediate inputs by 22%. The results are robust and stable to the inclusion of initial firm size trend in column (2). Column 3 shows that these results are robust when we use the median sigma for the US (5) to estimate imported inputs quality. These findings are consistent with the results found by Bas and Strauss-Kahn (2015) who apply a similar measure of imported inputs quality in their study on China.

We subject these results to further validation tests of the hypothesis that input-trade liberalization allows firms to increase their product scope and employment because of an increase in the quality of inputs: First, product quality in general may have increased due to technological progress and be correlated with import tariffs. We run a falsification test and estimate the effect of import tariffs on the quality of domestic intermediate inputs. As expected import tariff have no significant effect on the quality of domestic inputs (columns 4 and 5 of Table 4).

Table 4: Input tariff cuts, inputs quality and quantity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Quality imported inputs		Quality domestic inputs		Imported inputs	Domestic inputs	
	sectoral sigma	sigma 5	sectoral sigma	sigma 5	quantity	quantity	
Tariffs(k,t-1)	-2.244** (1.014)	-2.261** (1.012)	-0.913** (0.404)	0.980 (0.623)	0.329 (0.329)	-3.658*** (1.373)	3.720** (1.538)
Initial firm size trend		yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes	yes
Product fixed effects	yes	yes	yes	yes	yes	yes	yes
Industry-year fixed effect	yes	yes	yes	yes	yes	yes	yes
Observations	15,713	15,713	15,713	42,792	47,474	16,614	47,478
R-squared	0.286	0.287	0.249	0.289	0.244	0.676	0.676

Notes: In columns (1) to (5) the dependent variable is the estimated quality of imported (domestic) inputs of firm i and product k in year t . In columns (6) and (7) the dependent variable is the logarithm of the quantity of imported (domestic) products. Tariffs(k,t-1) is the corresponding import tariffs at the HS-6 product level applied by Ecuador in year $t - 1$. Heteroskedasticity-robust standards errors are reported in parentheses. Errors are corrected for clustering at the product level. ***, **, and * indicate significance at the 1, 5 and 10 percent levels respectively.

Second, it may be that our input quality measure is simply about higher prices but not quality. If this was the case then we would expect firms will not increase the quantity of intermediate inputs purchased from abroad. We test for this possibility and look at

the effects of input-trade liberalization on the quantity of imported inputs. Column (6) shows that domestic firms increase also the quantity of imported inputs with input tariff cuts. The estimated coefficient suggests that for a 10 percentage point reduction of input tariffs, importing firm have increase the quantity of their foreign intermediate inputs by 36%. This is consistent with an increase in the quality of foreign inputs with input-trade liberalization.

Finally, we look at the effect of input tariff on domestic quantity of intermediate goods. Results presented in column (7) suggest that firms have substituted domestic inputs by foreign ones during trade liberalization. The estimated coefficient indicates that actually Ecuadorian firms have reduced the demand of domestic input quantity by the same amount that they have increased the demand of foreign intermediate inputs.

6. Trade liberalization, input-quality upgrading, firm product scope and employment effects

This section explores whether higher quality of imported inputs explains why importers are more likely to widen their product scope with input-tariff liberalization. For a developing country like Ecuador that is highly dependent on foreign technology because of weak national capacities, input-trade liberalization might allow firms to upgrade the quality of their intermediate inputs to sell more final goods products and expand their employment even more than others.

6.1. Input-trade liberalization and firms' product growth

We start by investigating the relationship between the availability of imported intermediate goods due to input-tariff reductions and firms' decision to increase the number of products produced in Ecuador. We estimate the following model to test this relationship:

$$\ln N_{p_{ijt}} = \gamma_1 \text{Input } \tau_{j,t-1} + \gamma_2 \text{Importer}_{ijt} + \gamma_3 \text{Input } \tau_{j,t-1} * \text{Importer}_{ijt} + \gamma_4 \text{Output } \tau_{j,t-1} + \gamma_5 \text{Size}_{i,t0} * \alpha_t + \mu_i + \alpha_t + \varepsilon_{ijt} \quad (\text{II})$$

Here $\ln N_{p_{ijt}}$ is the logarithm of the number of products firm i produces (the products are available in the dataset at 13 digit levels) in industry j and year t . Input $\tau_{j,t-1}$ represents the input tariffs of 4-digit ISIC industry j in year $t - 1$. We compute the input tariffs of the 4-digit ISIC industry using the information we have on the inputs that Ecuadorian firms import. We rely on constant weights over the period to avoid endogeneity issues between changes in tariffs and import weights. Output $\tau_{j,t-1}$ is the corresponding output tariffs of the industry that controls for foreign competition effects. Importer_{ijt} is a dummy variable for firm i producing in industry s having positive imports of intermediate goods in year t . $\text{Size}_{i,t0} \times \alpha_t$ corresponds to initial firm size trends, where the initial size of firm i is defined by the logarithm of total production of the firm. All specifications include firm fixed effects, μ_i , that take into account unobservable and time-invariant firm characteristics and year fixed effects that control for macroeconomic shocks affecting all firms and industries in the same way, α_t . Since tariffs vary at the 4-digit industry level over time, the errors are corrected for clustering across 4-digit industry level. The coefficient of interest is γ_3 on the interaction term of input tariffs and the importer of intermediate inputs status. We expect that input tariffs cuts boost product scope for firms importing intermediate inputs.

Table 5 presents the estimation results for equation (II) using a within-firm estimator. Our findings show the impact of lower input tariffs on product innovation measured by the number of domestic products produced by each firm. In column (1) the coefficient on the input tariffs interacted with importer of intermediate goods status is negative and significant at the 5% confidence level, indicating that the drop in input tariffs between 1996 and 2007 increased importers' product scope. Moreover, the results suggest that firms sourcing inputs from abroad produced more products relative to firms relying only on domestic intermediate goods. The estimated coefficient of interest is robust to the inclusion of output tariffs for final goods (column 2) and of firm size trends (column 3). Column 4 presents our preferred specification, where we add 4-digit industry-year fixed effects to account for all observable and unobservable time-varying shocks at the industry level other than trade liberalization that took place during this period in Ecuador. The coefficient of interest is slightly smaller but remains significant indicating that input-trade

liberalization allows Ecuadorian firms that source their inputs from abroad to improve their product scope.

The estimated coefficient of the interaction term between input tariff and importer status implies that a 10 percentage point fall in input tariffs leads to almost 3% increase in the number of products for those firms importing intermediate goods. These findings confirm the results found by Goldberg et al. (2010) for India.

Table 5: Input tariff cuts and firms' domestic product growth

	Dependent variable: logarithm of the number of products of firm <i>i</i> in year <i>t</i>							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
					Quality upgrading channel	Differentiated Inputs	Homogeneous Inputs	
Input tariffs(<i>j,t-1</i>) x Importer inputs	-0.437** (0.180)	-0.432** (0.180)	-0.422** (0.183)	-0.293* (0.169)			-0.746** (0.321)	-0.238 (0.227)
Importer inputs	0.088*** (0.024)	0.089*** (0.024)	0.088*** (0.025)	0.064*** (0.021)			-0.023 (0.196)	0.106 (0.157)
Input tariffs(<i>j,t-1</i>) x Importer quality upgra					-0.314** (0.139)	-0.345* (0.188)		
Importer quality upgrading					0.041** (0.016)	0.051** (0.022)		
Input tariffs(<i>j,t-1</i>)	0.148 (0.120)	0.150 (0.122)	0.152 (0.124)		0.217* (0.130)		0.126*** (0.042)	0.053* (0.030)
Output tariffs(<i>j,t-1</i>)		-0.078 (0.132)	-0.049 (0.139)		0.054 (0.152)		0.467** (0.182)	-0.320* (0.190)
Initial firm size trend			yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Year fixed effects	yes	yes	yes		yes		yes	yes
Industry-year fixed effects				yes		yes		
Observations	12,495	12,410	12,199	12,180	9,858	9,937	4,561	6,809
R-squared	0.839	0.840	0.839	0.856	0.845	0.861	0.862	0.850

Notes: The dependent variable is the logarithm of the number of products of firm *i* in year *t*. Columns (7) and (8) show the estimates for two different subsamples of firms importing mainly differentiated or homogeneous inputs. Heteroskedasticity-robust standards errors are reported in parentheses. Errors are corrected for clustering at the 4-digit industry level. ***, **, and * indicate significance at the 1, 5 and 10 percent levels respectively.

Input-quality upgrading from trade liberalization: the effects on product scope

Next, we test if the quality of imported inputs channel can explain our findings on firms' product growth. We aggregate the measure of imported quality of inputs at the firm level and create a measure of quality upgrading as an indicator variable that equals to one if the average quality of firm *i*'s imported inputs increased between *t* and *t - 1*. This variable is then interacted with the industry input tariffs. We regress

the logarithm of the number of products sold by the firm on these interaction terms including firm, year fixed effects and firm initial size trend as in equation (II).

Results are presented in columns (5) and (6) of Table 5. Our findings suggest that upgrading the quality of imported inputs increases the product growth. Moreover, input-trade liberalization has a positive effect on the number of products sold by Ecuadorian firms that upgrade the quality of their inputs. The estimated coefficient of the interaction term between input tariff and importer quality upgrading implies that a 10 percentage point fall in input tariffs leads to a 3.5% increase in the number of products for those firms importing intermediate goods (column 6).

Finally, we provide additional evidence on the quality upgrading channel by looking at the effect of trade liberalization on product scope for firms importing mainly differentiated vs. homogeneous inputs. We expect the effect of input tariff reductions on firms' product growth via quality upgrading to be stronger for firms relying on differentiated inputs than for homogeneous goods, which have a referenced price and for which goods are more standardized. We implement this identification strategy by running estimations of equation (II) of the impact of input tariffs on product scope on the subsamples of firms using mainly differentiated and homogeneous inputs separately. A firm is in the subsample of firms relying on differentiated inputs if that firm uses more than 50 percent of differentiated intermediate goods in the production process. Goods are distinguished according to Rauch (1999) classification of product differentiation.

Results are presented in columns (7) and (8) of Table 5. Our findings suggest that the decrease in input tariffs increases the number of final goods products firms are selling only for those firms importing differentiated intermediate goods. Input tariff cuts have no impact on firms' product scope for the subsample of firms relying on homogeneous inputs. These results again suggest that we are indeed capturing the effect of input quality upgrading driven by trade liberalization on firms' product scope.

6.2. The effects of input tariff cuts on firms' employment growth

To investigate the effect of input-trade liberalization on the labor demand of firms that expanded their product scope, we restrict our sample to the firms that during the period sell new final good products that they were not producing previously. First, we look at the effect of input tariff cuts for importing firms adding new products on total employment and then we explore if the results are driven by the input-quality upgrading channel.

The estimation results are presented in Table 6. All specifications include firm fixed effects and year fixed effects. Our preferred specification includes 4-digit ISIC industry-year fixed effects that allow us to take into account all other time varying observable and unobservable shocks affecting industries during this period. Column (1) of Table 6 (Panel A) shows that firms that source inputs from abroad and also produce new final good products have increased their employment more over the period. The interaction term between input tariffs and importer status of inputs is negative significant in all specifications. Results suggest that firms selling new final goods products and importing inputs that produce in industries with largest input tariff cuts have expanded their employment size. This finding is robust and stable to the inclusion of output tariffs (column 2), initial firm size trends (columns 3 and 4) and industry-year fixed effects (column 4). The estimated coefficient of interest implies that the 10 percentage point fall in input tariffs during the period leads to almost 10% increase in employment for firms producing new products and importing intermediate goods.

Input-quality upgrading from trade liberalization: the employment effects

We now investigate if our previous results are driven by the input-quality upgrading channel. We regress the logarithm of firms' total employment on the interaction term of input tariffs and importer quality upgrading dummy including firm, year fixed effects and firm initial size trend as in equation (II).

Column (5) of Table 6 (Panel A) shows the results. These findings suggest that firms producing in industries with greater input tariff cuts have benefited from trade

liberalization to upgrade the quality of their intermediate inputs and expand their labor demand. These results are confirmed in columns (6) and (7) when we split the sample into firms relying mainly on differentiated and homogeneous inputs. Only those firms that source differentiated goods, for which there is a scope for quality upgrading, increase their employment thanks to input-trade liberalization.

Table 6: Input tariff cuts and employment growth of firms selling new products

Panel A: dependent variable total employment

	Dependent variable: logarithm of employment of firm i in year t						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
					Quality upgrading channel	Differentiated Inputs	Homogeneous Inputs
Input tariffs($j,t-1$) x Importer inputs	-1.032*** (0.327)	-1.026*** (0.328)	-0.977*** (0.333)	-0.982*** (0.343)		-1.824*** (0.531)	-0.590 (0.411)
Importer inputs	0.190*** (0.041)	0.187*** (0.041)	0.175*** (0.041)	0.160*** (0.043)		1.347*** (0.449)	0.664** (0.316)
Input tariffs($j,t-1$) x Importer quality upgra					-0.966*** (0.338)		
Importer quality upgrading					0.128*** (0.037)		
Input tariffs($j,t-1$)	0.867*** (0.290)	0.869*** (0.291)	0.956*** (0.288)			0.284*** (0.072)	0.130*** (0.050)
Output tariffs($j,t-1$)		-0.139 (0.168)	-0.125 (0.168)			-0.564* (0.304)	0.148 (0.208)
Initial firm size trend			yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes	yes
Year fixed effects	yes	yes	yes			yes	yes
Industry-year fixed effects				yes	yes		
Observations	9,107	9,038	8,898	8,849	8,849	3,491	4,948
R-squared	0.925	0.925	0.926	0.937	0.936	0.928	0.934

Panel B: dependent variable unskilled and skilled labor

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Low skilled labor				High skilled labor			
			Differentiated Inputs	Homogeneous Inputs		Quality channel	Differentiated Inputs	Homogeneous Inputs
Input tariffs($j,t-1$) x Importer inputs	-0.552 (0.394)		-1.276 (0.652)	-0.341 (0.637)	-1.055** (0.472)		-1.447** (0.731)	0.066 (0.813)
Importer inputs	0.113** (0.050)		0.212** (0.092)	0.098 (0.074)	0.204*** (0.060)		0.233** (0.105)	0.109 (0.094)
Input tariffs($j,t-1$) x Importer quality upgrading		-0.744 (0.424)				-1.076** (0.424)		
Importer quality upgrading		0.111** (0.047)				0.124*** (0.047)		
Initial firm size trend	yes	yes	yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Industry-year fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Observations	8849	8849	3,300	4,834	8,849	8,849	3,300	4,834
R-squared	0.914	0.914	0.920	0.928	0.903	0.903	0.916	0.920

Notes: In Panel A the dependent variable is the logarithm of total employment of firm i in year t . In Panel B columns (1) to (4) the dependent variable is the logarithm of low skilled labor and in columns (5) to (8) is the logarithm of high skilled labor of firm i in year t . Columns (6) and (7) in Panel A and (3), (4), (7) and (8) in Panel B show the estimates for two different subsamples of firms importing mainly differentiated or homogeneous inputs. Heteroskedasticity-robust standards errors are reported in parentheses. Errors are corrected for clustering at the 4-digit industry level. ***, **, and * indicate significance at the 1, 5 and 10 percent levels respectively.

Input-trade liberalization and skilled-biased input-quality upgrading

In this section, we test whether input-trade liberalization, through the quality-upgrading channel, results in skilled-biased production processes. If this was the case we would expect that particularly skilled labor will increase more for firms importing and upgrading the quality of their inputs. We test whether this is the case using the imperfect information in our dataset on total production and non-production workers that can be used as a proxy of unskilled and skilled labor.

We run the estimation of employment for firms that sell new products during the period using as dependent variables firms' unskilled and skilled labor. Results are presented in Panel B of Table 6. As can be noticed input-tariff cuts have no effect on unskilled labor demand (columns 1 to 4), while they have a positive and significant effect on skilled labor demand for firms adding new products and importing inputs (columns 5 to 8). Results presented in columns (6) to (8) suggest that firms producing in industries with larger input tariff reductions, that upgrade the quality of foreign inputs, increase their skilled labor demand. This indicates that one of the main channels through which input-trade liberalization affects firms' employment is the skilled-biased high quality foreign inputs.

7.1. Alternative explanations

There are other potential explanations why firms may increase the number of products they sell and increase in employment size then input-trade liberalization. In this section, we discuss and examine the role of the most important alternative explanations: (i) foreign demand shocks (export-channel) and (ii) the role of the currency crisis in Ecuador.

Foreign demand shocks (export-channel)

First, the expansion of export opportunities due to foreign demand shocks may increase the incentives for firms' to increase the number of products and employment. There is empirical evidence to show that, importing intermediate inputs leads to

higher exports (Feng et al., 2012; Bas, 2012). Higher export profits might allow overcoming the fixed costs of importing and producing more products.

We first include in the previous specification an export status dummy variable that is equal to one if the firm has positive export sales in the year. Then, we explicitly introduce the export tariff faced by Ecuador at the industry level by adding the average effectively applied tariff at the 4-digit ISIC revision 3 industry level set by the main trading partners (in Latin America, USA, European Union and China) to Ecuador (export tariff) during the 1996-2007 period from WITS dataset (World Bank). Finally, we include an interaction term between export status and the export tariffs. Table 7 reports the results.

Table 7: Controlling for foreign demand shocks (export-channel)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Number of products			Employment		Low skilled	High skilled
Input tariffs(j,t-1) x Importer inputs	-0.425** (0.184)	-0.396** (0.185)	-0.310* (0.170)	-0.985*** (0.339)	-0.933*** (0.340)	-0.505 (0.391)	-1.001** (0.473)
Input tariffs(j,t-1)	0.152 (0.125)	0.134 (0.126)					
Importer inputs	0.087*** (0.025)	0.084*** (0.025)	0.065*** (0.021)	0.155*** (0.042)	0.150*** (0.043)	0.104** (0.049)	0.193*** (0.060)
Output tariffs(j,t-1)	-0.051 (0.139)	-0.086 (0.140)					
Exporter	0.032*** (0.010)	0.032*** (0.010)	0.039** (0.017)	0.120*** (0.018)	0.178*** (0.035)	0.167*** (0.042)	0.201*** (0.050)
Export tariffs(j,t-1)		0.014 (0.109)					
Export tariffs(j,t-1) x Exporter			0.045 (0.170)		-0.680* (0.371)	-0.532 (0.466)	-0.800 (0.527)
Initial firm size trend	yes	yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes	yes
Year fixed effects	yes	yes					
Industry-year fixed effects			yes	yes	yes	yes	yes
Observations	12,199	12,148	12,131	8,780	8,816	8,816	8,816
R-squared	0.839	0.839	0.857	0.938	0.937	0.914	0.904

Notes: In columns (1) to (3) the dependent variable is the logarithm of the number of products of firm i in year t . In columns (4) and (5) the dependent variable is the logarithm of total employment and in columns (6) and (7) is the logarithm of low skilled and high skilled labor of firm i in year t . Heteroskedasticity-robust standards errors are reported in parentheses. Errors are corrected for clustering at the 4-digit industry level. ***, **, and * indicate significance at the 1, 5 and 10 percent levels respectively.

The effect of the export status of the firm is positive and significant across all specifications (using as dependent variable the number of products or employment) implying that exporters produce more products and are bigger. The effect of export

tariff is not significant on the number of products (columns 2 and 3). Next we look at the effect of export tariff changes depending on export status on total employment. Results presented in column (5) suggest that foreign demand shocks increase firms' employment, however it is not significant when we split the sample into low and high skilled labor. The coefficient on the input tariffs remains robust and stable in all specifications when we take into account the role of foreign demand.

Controlling for the crisis

The sample period under analysis includes the Ecuador economic and financial crisis of 1999 and 2000, during which time the country experienced banking crisis, depreciations and sovereign debt crisis.

To ensure that our results are not being driven by these factors, mainly the depreciations of the domestic currency at the end of 1999 that resulted in the adoption of the U.S. dollar in 2000, we exclude from the estimation the years of the crisis. Results are presented in columns (1) to (4) of Table 8. The magnitude of the coefficients of interest on the interaction term between input tariffs and importer status is robust and stable across all specifications when looking at the effect on the number of products, total employment, low skilled and high skilled labor.

As an alternative way of controlling for this currency crisis, we include in the full sample interaction terms between a dummy equal to one in the crisis years and input and output tariffs. Results are presented in columns (5) to (8) of Table 8. As can be seen the main findings on the effect of input tariff cuts on product scope and employment are robust and stable when we include those controls.

Finally, we also control directly for changes in the real exchange rate at the industry level and interacted with importer status. Adding these controls do not affect our main results on the effect of input tariffs on product scope and employment. These findings are reported in Table A7 in the Appendix.

Table 8: The effect of the economic crisis 1999-2000

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Product scope	Excluding crisis years Employment	Low skilled	High skilled	Product scope	Employment	Low skilled	High skilled
					Interaction crisis dummy and tariffs			
Input tariffs(j,t-1) x Importer in	-0.430** (0.205)	-1.116*** (0.403)	-0.571 (0.391)	-0.849** (0.413)	-0.421** (0.184)	-0.969*** (0.334)	-0.553 (0.392)	-0.851** (0.414)
Input tariffs(j,t-1)	0.165 (0.128)	0.726** (0.342)	0.996*** (0.329)	0.388 (0.340)	0.176 (0.127)	0.865*** (0.301)	0.843** (0.346)	0.375 (0.354)
Importer inputs	0.096*** (0.027)	0.197*** (0.047)	0.127*** (0.049)	0.193*** (0.052)	0.088*** (0.025)	0.174*** (0.041)	0.124** (0.049)	0.194*** (0.052)
Output tariffs(j,t-1)	0.028 (0.154)	-0.175 (0.184)	-0.132 (0.214)	0.095 (0.258)	-0.037 (0.142)	-0.199 (0.171)	-0.153 (0.220)	-0.014 (0.257)
Input tariffs(j,t-1) x Crisis					-0.105 (0.178)	0.260 (0.344)	0.711* (0.423)	-0.221 (0.391)
Output tariffs(j,t-1) x Crisis					-0.055 (0.109)	0.362 (0.224)	0.026 (0.294)	0.601** (0.293)
Initial firm size trend	yes	yes	yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Observations	9,498	6,978	8,898	8,898	12,199	8,898	8,898	8,898
R-squared	0.837	0.930	0.901	0.892	0.839	0.926	0.901	0.892

Notes: In columns (1) to (4) we exclude the years of the currency crisis from the estimation. In columns (5) to (8) we rely on the full sample and include interaction terms between a dummy equal to one during the crisis years and input and output tariffs. Heteroskedasticity-robust standards errors are reported in parentheses. Errors are corrected for clustering at the 4-digit industry level. ***, **, and * indicate significance at the 1, 5 and 10 percent levels respectively.

7.2. Other robustness tests

We now move on to additional robustness checks. Columns (3) to (6) of Table A7 in the Appendix present results obtained with alternative samples.

The number of firms has changed during the period due to entry and exit of firms from the sample. As a robustness check, we run our baseline regression on the subset of firms that are present over the entire period. Results found with this balanced sample are reported in columns (3) and (4) of Table A7. Although the sample size is largely reduced, coefficients on the impact of input tariffs cuts on product scope and employment for importing firms are still negative and highly significant. Moreover, the magnitude of the point estimates is similar relative to the baseline specification presented in Table 5 and 6.

Finally, we run our baseline estimation on subsamples excluding sectors that may present specific patterns. More precisely, we exclude firms from the food, beverage and tobacco industries from the analysis. The results are presented in columns (5) and

(6) of Table A7. These estimates show that omitting these sectors does not affect our main findings.

Conclusion

This paper contributes evidence on the impact of input-trade liberalization on firm performance by studying the effect input tariff cuts on firms' product scope and employment size. We document the role of input product quality upgrading in driving those impacts for unique firm-product-level data for Ecuador following trade liberalization in the context of Ecuador's accession to the WTO.

Our findings suggest that input tariff cuts allow firms to upgrade the quality of their inputs to introduce more products in the market and to expand their employment. Interestingly, the employment size expansion was biased towards skilled labor (non-production workers) suggesting that new production processes using high quality inputs were skill-biased. We do not find that access to export markets or the currency crisis are picking up our results.

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Appendix 1: Additional Figures and Tables

Figure A.1: Changes in input tariffs from 1996-2007

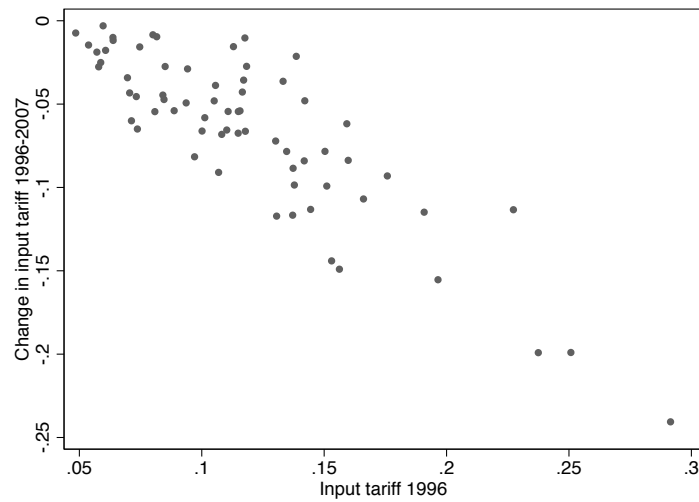


Table A.1: Share of output products in total plant products, average for 1997-2007

Outputs	1	2	3	4	5	6	7	8	9	10	11	12	13	14+
1	1	0.77	0.69	0.60	0.56	0.50	0.48	0.43	0.41	0.37	0.38	0.36	0.34	0.33
2		0.23	0.22	0.23	0.21	0.22	0.21	0.21	0.20	0.20	0.19	0.19	0.18	0.17
3			0.09	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.12	0.12	0.12	0.11
4				0.06	0.07	0.08	0.08	0.09	0.09	0.09	0.08	0.09	0.09	0.08
5					0.04	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.06
6						0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05
7							0.02	0.03	0.03	0.04	0.04	0.04	0.04	0.04
8								0.02	0.02	0.03	0.03	0.03	0.03	0.04
9									0.01	0.02	0.02	0.02	0.03	0.03
10										0.01	0.01	0.02	0.02	0.03
11											0.01	0.01	0.02	0.02
12												0.01	0.01	0.02
13													0.01	0.01
14+														0.03
Nbr of Firms	451	198	166	105	96	72	55	46	36	36	32	31	37	70

Table A.2: Share of input products in total plant inputs, average for 1997-2007

Inputs	1	2	3	4	5	6	7	8	9	10	11	12	13	14+
1	1	0.82	0.71	0.64	0.59	0.56	0.55	0.52	0.46	0.45	0.45	0.42	0.38	0.41
2		0.18	0.20	0.21	0.21	0.20	0.19	0.19	0.20	0.19	0.19	0.19	0.18	0.17
3			0.08	0.10	0.11	0.11	0.11	0.11	0.12	0.12	0.11	0.11	0.11	0.11
4				0.05	0.06	0.07	0.07	0.07	0.08	0.08	0.07	0.08	0.08	0.07
5					0.03	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06
6						0.02	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.04
7							0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.03
8								0.01	0.02	0.02	0.02	0.02	0.03	0.03
9									0.01	0.01	0.02	0.02	0.02	0.02
10										0.01	0.01	0.01	0.02	0.02
11											0.01	0.01	0.01	0.01
12												0.01	0.01	0.01
13													0.01	0.01
14+														0.01
Nbr of Firms	172	106	123	137	129.5	115.9	97	87.7	80	73.1	78	95	132	67

Appendix 2: Sample statistics and data treatment

Statistics of the main plant-level dataset

The original full manufacturing plant-level sample contains 17,001 plant-year observations, which is fairly balanced across 1997 – 2007 with at least 1,512 (2002) and at a maximum 1,655 (1999) firms each year. Table A.3 shows the average split across 2-digit industries for the entire sample period; more than one in four observations are of food and beverage producers.

Table A.3: Number of plant-year observations by 2-digit ISIC rev. 2 industry

Industry	Plants	Share in Total
Food and beverages [15]	4563	26.84
Tobacco [16]	18	0.11
Textiles [17]	1232	7.25
Wearing apparel [18]	1221	7.18
Leather products, luggage, saddlery and footwear [19]	597	3.51
Wood and wood products [20]	619	3.64
Paper and paper products [21]	577	3.39
Publishing, printing and reproduction of recorded media [22]	765	4.50
Coke, refined petroleum products and nuclear fuel [23]	93	0.55
Chemicals and chemical products [24]	1206	7.09
Rubber and plastics products [25]	1318	7.75
Other non-metallic mineral products [26]	1062	6.25
Basic metals [27]	544	3.2
Fabricated metal products [28]	766	4.51
Machinery and equipment n.e.c. [29]	474	2.79
Office, accounting and computing machinery [30]	4	0.02
Electrical machinery and apparatus n.e.c. [31]	239	1.41
Radio, television and communication equipment and apparatus [32]	8	0.05
Medical, precision and optical instruments, watches and clocks [33]	62	0.36
Motor vehicles, trailers and semi-trailers [34]	419	2.46
Other transport equipment [35]	40	0.24
Furniture, manufacturing n.e.c.[36]	1174	6.91

Notes: For each industry ISIC Rev. 3 2-digit codes are provided in brackets.

We eliminate plant observations in any single year if no information on overall product sales, employment and wage payments is provided since these will be essential for our analysis. In the few cases in which sales information is missing, we use product-plant data to complement the data. Our baseline plant-level dataset contains 16,678 plant-year observations for 1997 to 2007.

Data treatment for input- and output-product data

We use two separate datasets at the input-plant and output-plant level for 1997-2007. The original datasets provide for each product of plants an 11-digit product code, a description of the product itself and the unit of measurement of the quantities.⁷ The 11-digit product codes are based on the ISIC Rev. 3 classification. Baseline datasets include 1,861 and 1,606 distinct input and output 11-digit manufacturing product categories; these correspond to the intermediate inputs and outputs of the plant-level dataset defined above. The dataset on intermediate inputs includes also information on the purchasing price and quantity of goods across national and international

⁷ The data contains the following 11 different units of measurement across inputs and outputs datasets: i) kilograms, ii) grams, iii) metres, iv) square metres, v) cubic metres, vi) units, vii) pairs, viii) litres, ix) barrels, x) gallons and xi) heads.

purchases. The final products dataset has information on the production value and quantity as well as the sales value and quantity. Table A.4 provides a few examples of products in our dataset.

Table A.4: Examples of input and output products from the outputs and inputs datasets

Product description	ISIC Code	Unit
<i>A. Outputs</i>		
Sausages and similar products made of meat	15112113210	Kilograms
Woven fabrics of combed wool or of combed fine hair	17112654001	Metres
Ties, bow-ties and cravats	18102822903	Units
Footwear with uppers of leather or composition leather	19202933001	Pairs
Statuettes and other ornamental wooden articles	20293191302	Units
Gummed or adhesive paper and paperboard	21013214913	Kilograms
Exercise books	22213260001	Units
Preparations for use on the hair	24243532302	Litres
Brakes and servo-brakes and parts thereof	34304912901	Units
<i>B. Inputs</i>		
Tobacco extracts and essences	16002509002	Litres
Bovine leather and equine leather, without hair	19112912012	Units
Paper or paperboard labels of all kinds	21093219700	Units
Paraffin wax, crude or refined	23203350001	Kilograms
Prepared glues and other prepared adhesives	24293542005	Litres
Ceramic tableware, kitchenware and other ceramic household and toilet articles	26913722102	Units
Electrical plugs and sockets	31204621206	Units
Pressure regulators and controllers (manostats)	33134827001	Units
Spectacle lenses of glass	33204831102	Pairs

We applied several basic data cleaning procedures to obtain our final dataset. First, we removed those observations without any product code for both the input and the output datasets. Second, we also exclude observations on subcontracted production since information on product values in such cases might not reflect actual market values. Third, the original dataset contains cases where firms have more than one output or import product with the same 11-digit product code. We eliminate duplicate observations. As for the remaining cases when firms have more than one input and/or output in the same year with the same 11-digit code we create a more disaggregate product category rather than aggregate these observations. Fourth, any within-product price and quantity comparisons will only be meaningful if the same units of measurement are used. While this is the case for most of the products in our datasets, in certain cases the same product is reported in a different unit of measurement by different firms. We create a supra-product category to deal with those cases whenever our analysis requires within-product comparisons. We eliminate those products without information on the unit of measurement for analysis involving price and quantity. (We will use the information whenever we are interested in the number of input or output products only.)

Our final datasets contain 74,823 output-plant-year and 107,359 input-plant-year observations at the 11-digit ISIC Rev. 3 product level. We will use the dataset for our analysis including to compute product adoption, the number of product outputs or inputs and other measures which do not require comparisons within products and/or price and quantity product information. Excluding observations with no information on units of measurement and/or subcontracted products produces a final dataset of 72,300 output-plant year observations and 100,095 input-plant year observations at the 11-digit ISIC Rev. 3 product level with a fairly equal split across years as described in Tables A.5 and A.6 below. Note that final products and inputs datasets

cover most firms across all years with the only exception of 2007. For 2007 we only have information on about 64% of plants both in terms of inputs and outputs.

Table A.5: Number of plant-outputs by year

Year	Plants-Products	Share in Total	Plants	Share of All Plants
1997	6507	9.00	1535	0.94
1998	6626	9.16	1523	0.94
1999	6427	8.89	1434	0.96
2000	6550	9.06	1438	0.96
2001	6669	9.22	1446	0.96
2002	6727	9.30	1427	0.97
2003	6885	9.52	1429	0.97
2004	7097	9.82	1462	0.97
2005	6936	9.59	1440	0.97
2006	7135	9.87	1456	0.98
2007	4741	6.56	961	0.64
Total	72,300	100	15,551	0.93

Table A.6: Number of plant-inputs by year

Year	Plants-Products	Share in Total	Plants	Share of All Plants
1997	9713	9.70	1584	0.97
1998	9582	9.57	1559	0.97
1999	9033	9.02	1462	0.98
2000	9088	9.08	1461	0.98
2001	9369	9.36	1469	0.98
2002	9247	9.24	1442	0.98
2003	9425	9.42	1451	0.98
2004	9534	9.52	1485	0.98
2005	9330	9.32	1460	0.98
2006	9713	9.70	1471	0.99
2007	6061	6.06	960	0.64
Total	100,095	100	15,804	0.95

Converting monetary indicators for 1997-1999

Our data are provided in Ecuadorian sucre for 1997-1999 and in US dollars for 2000-2007 reflecting the country's adoption of the US dollar in 2000. In order to create a common dataset we convert 1997-1999 monetary values into US dollars using annual exchange rates from the Ecuadorian Central Bank.

Table A.7: Robustness tests

	(1) RER shocks		(3) Balance sample		(5) Excluding food, beverage and tobacco	
	Product scope	Employment	Product scope	Employment	Product scope	Employment
Input tariffs(j,t-1) x Importer inputs	-0.416** (0.182)	-0.945*** (0.350)	-0.320* (0.192)	-0.910** (0.384)	-0.518** (0.216)	-0.591* (0.350)
Input tariffs(j,t-1)	0.153 (0.122)		0.098 (0.153)	0.687** (0.271)	0.231 (0.157)	0.407 (0.283)
Importer inputs	0.087*** (0.024)	0.108 (0.082)	0.096*** (0.024)	0.137*** (0.047)	0.102*** (0.028)	0.144*** (0.043)
Output tariffs(j,t-1)	-0.039 (0.139)		-0.164 (0.125)	0.041 (0.198)	0.006 (0.187)	0.108 (0.178)
RER(j,t-1)	0.009** (0.004)					
RER(j,t-1) x importer inputs		-0.006 (0.008)				
Initial firm size trend	yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes
year fixed effects	yes	yes	yes	yes	yes	yes
Observations	12,199	8,849	7,180	5,605	8,976	6,757
R-squared	0.839	0.937	0.832	0.932	0.836	0.921