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Imports, productivity and substitutability between intermediate inputs: a quantile regressions approach

Segundo Camino-Mogro
Universidad Complutense de Madrid; ESAI Business School; Universidad Católica Santiago de Guayaquil

Paul Carrillo-Maldonado
Ecuadorian Political Economy Lab (EPEL); Inter-American Development Bank (IADB)

Alberto López
Department of Economic Analysis. Universidad Complutense de Madrid

Abstract

Using firm-level data from Ecuador, we study the impact of imported intermediates on productivity and estimate the elasticity of substitution between domestic and imported intermediates. We contribute to the literature by complementing mean regression results with quantile regression results. Our results suggest that, first, there is a positive effect of imports on productivity; second, this effect is significant at all quantile levels of output, although this effect seems to have an inverted-U shape; and third, domestic and imported intermediates are substitutes.

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Contact: Segundo Camino-Mogro - segundo.camino@gmail.com, Paul Carrillo-Maldonado - paulcar@iadb.org, Alberto López - alberto.lopez@ccee.ucm.es.

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1. Introduction

The effect of firms' international trade activities has been well-documented since the seminal study of Bernard and Jensen (1995). Although most studies have focused on analyzing the effect of exports on total factor productivity (TFP), there is an increasing but still scarce trend in the analysis of the effect of imports on TFP. The general consensus is that exporters/importers have better TFP than their counterparts. Wagner (2012) and Cassiman and Golovko (2018) present reviews of this literature.

Most studies have focused on the average impact of exports/imports on TFP, and only a few studies have studied the effect of exports at different quantiles of the conditional output distribution (see Yasar et al., 2006; Powell and Wagner, 2014). However, to our knowledge, no study has analyzed the effect of imported intermediate inputs at different points of the conditional output distribution. Along this line, the "new" new international trade theory has focused its attention on the role of firm heterogeneity in explaining relationships between productivity and international trade activities (see Melitz, 2003; Melitz and Redding, 2015). Authors like Orts and Martí (2018) and Wagner (2011) argue that if we agree that heterogeneity is one of the stylized facts of this new approach, we should probably go a step further and ask ourselves whether the relationship between firms' characteristics and their behavior in foreign markets should be the same for all of them or not**,** but one striking finding in this literature is the enormous amount of heterogeneity between firms within narrowly defined industries and size classes (Wagner, 2006).

Although productivity issues have received most of the attention, literature on imports has also analyzed the substitutability between domestic and imported intermediate inputs. This literature is still scarce and finds mixed results that support that these inputs are both substitutes (Kasahara and Rodrigue, 2008) and complements (Zhang, 2017). This is particularly important in developing countries for making decisions on import restriction policies, since there are substantial gains from trade through access to new imported intermediate inputs (see, for example, Goldberg et al. 2010). Again, this scarce literature has analyzed the average elasticity of substitution, leaving aside the firm's heterogeneity and how the elasticity of substitution might vary across the output distribution. This is especially important in developing countries, where significant inter firm variation in capital, labor force, productivity and size is likely (Yasar et al., 2006).

This paper contributes to the empirical literature on international trade and productivity in three ways. First, we analyze the effect of imported intermediate inputs on productivity, considering the whole distribution of output. Second, we provide further evidence on the debate on the substitutability between intermediate inputs. Again, we do this analyzing the whole distribution of output. Finally, we analyze heterogeneity in the effect of imports for a developing country.

Following Kasahara and Rodrigue (2008), we use an augmented production function with the ratio of total intermediate inputs to domestic intermediate inputs. We exploit an unbalanced panel data of 4,847 Ecuadorian manufacturing firms over the period 2007-2018. We present both average effects, using a modified version of the Levinsohn and Petrin (2003) estimator (LP estimator), and results by using a generalized quantile regression (GQR) estimator to offer a detailed picture of the effect along the whole distribution of output.

The remainder of the article is as follows. Section 2 presents the methodology and data sources. Section 3 discusses the empirical results. Section 4 concludes.

2. Methodology and data

2.1. Specification and estimation of the production function

We adopt the theoretical framework in Kasahara and Rodrigue (2008), where intermediate inputs in the production function are horizontally differentiated by the location of the input producer (i.e., intermediate inputs can be produced locally or in international markets). This specification also takes into account the role of the substitutability between domestic and imported intermediate inputs. The range of total intermediate inputs used by a firm is a function of the range of intermediate inputs produced locally and the range of intermediate inputs available abroad. Assuming that, in equilibrium, intermediate inputs are produced symmetrically, this theoretical model leads to an equation where productivity is positively related to the range of intermediate inputs employed. Firms using varieties of intermediate inputs through importing can choose from a larger variety of intermediate inputs, and therefore these firms will exhibit higher productivity.

We also adopt the empirical specification of Kasahara and Rodrigue (2008), and use an augmented production function with a continuous measure of imported intermediate inputs (n_{it}) defined as the log of the ratio of total intermediates to domestic intermediates. Therefore, the more imported intermediates are used relative to domestic intermediates, the higher this ratio will be.

This framework allows us to both analyze the effect of imported intermediate inputs on productivity and estimate the elasticity of substitution between intermediate inputs. The augmented Cobb-Douglas production function to be estimated is:

$$y_{it} = \alpha_k k_{it} + \alpha_l l_{it} + \alpha_m m_{it} + \alpha_n n_{it} + \delta' z_{jt} + \omega_{it} + \varepsilon_{it} \quad (1)$$

where y_{it}, k_{it}, l_{it} and m_{it} are output, capital, labor and total intermediate inputs (i.e., intermediate inputs produced locally and in international markets) of firm *i* at time *t* in logs, respectively. Eq. (1) includes our coefficient of interest, α_n. We also include a set of control variables(z_{it}),[1] a serially correlated productivity shock (ω_{it}), and an uncorrelated zero mean error term (ε_{it}). The estimate of the elasticity of substitution between intermediate inputs is given by $\hat{\theta} = \frac{\hat{\alpha}_m}{\hat{\alpha}_n} + 1$. This estimated parameter determines whether intermediate inputs are substitutes or complements.

Again, as proposed by Kasahara and Rodrigue (2008), we estimate Eq. (1) applying the conventional LP estimator with two modifications.[2] First, we include the contemporaneous measure of n_{it} as an additional state variable (the firm import decision is not reversible once the productivity shock occurs). Second, we endogenize the law of motion for productivity, allowing past decisions to import to affect future productivity. To do this, the unobserved productivity term (ω_{it}) is assumed to evolve as a first-order endogenous Markov process:

$$\omega_{it} = f(\omega_{it-1}, n_{it-1}) + \xi_{it} \quad (2)$$

where ξ_{it} is a productivity shock uncorrelated with productivity and with state variables. Therefore, this specification incorporates the role of importing experience (i.e., the learning-by-importing hypothesis).

To consider the potential heterogeneous impacts of imported intermediates on productivity along the whole distribution, we use the generalized quantile regression (GQR) estimator

[1] Our control variables include year, region and industry dummies that allow us to control for macroeconomic shocks and productivity differences across regions and industries (Yasar et al., 2006).

[2] We perform our estimations using the *prodest* command of Stata, developed by Rovigatti and Mollisi (2018).

introduced by Powell (2019).[3] This methodology estimates the effect of a change of the ratio of total intermediates to domestic intermediates (n_{it}) in the τ^{th} quantile ($0 < \tau < 1$) of the outcome distribution, conditional to the inputs (x_{it}), as follows:

$$y_{it}(\tau) = x'_{it}\beta(\tau) + \varepsilon_{it} \text{with } Q_{y|x}(\tau) = x'_{it}\beta(\tau) \quad (3)$$

where x is a vector of all regressors given in Eq (1). In particular, we apply an instrumental variables quantile regression (IVQR) approach**.** The instrumental variables used are the state variables in LP estimator (i.e., capital stock and the ratio of total intermediates to domestic intermediates), the labor input (and their lags), and the state variables' third-order polynomials.

2.2. Data description

Our empirical study is based on an unbalanced panel data of 4,847 Ecuadorian firms for the period 2007-2018. This novel and underexplored data is collected by the *Superintendencia de Compañías, Valores y Seguros* (SCVS), which is the supervisory and regulatory institution of the population of all formal firms. All the information is collected from the balance sheets and financial statements, which allows us to obtain our variables of interest such as gross revenue (output), net tangible assets (capital stock), number of formal employees (labor input), domestic intermediate purchases, imported intermediate purchases, and other firm characteristics (e.g.**,** size, geographical location and industry in the six-digit ISIC classification). All nominal variables are deflated to express values in real terms (using the respective annual price deflator).

Table 1 shows the descriptive statistics by importer and non-importer firms. Importers account for 23.52% of the total and non-importers for 76.48%. Although the firms that import represent a small proportion of the total number of manufacturing firms, they have, on average, higher revenues, capital stock, employment and intermediate inputs. This advantage over non-importer firms is maintained along the whole distribution. This preliminary evidence is consistent with the empirical literature which argues that importers perform better than non-importers.

Moreover, Table 1 shows that both importers and non-importers are highly heterogeneous with regard to revenues, capital stock, employment and intermediate inputs not only at the mean, but also in each percentile. This preliminary descriptive analysis shows that Ecuadorian firms are heterogeneous. In this sense, we could suspect that the effects of inputs on output are not the same for all firms. This reinforces the point that if we only use mean estimators, there is no option to attend to the firm's heterogeneity.

[3] We use the *genqreg* command in Stata developed by Powell et al. (2014).

Table 1. Descriptive statistics

	Mean	SD	Q10	Q20	Q30	Q40	Q50	Q60	Q70	Q80	Q90
Importers											
y	15.308	1.715	13.219	13.858	14.320	14.772	15.181	15.631	16.154	16.752	17.677
k	4.019	1.520	2.197	2.844	3.258	3.663	3.988	4.394	4.7791	5.318	5.991
l	13.633	2.188	10.864	11.813	12.500	13.072	13.679	14.234	14.863	15.550	16.465
m	14.567	1.798	12.369	13.070	13.592	14.017	14.464	14.913	15.419	16.052	17.024
n	0.782	0.814	0.0466	0.123	0.230	0.365	0.538	0.751	1.016	1.310	1.818
Non-importers											
y	12.884	1.881	10.667	11.526	12.074	12.512	12.908	13.304	13.750	14.296	15.110
k	2.288	1.302	0.693	1.098	1.386	1.791	2.197	2.564	2.890	3.332	3.931
l	10.810	2.649	7.760	9.002	9.813	10.377	10.918	11.475	12.084	12.719	13.670
m	10.676	2.654	7.333	8.502	9.321	10.061	10.776	11.474	12.145	12.865	13.946

Notes: All variables are measured in logs of USD, except for labor input (*l*) which is measured in logs of number of formal employees. All nominal variables are deflated to express values in real terms (using the respective annual price deflator).

3. Results

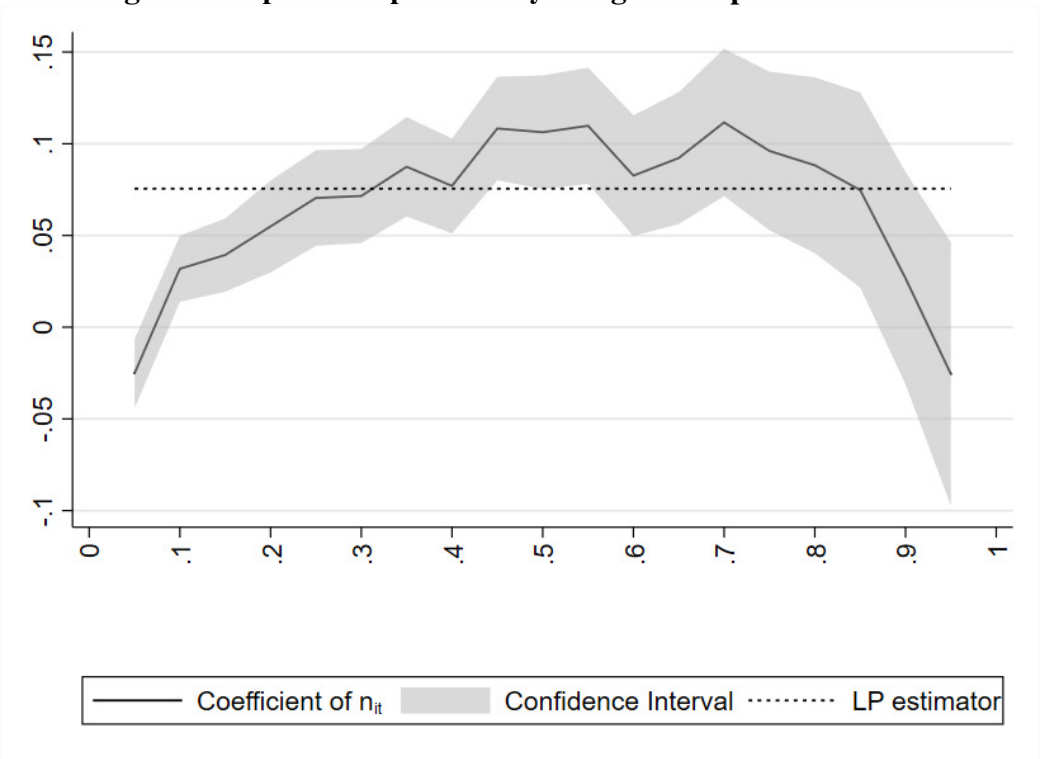
Column (1) in Table 2 reports results based on the average regression approaches using the modified LP estimator of Eq. (1). Our results suggest that there is a positive impact of an increase in the share of imported intermediates on productivity. In particular, a 1 percent increase in the ratio of total intermediates to domestic intermediates increases productivity by about 0.062 percent.

Table 2. Imports and productivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	LP	**Q10**	**Q20**	**Q30**	**Q40**	**Q50**	**Q60**	**Q70**	**Q80**	**Q90**
k_i	0.120***	0.109	0.119	0.146	0.168	0.175	0.209	0.213	0.212	0.177
	(0.024)	(3.589)	(3.038)	(3.213)	(3.544)	(4.589)	(4.032)	(3.00)	(1.359)	(1.138)
l_{it}	0.313***	0.346***	0.402***	0.413***	0.454***	0.432***	0.382***	0.350***	0.334***	0.320***
	(0.01)	(0.015)	(0.015)	(0.012)	(0.016)	(0.024)	(0.022)	(0.017)	(0.014)	(0.014)
m_{it}	0.237***	0.603***	0.485***	0.421***	0.361***	0.314***	0.284***	0.264***	0.236***	0.241***
	(0.029)	(0.016)	(0.025)	(0.013)	(0.011)	(0.009)	(0.008)	(0.009)	(0.010)	(0.012)
n_{it}	0.062***	0.032***	0.055***	0.071***	0.077***	0.106***	0.0826***	0.112***	0.0883***	0.027
	(0.011)	(0.009)	(0.013)	(0.013)	(0.013)	(0.016)	(0.017)	(0.021)	(0.0245)	(0.029)
Implied θ	5.162	19.95	9.830	6.891	5.690	3.953	4.442	3.365	3.671	10.030

Standard errors in parentheses. Estimates include year, region and industry dummies, but they are not reported. *** significant at 1%.

Figure 1. Imports and productivity along the output distribution



Columns (2) to (10) in Table 2 report results for the 10, 20, 30, 40, 50, 60, 70, 80 and 90 percent quantiles. Results of the quantile regression are consistent with the LP results and show that imported intermediates are associated with an increase in productivity at all quantile levels. In this case, the effect varies between 3% and 11% depending on the quantile. Interestingly, we find evidence consistent with an inverted U-shaped relationship between imported intermediates and productivity, with relatively large coefficient estimates in the intermediate quantiles of output (see Figure 1). Therefore, our results show that middle size firms benefit more (in terms of productivity gains) from international exposure through imports. This result is in line with the findings of Yasar and Morrison Paul (2007), who find that international linkages have a greater productivity effect for firms in the intermediate quantiles of output distribution. However, their results show that this inverted U-shaped relationship is more pronounced for exports than imports.[4]

Finally, the last row in Table 2 presents the estimates of the elasticity of substitution between domestic and imported intermediates for each regression. Our results suggest that these two intermediate inputs are substitutes. In this case, our findings are somewhat consistent with a U-shaped relationship, with relatively large values in the extreme quantiles of output.

4. Conclusions

We find a positive effect of imports on productivity in Ecuadorian manufacturing firms. Using a quantile regression approach, we find that this effect is significant at all quantile

[4] A key difference with respect to our study is that these authors focus on the effect of importing machinery and equipment (instead of on the effect of importing intermediate inputs).

levels of output and that it seems to have an inverted-U shape. Finally, our results suggest that domestic and imported intermediates are substitutes.

In terms of policy implications, our results are helpful for policy design aimed at defining initiatives for encouraging firm productivity. In this sense, our results highlight the potential of trade liberalization (and, particularly, the potential of reducing input tariffs) to foster firm productivity. Moreover, this policy issue is of particular interest for developing countries, which, on average, impose higher barriers to international trade.

References

Bernard, A.B. and Jensen, J.B. (1995). Exporters, jobs, and wages in US manufacturing: 1976-1987. *Brookings Papers on Economic Activity. Microeconomics*, 1, 67-119.

Cassiman, B. and Golovko, E. (2018). Internationalization, innovation, and productivity. In *The Oxford Handbook of Productivity Analysis*, Oxford University Press, 438-362.

Goldberg, P., Khandelwal, A., Pavcnik, N. and Topalova, P. (2010). Imported intermediate inputs and domestic product growth: Evidence from India. *The Quarterly Journal of Economics*, *125*(4), 1727-1767.

Kasahara, H. and Rodrigue, J. (2008). Does the use of imported intermediates increase productivity? Plant-level evidence, *Journal of Development Economics*, 87(1), 106-118.

Levinsohn, J. and Petrin, A. (2003). Estimating production functions using inputs to control for unobservables. *The Review of Economic Studies*, 70(2), 317-341.

Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, *71*(6), 1695-1725.

Melitz, M.J. and Redding, S.J. (2015): Heterogeneous Firms and Trade. In G. Gopinath, E. Helpman and K. Rogoff, ed. *Handbook of International Economics*, Amsterdam: Elsevier. Vol. 4 (ch.1), 1-54.

Orts, V. and Martí, J. (2018). Firm heterogeneity and export activity of European Firms: a quantile analysis. *Revista de Economía Mundial*, *49*, 79-102.

Powell, D. (2019). Quantile treatment effects in the presence of covariates. *Review of Economics and Statistics*, 1-39.

Powell, D., Baker, M. and Smith, T. (2014). Generalized quantile regression in Stata. In *2014 Stata Conference* (No. 12). Stata Users Group.

Powell, D. and Wagner, J. (2014). The exporter productivity premium along the productivity distribution: evidence from quantile regression with non additive firm fixed effects. *Review of World Economics*, *150*(4), 763-785.

Rovigatti, G. and Mollisi, V. (2018). Theory and practice of total-factor productivity estimation: The control function approach using stata, *The Stata Journal*, 18(3), 618-662.

Wagner, J. (2006). Export intensity and plant characteristics: What can we learn from quantile regression?. *Review of World Economics*, *142*(1), 195-203.

Wagner, J. (2011). From estimation results to stylized facts twelve recommendations for empirical research in international activities of heterogeneous firms. *De Economist*, *159*(4), 389.

Wagner, J. (2012). International trade and firm performance: a survey of empirical studies since 2006. *Review of World Economics*, *148*(2), 235-267.

Yasar, M. and Morrison Paul, C.J. (2007). International linkages and productivity at the plant level: Foreign direct investment, exports, imports and licensing. *Journal of International Economics*, 71(2), 373-388.

Yasar, M., Nelson, C.H. and Rejesus, R. (2006). Productivity and exporting status of manufacturing firms: Evidence from quantile regressions. *Review of World Economics*, *142*(4), 675-694.

Zhang, H. (2017). Static and dynamic gains from costly importing of intermediate inputs: Evidence from Colombia. *European Economic Review*, *91*, 118-145.