Imported intermediates and productivity: Does absorptive capacity matter? A firm-level analysis for Uruguay

Preliminar Draft

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May, 2013

Abstract

International trade is considered a vehicle for technology diffusion, which in turn can induce productivity growth. Particularly, trade may give domestic firms access to a larger variety and/or better quality of intermediate or capital inputs in which new technologies are embodied. However, the lack of sufficiently skilled labour, an issue especially relevant for small developing countries, may prevent firms from taking advantage of these technologies.

Using a panel of Uruguayan manufacturing firms (1997-2008) we explore the impact of imported inputs on firms' productivity and evaluate whether the effect is mediated by the firm's absorptive capacity (proxied by the proportion of skilled labour). We apply an indirect (two-stage) approach by first estimating firms' productivity and then using impact evaluation techniques to analyze causality between imported inputs and productivity. Our results suggest that imported intermediates have an enhancing effect on Uruguayan firms' productivity and absorptive capacity plays a role on this effect.

Keywords: productivity, imports, absorptive capacity

JEL classification: F2, O1, O2

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1. Introduction

The ability of a country to improve its standard of living is determined in the long run by productivity growth. In an increasingly global economic environment, international linkages can be an important channel for enhancing total factor productivity (TFP). Particularly, international trade is argued to have dynamic effects on TFP, most of which are related to technological knowledge diffusion. The conceptual framework is based on open-economy endogenous growth models, which postulate that knowledge is not enclosed within national boundaries but it can be transferred across countries, spurring productivity and economic growth. This is especially relevant for developing economies, where domestic research and development (R&D) efforts are generally very low.

The main channels for international diffusion of technological knowledge are: i) imports of intermediate and capital inputs, ii) learning by exporting, and iii) foreign direct investment (FDI). With regards to imports, international trade can expand the menu of inputs available to domestic firms, giving them access to a wider or more sophisticated range of technologies -embodied in imported inputs- that may generate productivity gains. On the other hand, exporting may increase firms' productivity through learning, as exposure to international markets may provide access to technical expertise from foreign buyers (including both new product designs and production methods). In addition, international technology transfer can take place through FDI, both directly and indirectly (through knowledge spillovers from foreign to local firms).[1]

The pioneering work of Ethier (1982) showed that, in the presence of firm-level scale economies, imports of differentiated intermediate inputs increase firms' efficiency by allowing a better division of labour. In a dynamic extension of the Ethier model, Rivera-Batiz and Romer (1991) show that, under certain conditions, economic integration between two similar countries (that could take the form of trade in goods, flows of ideas, or both) can permanently increase the rate of growth. However, Grossman and Helpman (1990) point out that, in the presence of cross-country differences in efficiency at R&D versus manufacturing (i.e. comparative advantage), trade can induce shifts between sectors that may either speed up or slow down growth.[2] On the other hand, Lee (1995) develops a model where the growth rate of income is higher if capital goods are foreign capital-intensive,

[1] In this work we focus on the role of imported inputs in the process of international technology diffusion. With regards to the role of exporting see, for example, Kraay (1999), Castellani (2002), Van Biesebroeck (2003), Girma, Greenaway and Kneller (2004), Blalock and Gertler (2004), Baldwin and Gu (2004), Alvarez and López (2005), Fernandes and Isgut (2005), Yasar and Morrison (2007), De Loecker (2007), and Wagner (2007). Regarding FDI see, for instace, Haddad and Harrison (1993), Blomström and Kokko (1998), Aitken and Harrison (1999), Kugler (2000), Kathuria (2001), Smarzynska (2002), Blalock and Gertler (2003), and Görg and Greenaway (2004).

[2] As in Ethier (1982), in the Grossman and Helpman model new intermediate products allow greater specialization in final production, thereby enhancing productivity. However, trade liberalization can divert resources away from R&D, thus negatively affecting the rate of innovation and growth in the country with comparative disadvantage in R&D.

showing that the composition of investment is an important determinant of economic growth (particularly in developing countries).[3]

A number of empirical studies have analysed the impact of trade-related international technology diffusion on productivity. A seminal work on the role of imports as a vehicle for productivity-enhancing technology transfer is Coe and Helpman (1995), a country-level study for industrialized economies that analyses the effect of R&D capital stocks on productivity. Their findings show that both domestic and foreign R&D have a significant positive impact, and that the effect of the latter is stronger the more open an economy is to international trade. They also find that in the smaller countries the elasticity of productivity to foreign R&D is larger than that to domestic R&D. In a closely related paper, Coe, Helpman and Hoffmaister (1997) extend the analysis to a sample of developing countries, finding that productivity gains from foreign R&D spillovers are larger the more open these countries are to trade with industrialized economies and the more skilled is their labour force.

Other country-level studies have found evidence on import-related international technology spillovers that lead to productivity gains in the recipient countries (see, for example, Verspagen (1997), Keller (1999), Navaretti and Soloaga (2002), Park (2004), Schiff and Wang (2004), and Lumenga-Neso, Olarreaga and Schiff (2005)). Although these findings provide support to the hypothesis that imports are an important channel through which knowledge is transferred across countries, most of the effects on productivity are observable primarily at the micro-level. Moreover, aggregate data do not allow controlling for differences across firms, which may be correlated with the use of imported inputs and lead to biased estimates of the effect of these inputs. Since Bernard and Jensen (1995), who showed that there exist substantial differences between exporting and non-exporting firms (in terms of size, productivity and capital intensity), a new heterogeneous-firms literature which examines the impact of international trade on productivity has emerged. This literature, which is part of the so-called "new-new" trade theory, focused initially on the relationship between exports and productivity. More recently, it has also begun to analyze the impact of firms' importing activity.

Navaretti and Tarr (2000) present a survey of studies on the microeconomic links between international trade and knowledge diffusion, which find evidence that imported technologies increase productivity in importing countries, particularly when technologies are acquired through imports of intermediate goods. However, empirical work on the impact of foreign intermediates at the micro-

[3] Lee (1995) shows that trade liberalization reduces the price of capital goods in capital-poor developing countries, increasing the return to investment and the growth rate of capital stock in these countries. Similarly, trade liberalization reduces the price of imported technology in developing countries, thereby stimulating technology progress.

level provides heterogeneous findings. On one hand, Van Biesebroeck (2003b), Muendler (2004), and Vogel and Wagner (2010) show that imported inputs have a minor or no significant effect on productivity in Colombia, Brazil and Germany, respectively. By contrast, Kasahara and Rodrigue (2008), Lööf and Andersson (2008), Goldberg et al. (2010a), and Halpern, Koren and Szeidl (2011) find that firms' access to new imported intermediates produces substantial productivity gains in Chile, Sweden, India and Hungary, respectively.

An important issue regarding international technology diffusion is that the transfer of technological knowledge may be affected by skill constraints in the host country, particularly in developing economies. As shown by Barba Navaretti and Soloaga (2002), the ability of a country to benefit from imported technologies depends on its absorptive capacity, that is, on its ability to adopt and efficiently implement technology from abroad. In this sense, Acemoglu and Zilibotti (2001) argue that access to new technologies may not suffice to increase productivity in developing countries, as many technologies used in these countries are developed in industrialized economies and tend to be inappropriate for the skill composition of local labour force.

Although the role of absorptive capacity in determining the successful of international technology transfer is theoretically clear, it is not supported by all empirical studies (Hoppe, 2005). The weakness of empirical findings might be explained by the fact that most works are country or industry level analyses, and are based on aggregate measures of human capital (like school enrolment rates or variables related to the educational attainment of the adult population) that do not capture the actual skill levels of the workforce.[4] A micro-level analysis, based on a more precise measurement of firms' capacity to absorb new technologies, may provide a better assessment of the impact of international technology spillovers.

One of the few empirical studies that assess the effect of absorptive capacity at the firm-level is Augier, Cadot and Dovis (2012), which finds evidence that the enhancing effect of imported intermediate and capital inputs on Spanish manufacturing firms' productivity will be stronger if workers understand how to use those inputs, which is likely to depend on their skills. In this paper, we follow a similar approach by evaluating the impact of imported intermediates on Uruguayan manufacturing firms' TFP over the period 1997-2008, and analysing whether this impact depends on firms' capacity to absorb technology. We apply a two-stage or indirect approach: in the first stage, we estimate firms' productivity using semi-parametric methods, which corrects for simultaneity bias; in the second stage, we use treatment effects techniques to analyze causality between imported inputs, absorptive capacity and productivity. Like Augier, Cadot and Dovis (2012), we base our analysis on

[4] See, for example, Coe, Helpman and Hoffmaister (1997), Mayer (2001), Crespo, Martín and Velázquez (2002, 2004), and Schiff and Wang (2004b).

the conjecture that the lack of sufficiently skilled labour may prevent firms from taking advantage of the technology embodied in imported inputs.

Uruguay provides an interesting case to analyze the effect of imports on productivity in a small developing economy. In the 1970s this country initiated a trade liberalization process that was deepened during the 1990s and combined a gradual unilateral tariff reduction with the regional integration in the framework of the Southern Common Market (MERCOSUR). Like in most developing economies, Uruguay's R&D expenditure is low, although it has increased in the last years reaching 0.66 percent of gross domestic product (GDP) in 2008 (last year available). This figure is well below the world average and even below the low and middle-income countries average (2.14 percent and 1.07 percent of GDP, respectively, in 2008).[5] Consequently, international technology transfer can play an important role for a country like Uruguay, and trade with countries where technological innovations are generated can be a major channel for knowledge acquisition.

Some recent studies have evaluated the impact of imports on Uruguayan firms' productivity. On one hand, using industry-level data for the period 1988-1995, Peluffo (2011) finds that Uruguayan manufacturing TFP seems to benefit more from goods imported from MERCOSUR than from those imported from other origins (European Union, NAFTA, and rest of the world), mostly in high R&D intensive sectors, possibly due to relatively lower technological distance and face-to-face contact with MERCOSUR partners. However, this work may suffer from aggregation biases resulting from the use of industry-level data. Peluffo (2010), working at the firm level for the period 1997-2001, finds considerable productivity gains from using imported intermediates, results that are also confirmed for the period 1988-2005 (Peluffo, 2012). On the other hand, Zaclicever and Pellandra (2013) carry out a firm-level analysis for the period 1997-2008, finding a productivity-enhancing effect of foreign intermediate inputs, which is positively related to the number of varieties imported and the technology embodied in them. They also find evidence that the effect on firms' productivity is stronger for inputs imported from advanced economies, while inputs from other origins (particularly those from MERCOSUR countries) exhibit a weaker and less robust impact. By adding the absorptive capacity dimension to the evaluation of import-related technology diffusion, our study may contribute to shed new light on this issue.

The remainder of the paper is organized as follows. Section 2 discusses the empirical strategy, section 3 describes the data, section 4 presents the estimation results and, finally, section 5 concludes.

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[5] Source: World Development Indicators, World Bank
(available at: http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS/countries?display=default).

2. Empirical strategy

We follow an indirect, or two-stage, approach by first estimating TFP at the firm level and then using impact evaluation techniques to analyze the effect of imported inputs on productivity.

The estimation of firms' TFP is carried out using semiparametric techniques, the Levinsohn and Petrin (2003) and the Olley and Pakes (1996) methodologies, which address one of the main endogeneity problems that usually arises in empirical estimation of production functions at the micro level, the so-called simultaneity bias (i.e. the fact that firms' input choices may respond to productivity shocks). The Levinsohn-Petrin estimator uses firm's intermediate inputs to proxy for unobservable productivity shocks, while Olley-Pakes uses investment as a proxy.

We estimate the following Cobb-Douglas production function:

$$y_{it} = b_l l_{it} + b_k k_{it} + v_{it} + h_{it} \qquad (1)$$

where y_{it} is output (value added), l_{it} labour, and k_{it} capital stock of firm i at time t (all variables in logarithms); and w_{it} and h_{it} are firm- and time-specific unobserved shocks (w_{it} is a productivity shock that affects firm's input choices, while h_{it} is an i.i.d. shock that has no impact on the firm's decisions).

The residual of equation (1) is firm's TFP, retrieved from the estimated coefficients as:

$$TPF_{it} = y_{it} - \hat{b}_l l_{it} - \hat{b}_k k_{it} \qquad (2)$$

The second stage consists on the treatment-effect estimation, performed using propensity-score matching, difference-in-differences and instrumental variables techniques.[6] We analyze the causal effect of imported intermediates (the treatment) on the productivity of those firms that start importing inputs (the treated group), relative to those that do not (the control group). Additionally, we evaluate whether the impact of imported intermediate inputs is mediated by the firm's absorptive capacity (i.e. firm's capacity to absorb the technology embodied in those inputs).

The effect of using imported intermediates is the estimated difference in firms' productivity (the outcome) between the treated and the control groups. Causal inference relies on the construction of the counterfactual, which in this case is the outcome firms would have experienced, on average, had they not started importing intermediates. Let $IMPI_{it}$ be an indicator (dummy) variable that takes the value one if firm i imports intermediate inputs at time t (zero otherwise), and q_{it} another indicator

[6] For a review of non-experimental methods used in the evaluation literature see Blundell and Costa Dias (2000) and Khandker, Koolwal and Samad (2010).

variable that takes the value one if firm *i* switches import status at *t*, from $IMPI_{it-1}$=0 to $IMPI_{it}$=1 (zero otherwise). Also, let $Y^1_{i,t+s}$ be the outcome of firm *i* at time *t+s*, after starting to import intermediates, and $Y^0_{i,t+s}$ the outcome of firm *i* had it not started importing at *t* (i.e. the counterfactual). Thus, the causal effect of importing for firm *i* at time *t+s* is defined as:

$$Y^1_{i,t+s} - Y^0_{i,t+s} \qquad (3)$$

Since $Y^0_{i,t+s}$ is unobservable, the counterfactual is estimated by the corresponding average value of firms that remain non-importers, which requires the selection of a valid control group. To this end, we make use of matching techniques, a non-parametric approach that assumes that all the difference in productivity between firms that started importing intermediate inputs (the treated group) and those that did not (the control group) is captured by a set of observable variables. In this way, once we control for these observable variables, the non-treated outcome is what the treated outcome would have been without the treatment.

A matching procedure is preferable to randomly or indiscriminately choosing the comparison group because it is less likely to suffer from selection bias (derived from the fact that treatment is endogenous or selected in relation to potential outcomes) (Blundell and Costa Dias, 2000). However, identifying treatment effects by matching methods requires that all variables that affect simultaneously the participation decision (in this case, firms' decision to start importing inputs) and the outcome of interest (in the absence of participation) are included. The omission of relevant variables that are correlated with the treatment lead to biased estimates of treatment effect.

The idea of matching is to select from the control group those firms in which the distribution of variables affecting the outcome is as similar as possible as that of firms belonging to the treated group. The process consists on pairing each firm receiving the treatment with one or more non-treated firms that have similar values of the matching variables, the only remaining difference being their treatment status. The method adopted here is the propensity score matching, first introduced by Rosenbaum and Rubin (1983), where firms are paired on their probability to receive the treatment (conditional on covariates). This probability, called propensity score, is estimated for all firms, irrespective of their treatment status, from a logit regression[7]:

$$\Pr(q_{it} = 1/X) = F\left(X_{i,t-1}, d_t, d_j\right) \qquad (4)$$

[7] By all firms we mean those that start importing during the period of analysis and those that never import along this period, leaving out firms that are permanent importers.

where $X_{i,t-1}$ is a vector of lagged firm characteristics, and d_t and d_j are time and industry dummies, respectively. The set of firm characteristics includes (log) TFP, profit-value added ratio, export intensity (share of exports in total sales), (log) size (number of employees), capital intensity (capital-labour ratio), and (log) average wage per employee.

In the propensity score matching case, the comparison group for each treated firm is chosen with a pre-defined criterion of proximity. One or more non-importing firms, which are closest in terms of their propensity score to a treated firm, are selected as match for the former. In order to associate the selected set of non-treated observations with each treated one, appropriate weights need to be chosen. We use the kernel method, which matches each treated unit to a weighted average of all non-treated units, using weights that are inversely proportional to the distance between the propensity scores of treated and non-treated.

Once the comparison group is selected, we apply the difference-in-differences (also known as double-difference) method to evaluate the effect of imported inputs on firms' performance. The combination of matching and difference-in-differences is likely to improve the quality of non-experimental evaluation studies (Blundell and Costa Dias, 2000). The reason for this is that the matching method relies on the assumption that unobserved factors do not affect participation, so that the outcomes of the non-treated are independent of the participation status, once we control for the observable variables. By combining matching with difference-in-differences, there is scope for an unobserved determinant of participation (unobserved heterogeneity) that may lead to selection bias.

In the difference-in-differences approach, the difference between the average outcome variable (firms' productivity) before and after starting the importing activity is estimated for firms belonging to the treated group, conditional on a set of covariates. Since this difference cannot be attributed only to the treatment (the outcome variable might be affected by other factors that are contemporaneous with the treatment), in a second stage it is further differenced with respect to the before and after difference for the control group of non-importing firms.

Our second-stage baseline equation, run on the common support (i.e. the resulting set of observations corresponding to the sub-sample of matched firms), is:

$$\ln(TFP_{it}) = b_1 q_{it} + b_2 mshare_{it} + b_3 skill_{it} + b_4 \left(skill_{it} \times mshare_{it}\right) + g_k Z_{it-1} + d_j + d_t + e_{it} \qquad (5)$$

where TFP_{it} is our first stage estimate of firm's productivity, $mshare_{it}$ is the share of imported inputs in firm's intermediate purchases, $skill_{it}$ is the proportion of skilled workers in firm's labour force (defined as professionals and technicians over total employment), and Z_{it-1} is a vector of lagged firm characteristics (size, capital intensity, profit-value added ratio, and export intensity). As before, q_{it} is the treatment variable (an indicator variable that takes the value one if firm i switches import status at t), d_j are industry dummies, and d_t are time dummies. We also include as controls a dummy variable indicating whether foreign capital is present in firm's total capital and a four-digit level Herfindhal index of market concentration. Finally, following Girma, Greenaway and Kneller (2004), who analyse the impact of exporting on UK manufacturing firms' performance, we consider an indicator variable which pre-dates importing (i.e. takes the value one at time t if the firm starts or re-starts importing at time $t+1$) in order to further controlling for any performance-importing relationship in the pre-importing period that is not captured by the matching procedure.

The role of firms' absorptive capacity in affecting their benefits from import-related knowledge spillovers is evaluated in equation (5) by means of the interaction term between the proportion of skilled workers and the share of imported intermediates. If the effect of imported intermediate inputs on firms' TFP positively depends on firms' ability to assimilate and implement the technology embodied in those inputs, the estimated coefficient on this interaction term should be significantly positive ($b_4 > 0$). We account for the use of imported intermediates by using the share of imports in firm's intermediate purchases, in this way capturing the fact that not only importing but also import intensity may matter for productivity growth. Additionally, we consider alternative treatment variables, studying the effects of imported intermediates after one to three years following entry (i.e. starting importing), with a view to evaluating whether changes in productivity, if any, take time to occur.

An important issue regarding the estimation of equation (5) is that the difference-in-differences method assumes that treatment assignment depends on time-invariant unobserved characteristics, so the selection bias cancels out through differencing. When unobserved characteristics vary with time, the correlation between the error term (e) and the treatment variable (q) will persist after differencing, and the estimation by ordinary least squares (OLS) will therefore yield biased coefficients. In this case, the use of the instrumental variable (IV) method may correct the unobserved selection bias, by finding an observable exogenous variable (instrument) that is highly correlated with q but not correlated with unobserved characteristics affecting the outcome (and, hence, not correlated with e). Since the assumption of time-invariant unobserved heterogeneity may not be plausible in the context of our analysis (we might expect that firms' behaviour would respond dynamically), we apply both OLS and IV estimation methods and compare the results.

3. Data

Our empirical analysis is based on an unbalanced panel of Uruguayan manufacturing firms covering the period 1997-2008, which was constructed using data from the IV Economic Census (1997) and the annual Economic Activity Survey (EAE, 1998-2008), carried out by the National Institute of Statistics of Uruguay (INE).[8] The panel contains annual data on sales (domestic and exports), value added, capital, intermediate inputs, energy, and other expenditures, which were deflated using detailed price indices (base year 1997).[9] It also includes data on employment (by category), wages, profits, and foreign capital participation. Additionally, we use data from the "input sheets" (available from the same surveys), which contain the value of each firm's purchases of intermediate inputs, disaggregated by product in domestically-purchased and imported.

We have 1,444 different firms present at least in one period, with an average of 672 firms per year and a total of 8,063 firm-year observations.[10] As in Augier, Cadot and Dovis (2012), firms are classified into three categories, according to their import status over the period of analysis: i) non-importers: firms that never imported intermediate inputs (53.8 percent of total firms and 39.5 percent of observations), ii) importers: firms that always imported intermediates (23.3 of total firms and 27.6 percent of observations), and iii) switchers: firms that switched status once or more along the sample period (22.9 of total firms and 32.9 percent of observations). From the first group of firms a subset is selected as control group by means of propensity score matching, while permanent importers (i.e. firms classified in the second group) are excluded from the treatment-effect estimation.

In Table 1 we present descriptive statistics for the firms in our panel, averaged over the sample period. We observe that importing firms are larger in terms of output, capital, and labour than non-importing firms, particularly permanent importers. They are also more capital intensive, have a larger share of skilled workers and tend to export more.

[8] The EAE includes all firms in the formal sector with 50 or more employees and a random sample of those with 5 to 49 employees.

[9] For sales and materials we computed firm-specific deflators as the weighted average of the four-digit ISIC revision 3 price indices corresponding to all items produced/used as inputs each year by the firm. The capital stock was constructed using the perpetual inventory method (PIM), taking as initial stock the asset's book value of the first year available for each firm.

[10] We discarded firms that were only present in the Economic Census, as well as those with no data available from the input sheets.

Table 1
Descriptive Statistics, averages 1997-2008[a]

	All	Non-importing firms	Importing firms (permanent importers)	Switchers
Number of firms	1,444	777	336	331
Number of observations	8,063	3,185	2,227	2,651
Output[b]	74.00	37.75	114.56	83.47
	(244.83)	(166.21)	(283.96)	(279.95)
Value added[b]	32.76	11.45	51.99	42.23
	(144.65)	(72.63)	(146.50)	(195.80)
Capital[b]	15.69	9.15	24.01	16.53
	(106.75)	(154.74)	(66.62)	(45.93)
Intermediate inputs[b]	27.23	19.81	40.15	25.27
	(96.65)	(89.45)	(121.93)	(78.14)
Labour[c]	81.59	45.79	117.50	94.45
	(151.78)	(86.78)	(188.13)	(168.87)
Skilled-labour share[d]	2.46	1.33	3.90	2.60
	(6.17)	(5.02)	(7.25)	(6.15)
Capital-labour ratio	10.87	10.28	11.29	11.19
	(1.43)	(1.52)	(1.27)	(1.21)
Export share	15.99	8.27	24.93	17.49
	(29.55)	(22.72)	(33.25)	(30.92)
Import share	26.10		61.27	26.53
	(35.41)		(30.13)	(34.10)
Age	27	21	32	31
	(17)	(14)	(18)	(17)

Notes:
[a] Standard deviations in parentheses
[b] Millions of constant Uruguayan pesos
[c] Total employment (number of employees)
[d] Professionals and technicians over total employment

4. Results

In Table 2 we report the balancing-score test, which verifies the correct performance of the propensity score matching procedure (after matching, the distribution of observable characteristics is not statistically different between the treated and control groups).[11]

Table 2
Balancing score tests (propensity score matching)

	Mean			t-test	
Variable	**Treated**	**Control**	**%bias**	**t**	**p>t**
TFP	8.423	8.442	-2.1	-0.22	0.825
Labour	3.927	3.877	4.7	0.51	0.612
Capital-labour ratio	11.213	11.095	9.0	0.98	0.328
Average wage	11.125	11.080	6.1	0.68	0.494
Export share	0.190	0.178	3.9	0.41	0.680
Profit-value added ratio	0.106	0.133	-1.3	-0.20	0.844

Source: Authors' estimations.

The results of the OLS estimation of our baseline second-stage equation, run on the matched sample, are presented in Table 3.[12] They show that starting importing intermediate inputs has, by itself, a significant positive impact on Uruguayan firms' TFP (see column 1). Although this effect vanishes when we add other control variables (besides time and industry dummies), we find evidence of a significant positive impact of the share of imported intermediates on firms' productivity, indicating that import intensity matters for achieving higher productivity levels (see columns 2 to 4). We also find a strong significant productivity-enhancing effect of labour-force skills, while the positive and significant coefficient on the interaction term between the share of skilled labour and the share of imported inputs indicates that the effect of these inputs would depend on firm's capacity to absorb the technology embodied in them. Furthermore, the coefficient on the interaction term is significantly higher than those on the share of skilled labour and the share of imported inputs, pointing to a complementarity effect between these two variables. Finally, regarding our control variables, they are statistically significant and have the expected coefficient signs, with the exception of capital intensity that turns out to be negatively significant.

[11] For the sake of brevity, we do not report the results on the industry and time dummies.
[12] The second-stage results reported here are those obtained considering the Levinsohn-Petrin productivity estimate. Results under Olley-Pakes, available upon request from the authors, are very similar.

Table 3
Second-stage estimation results: OLS regressions of Levinsohn-Petrin TFP estimate

	(1)	(2)	(3)	(4)
Treatment variable (*q*)	0.108**	-0.0533	-0.0312	-0.0256
	(0.051)	(0.050)	(0.050)	(0.051)
Import share (*mshare*)		0.724***	0.521***	0.550***
		(0.056)	(0.057)	(0.059)
Skilled-labour share (*skill*)		2.447***	1.634***	1.380***
		(0.450)	(0.414)	(0.326)
skill*mshare (*skill_i*)		2.815**	3.274***	3.634***
		(1.197)	(1.086)	(1.027)
Size (total employment)			0.103***	0.102***
			(0.016)	(0.016)
Capital-labour ratio			-0.0505***	-0.0545***
			(0.012)	(0.012)
Profit-value added ratio			0.0395**	0.0392**
			(0.017)	(0.017)
Export share			0.275***	0.267***
			(0.068)	(0.069)
Foreign capital			0.392***	0.379***
			(0.054)	(0.056)
Herfindhal index			0.403***	0.414***
			(0.122)	(0.123)
Pre-importing period				0.225***
				(0.066)
Time dummies	yes	yes	yes	yes
Industry dummies	yes	yes	yes	yes
Observations	3,545	3,505	3,400	3,316

Notes: i) Dependent variable is log TPF estimated using the Levinsohn-Petrin method. ii) Robust standard errors in parentheses; *** significant at 1%, ** significant at 5%, * significant at 10%.
Source: Authors' estimations.

The positive and significant coefficient on the pre-importing period dummy indicates that firms that start importing intermediates are more productive, prior to importing, than those that remain non-importers (see column 4, Table 3).[13] This evidence of productivity-based self-selection into importing suggests that there might be some pre-treatment unobserved factors, not captured by the matching procedure, that affect firms' import decisions and may lead to unobserved selection bias. Although the difference-in-differences method, used to obtain the estimates presented in Table 3, accounts for this potential bias, it assumes that unobserved characteristics are time invariant, which may not be plausible in the context of our analysis. To address this issue, we re-estimate equation (5) by IV using the "treatreg" command in Stata, which fits a treatment-effects model when the endogenous regressor

[13] The inclusion of the pre-importing period dummy does not affect the results on the other variables (coefficients' values experience small changes, while their signs and significance are unaffected).

is binary (treated/non-treated). Simultaneously with the regression of the outcome variable on the treatment variable and the other covariates, this command estimates a probit model to predict the probability of treatment, assuming that the error terms of the two equations are correlated. Table 4 presents the results of this IV estimation, showing that the only significant difference with OLS is found in the treatment variable, which remains significant and changes sign when adding the control variables (see columns 3 and 4). The likelihood ratio test indicates the validity of the assumption of nonzero correlation between the error terms, suggesting that applying this IV approach is appropriate. Additionally, the Wald test points to a good fit of the model.

Table 4
Second-stage estimation results: IV regressions of Levinsohn-Petrin TFP estimate

	(1)	(2)	(3)	(4)
Treatment variable (*q*)	1.399***	1.056***	-1.067***	-1.056***
	(0.082)	(0.118)	(0.108)	(0.111)
Import share (*mshare*)		0.687***	0.506***	0.530***
		(0.056)	(0.057)	(0.059)
Skilled-labour share (*skill*)		2.144***	1.649***	1.366***
		(0.406)	(0.415)	(0.319)
skill*mshare (*skill_i*)		2.240*	3.041***	3.434***
		(1.204)	(1.055)	(0.992)
Size (total employment)			0.114***	0.114***
			(0.017)	(0.017)
Capital-labour ratio			-0.0404***	-0.0435***
			(0.013)	(0.013)
Profit-value added ratio			0.0399**	0.0395**
			(0.017)	(0.017)
Export share			0.287***	0.278***
			(0.069)	(0.070)
Foreign capital			0.387***	0.378***
			(0.054)	(0.056)
Herfindhal index			0.413***	0.422***
			(0.121)	(0.121)
Pre-importing period				0.216***
				(0.065)
Time dummies	yes	yes	yes	yes
Industry dummies	yes	yes	yes	yes
Observations	3,545	3,505	3,400	3,316
Likelihood ratio test (p-value)	0.0000	0.0000	0.0000	0.0000
Wald test (p-value)	0.0000	0.0000	0.0000	0.0000

Notes: i) Dependent variable is log TPF estimated using the Levinsohn-Petrin method. ii) Robust standard errors in parentheses; *** significant at 1%, ** significant at 5%, * significant at 10%.
Source: Authors' estimations.

The negative sign of q can be explained by the fact that, as in the case of exporting, import activity involves sunk trade costs (related to the search of foreign providers, management capacity, technical and legal aspects of foreign trade, logistics, transport, etc.). Such costs, that give rise to productivity-based self-selection into importing, may induce a negative impact on TFP during the entry year. This provides a rationale for analysing the effect of importing on productivity some years after starting this activity. To this end, we consider alternative treatment variables, studying the effect of imported intermediates after one to three years following entry. Tables 5 and 6 present the results of the OLS and IV estimations, respectively. Once again, the main difference between the two methods is found in relation to the treatment variables, which show a significant positive effect in the IV case.

Table 5
Second-stage estimation results: OLS regressions of Levinsohn-Petrin TFP estimate on alternative treatment variables

	(1)	(2)	(3)	(4)	(5)	(6)
stay1	0.039	0.047				
	(0.061)	(0.061)				
stay2			0.0982	0.106		
			(0.079)	(0.079)		
stay3					0.0775	0.0861
					(0.085)	(0.085)
Import share (*mshare*)	0.568***	0.606***	0.628***	0.662***	0.649***	0.684***
	(0.065)	(0.066)	(0.064)	(0.065)	(0.074)	(0.077)
Skilled-labour share (*skill*)	1.723***	1.439***	1.655***	1.384***	1.590***	1.262***
	(0.472)	(0.363)	(0.463)	(0.361)	(0.545)	(0.401)
skill*mshare (*skill_i*)	3.112***	3.516***	3.692***	4.068***	4.027***	4.491***
	(1.178)	(1.102)	(1.184)	(1.109)	(1.260)	(1.139)
Size (total employment)	0.0978***	0.0965***	0.0992***	0.0997***	0.106***	0.107***
	(0.017)	(0.017)	(0.019)	(0.019)	(0.021)	(0.022)
Capital-labour ratio	-0.0521***	-0.0565***	-0.0621***	-0.0667***	-0.0660***	-0.0706***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.014)	(0.014)
Profit-value added ratio	0.0948*	0.0941*	0.0382**	0.0380**	0.0338**	0.0336**
	(0.051)	(0.051)	(0.016)	(0.016)	(0.014)	(0.014)
Export share	0.288***	0.274***	0.404***	0.406***	0.456***	0.442***
	(0.075)	(0.076)	(0.074)	(0.076)	(0.088)	(0.090)
Foreign capital	0.397***	0.382***	0.421***	0.401***	0.465***	0.452***
	(0.059)	(0.062)	(0.061)	(0.064)	(0.075)	(0.079)
Herfindhal index	0.332**	0.334**	0.220	0.228	0.153	0.153
	(0.140)	(0.141)	(0.137)	(0.139)	(0.154)	(0.156)
Pre-importing period		0.226***		0.199***		0.186**
		(0.064)		(0.066)		(0.078)
Time dummies	yes	yes	yes	yes	yes	yes
Industry dummies	yes	yes	yes	yes	yes	yes
Observations	2,971	2,886	2,940	2,854	2,182	2,107

Notes: i) Dependent variable is log TPF estimated using the Levinsohn-Petrin method. ii) *stay1* takes the value one at time *t* if the firm started importing at *t-1* and remain importing at *t*, *stay2* takes the value one at time *t* if the firm started importing at *t-2* and remain importing at *t*, *stay3* takes the value one at time *t* if the firm started importing at *t-3* and remain importing at *t*. iii) Robust standard errors in parentheses; *** significant at 1%, ** significant at 5%, * significant at 10%.
Source: Authors' estimations.

Table 6
Second-stage estimation results: IV regressions of Levinsohn-Petrin TFP estimate on alternative treatment variables

	(1)	(2)	(3)	(4)	(5)	(6)
stay1	0.979***	0.986***				
	(0.132)	(0.131)				
stay2			1.060***	1.049***		
			(0.117)	(0.118)		
stay3					1.222***	1.218***
					(0.114)	(0.116)
Import share (*mshare*)	0.560***	0.598***	0.608***	0.642***	0.606***	0.640***
	(0.063)	(0.065)	(0.062)	(0.064)	(0.072)	(0.075)
Skilled-labour share (*skill*)	1.605***	1.341***	1.557***	1.297***	1.418***	1.119***
	(0.444)	(0.350)	(0.443)	(0.349)	(0.499)	(0.379)
skill*mshare (*skill_i*)	2.771**	3.149***	3.397***	3.764***	3.653***	4.068***
	(1.165)	(1.100)	(1.156)	(1.085)	(1.227)	(1.129)
Size (total employment)	0.0943***	0.0930***	0.0982***	0.0982***	0.102***	0.102***
	(0.018)	(0.018)	(0.019)	(0.019)	(0.022)	(0.022)
Capital-labour ratio	-0.0527***	-0.0572***	-0.0621***	-0.0673***	-0.0647***	-0.0699***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.014)	(0.015)
Profit-value added ratio	0.0919*	0.0911*	0.0376**	0.0374**	0.0326**	0.0324**
	(0.050)	(0.050)	(0.016)	(0.016)	(0.014)	(0.014)
Export share	0.286***	0.273***	0.410***	0.414***	0.476***	0.465***
	(0.078)	(0.079)	(0.075)	(0.077)	(0.090)	(0.091)
Foreign capital	0.383***	0.367***	0.391***	0.372***	0.423***	0.412***
	(0.058)	(0.060)	(0.060)	(0.063)	(0.071)	(0.076)
Herfindhal index	0.303**	0.304**	0.208	0.218	0.136	0.137
	(0.140)	(0.141)	(0.139)	(0.140)	(0.156)	(0.158)
Pre-importing period		0.224***		0.195***		0.184**
		(0.063)		(0.065)		(0.076)
Time dummies	yes	yes	yes	yes	yes	yes
Industry dummies	yes	yes	yes	yes	yes	yes
Observations	2,971	2,886	2,940	2,854	2,182	2,107
Likelihood ratio test (p-value)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Wald test (p-value)	-	-	0.0000	0.0000	0.0000	0.0000

Notes: i) Dependent variable is log TPF estimated using the Levinsohn-Petrin method. ii) *stay1* takes the value one at time *t* if the firm started importing at *t-1* and remain importing at *t*, *stay2* takes the value one at time *t* if the firm started importing at *t-2* and remain importing at *t*, *stay3* takes the value one at time *t* if the firm started importing at *t-3* and remain importing at *t*. iii) Robust standard errors in parentheses; *** significant at 1%, ** significant at 5%, * significant at 10%.
Source: Authors' estimations.

The IV results show a significant positive impact of starting importing intermediates in the period following entry (see columns 1 and 2, Table 6). The effect is higher two and three years after entry (see columns 3 to 6). The results on the share of skilled labour, the share of imported inputs and the interaction term show as well a significant positive impact of these variables in all the specifications considered. Also in this case, the likelihood ratio test and the Wald test suggest the appropriateness of the IV approach for accounting for the endogeneity of treatment.

5. Concluding remarks

In this paper we explore the impact of imported intermediates on Uruguayan manufacturing firms' productivity and evaluate whether this impact is mediated by firms' capacity to absorb the technology embodied in imported inputs (proxied by the proportion of skilled labour). Although the role of absorptive capacity in determining the ability of a country to benefit from imported technologies may be highly relevant for small developing economies like Uruguay, where domestic R&D efforts are low, this issue has been overlooked in most empirical analysis (particularly at the micro level).

We apply an indirect (two-stage) approach by first estimating firms' TFP and then using impact evaluation techniques to analyze causality between imported inputs and productivity. Our results show evidence of an enhancing effect of imported intermediates on TFP, which is robust across a variety of specifications. We also find evidence that labour-force skills raise firms' productivity both directly and through their interaction with imported intermediates (i.e. the effect of switching to imported inputs depends on firm's capacity to absorb the technology embodied in those inputs). These results imply that trade-liberalization policies would have a greater impact on TFP if they are accompanied by educational policies aiming at improving the skill level of the labour force.

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