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Revisiting the role of Imported intermediates on Productivity: A firm-level analysis for Uruguay

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INSTITUTO DE ECONOMÍA
Serie Documentos de Trabajo

Marzo, 2019
DT 03/2019

ISSN: 1510-9305 (en papel)
ISSN: 1688-5090 (en línea)

Agradecemos los microdatos de las Encuestas Anuales brindados por el Instituto Nacional de Estadísticas, así como el código brindado por el Prof. Jagadeesh Sivadasan para la estimación de la productividad total factorial por el método de Ackerberg, Caves and Frazer (2006). Cualquier error es nuestra entera responsabilidad.

Forma de citación sugerida para este documento: Blanchard, Peluffo, y Zaclicever (2019) "Revisiting the role of Imported intermediates on Productivity: A firm-level analysis for Uruguay". Serie Documentos de Trabajo, DT 03/2019. Instituto de Economía, Facultad de Ciencias Económicas y Administración, Universidad de la República, Uruguay.

Revisando el rol de los productos intermedios importados en la productividad: un análisis a nivel de empresa para Uruguay

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Resumen

El comercio internacional se considera un vehículo para la difusión de tecnología, que a su vez puede inducir el crecimiento de la productividad. En particular, las importaciones pueden dar a las empresas nacionales acceso a una mayor variedad y / o mejor calidad de insumos intermedios o de capital en los que se incorporan las nuevas tecnologías. Sin embargo, la falta de mano de obra suficientemente calificada, un problema especialmente relevante para los pequeños países en desarrollo, puede impedir que las empresas aprovechen estas tecnologías.

Utilizando un panel de empresas manufactureras uruguayas para el período 1997-2008, exploramos el impacto de los insumos importados en la productividad de las empresas y evaluamos si el efecto está mediado por la capacidad de absorción de la empresa, representada por la proporción de mano de obra calificada. Utilizamos dos enfoques alternativos. Primero, aplicamos un enfoque de dos etapas al estimar primero la productividad de las empresas y luego utilizar técnicas de evaluación de impacto para analizar la causalidad entre los insumos importados y la productividad. En segundo lugar, utilizamos un enfoque directo, estimando la PTF con insumos importados como una variable de estado. Nuestros resultados muestran que los insumos intermedios importados tienen un efecto de mejora en la productividad de las empresas uruguayas, y que la capacidad de absorción desempeña un papel importante en este efecto.

Palabras clave: productividad, importaciones, capacidad de absorción.

Código JEL: F14, D24, O33

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Abstract

International trade is considered a vehicle for technology diffusion, which in turn can induce productivity growth. Particularly, imports 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 labor, an issue especially relevant for small developing countries, may prevent firms from taking advantage of these technologies.

Using a panel of Uruguayan manufacturing firms for the period 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 labor. We use two alternative approaches. Firstly, we apply a two-stage approach by first estimating firms' productivity and then using impact evaluation techniques to analyze causality between imported inputs and productivity. Secondly, we use a direct approach, estimating TFP with imported inputs as a state variable. Our results show that imported intermediates have an enhancing effect on Uruguayan firms' productivity, and that absorptive capacity plays an important role on this effect.

Keywords: productivity, imports, absorptive capacity
JEL Classification: F14, D24, O33

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 long-run growth is endogenously determined by research and development (R&D) investment and knowledge spillovers transmitted across countries. This is especially relevant for developing economies, where domestic R&D efforts are generally very low.

The main channels for international diffusion of technological knowledge are imports of intermediate and capital inputs, exports, and foreign direct investment (FDI). International trade can give domestic firms access to inputs that embody a higher level of technology than locally available ones, allowing them to improve their production methods and generate productivity gains. Exporting may increase firms' productivity through learning, a mechanism called learning-by-exporting, as exposure to international markets may provide access to technical expertise from foreign buyers, including both new product designs and production method. In addition, international technology transfer can take place through FDI, both directly and indirectly through knowledge spillovers from foreign to local firms.[1]

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 capabilities and 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 many works are country or industry level analyses, and are based on aggregate measures of human capital like school enrolment rates or indicators related to the educational attainment of the adult population, that do not capture the actual skill levels of the workforce.[2] A micro-level analysis,

[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] See, for example, Coe, Helpman and Hoffmaister (1997), Mayer (2001), Crespo et al. (2002, 2004), and Schiff and Wang (2004).

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.

There are some recent works that analyse the role of absorptive capacity on the interplay between imports and productivity at the firm level: Augier et al. (2013), Yasar (2013), and Foster-McGregor et al. (2016). Using data from different countries and different methodologies these works find that absorptive capacity plays a role in enhancing productivity through imports.

In this paper, we follow a similar approach to the one used by Augier et al. (2013) 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. Firstly, 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 analyse causality between imported inputs, absorptive capacity and productivity. We use a binary treatment (starting to import) as well as the continuous case (share of imported intermediates). The latter technique has been scarcely used to analyse the impact of imported intermediates on firms' productivity. Secondly, we use a direct approach, estimating TFP with imported inputs as a state variable, using Ackerberg, Caves and Frazer (2006) and Olley and Pakes (1996) techniques. We base our analysis on the assumption 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 analyse 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 0.43 percent of gross domestic product (GDP) in 2013 (last year available). This figure is well below the world average and even below the low and middle-income countries average (2.06 per cent and 1.27 per cent of GDP, respectively, in 2013).[3] 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. Moreover, this work contributes to the existing literature by using a more precise measure of skilled labour, namely the share of professional and technicians on total employment instead of white collar workers. Also, more precise estimation of TFP is used, as well as novel techniques as the continuous impact evaluation technique developed by Cerulli (2014).[4]

Some recent studies have evaluated the impact of imports on Uruguayan firms' productivity. Peluffo (2008), 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). Zaclicever and Pellandra (2012) 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

[3] Source: World Development Indicators, World Bank (available at: http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS/countries?display=default, last accessed on December 10, 2017).

[4] CTREATREG Stata module for estimating dose-response models under exogenous and endogeneous treatment.

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 presents a brief review of the literature, section 3 discusses the empirical strategy, section 4 describes the data, section 5 presents the estimation results and, finally, section 6 concludes.

1. Literature review

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.[5] Lee (1995) develops a model where the growth rate of income is higher if capital goods are foreign capital-intensive, showing that the composition of investment is an important determinant of economic growth, particularly in developing countries.[6]

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 (1995a), 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 et al. (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.

The results obtained by Keller (1998), based on the same dataset used by Coe and Helpman (1995), cast doubts as to whether trade patterns are important in driving international technology diffusion.[7] However, other study by the same author, using industry-level data for

[5] 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.

[6] 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.

[7] Keller (1998) constructs indexes of foreign R&D with weights based on randomly generated bilateral trade patterns, finding "positive international R&D spillover estimates, which are often larger, and

developed countries, shows evidence that technology is transmitted internationally, in part through being embodied in intermediate goods which are traded (Keller, 2002).

Other country- or industry-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); Barba Navaretti and Soloaga (2002); Park (2004); Schiff and Wang (2004); and Lumenga-Neso et al. (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, named 'new-new' trade theory, focused initially on the relationship between exports and productivity and, more recently, has also begun to analyse the impact of firms' importing activity.

We can identify various possible links between trade and productivity. First, a vertical link associated to better access to imported intermediates. This can improve productivity due to a better quality of intermediates or due to a greater access to inputs varieties pointed out in the endogenous growth models (Romer (1990); Rivera-Batitz and Romer (1991)). Second, foreign competition can help to reduce x-inefficiency, and/or reduce mark-ups along with scale effects (Helpman and Krugman (1985); Bernard et al. (2003)), and a higher speed of technology adoption through the reduction in the number of firms (Ederington and McCalman ((2008)). Third, on the other hand foreign competition in the final goods market can reduce firm productivity by slowing the rate of adoption of new technology due to a reduced market share of domestic firms Rodrik ((1992). Fourth, reallocation effects due to the fact that foreign competition in the final good market can leave firm productivity unchanged but increase average productivity through a reallocation effect, since least productive firms exit the market and more productive firms increase their market share (Melitz (2003)).

As we mention above, recently, the availability of microdata allows analysing the mechanisms through which imported goods translate into domestic productivity growth. Recently, studies that analyse the link between imports and productivity have blossomed, though there is substantial heterogeneity in the results.

Several studies have found a positive relationship between imports and firms' productivity (Bernard et al. (2009); Muûls and Pisu (2009); Andersson et al. (2008); Tucci (2005)). Barba 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-level provides heterogeneous findings. On one hand, Van Biesebroeck (2003), 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, Pavcnik (2000), Kasahara and Rodrigue (2008), Lööf and Andersson (2008), Goldberg et al. (2010), and Halpern et al. (2009) find that firms' access to new

explain more of the variation in productivity across countries than if 'true' bilateral trade patterns are employed".

imported intermediates produces substantial productivity gains in Chile, Sweden, India and Hungary, respectively. Augier et al. (2013), 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.

Yasar (2013) is other work that analyses the effect of absorptive capacity on the link between imports and productivity at the firm level. Using instrumental variable and threshold regressions he finds that Chinese firms with higher absorptive capacity benefit more from imported goods. More recently Foster-McGregor et al. (2016) using quantile threshold regression methods for a set of firm data of Sub-Saharan Africa, these authors find that higher levels of absorptive capacity are associated with a stronger relationship between importing and productivity.

Thus, our work contributes to gather empirical evidence of the role of absorptive capacity measured by the share of professionals and technicians in total employment on the interplay between imported inputs and TFP. Using impact evaluation and augmented production functions our results show that imported inputs and skilled labour raise TFP. We note that switching into imports is not instantaneous but take some time to impact on productivity. Moreover, the level of imported intermediates, as well as of skilled labour plays a role in enhancing TFP.

2. Empirical strategy

As we mention in the introduction, firstly we follow an indirect, or two-stage, approach by first estimating TFP at the firm level and then using impact evaluation techniques to analyse the effect of imported inputs on productivity.

2.1. Two-Step Approach

The estimation of firms' TFP is carried out using two semiparametric techniques, the Olley and Pakes (1996) –henceforth OP- and Ackerberg, Caves and Frazer (2006) (ACF) methodologies. These techniques 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 OP and ACF methodology provide consistent estimates in the presence of endogenous input choices. They differ in the choice of the state variable. In OP the state variable is capital, chosen in period t-1, and labour adjusts freely in period t. While in ACF labour is not considered to freely adjust in t, but somewhere else before, since may exist rigidities in the labour market that prevents a free adjustment due to labour regulations.

We estimate the following Cobb-Douglas production function:

$$y_{it} = \beta_{sl} sl_{it} + \beta_{ul} ul_{it} + \beta_k k_{it} + \beta_m m_{it} + \varpi_{it} + \eta_{it} \qquad (1)$$

where y_{it} is gross output (additionally we perform the estimations with value added as the dependent variable), sl_{it} skilled labour, ul_{it} is unskilled labour, m_{it} is materials and inputs, and k_{it} capital stock of firm *i* at time *t* (all variables in logarithms); and ω_{it} and η_{it} are firm- and time-specific unobserved shocks (ω_{it} is a productivity shock that affects firm's input choices, while η_{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:

$$TPF_{it} = y_{it} - \hat{\beta}_{sl} sl_{it} - \hat{\beta}_{ul} ul_{it} - \hat{\beta}_m m_{it} - \hat{\beta}_k k_{it} \qquad (2)$$

The second stage consists on the treatment-effect estimation, performed using propensity-score matching and double difference techniques.[8] We analyse the causal effect of imported intermediates (the treatment) on the productivity of those firms that: 1) start importing inputs -the treated group-, relative to those that do not -the control group-; 2) start to import and keep importing over different time spans of the sample period; 3) impact of the level of imported inputs, or continuous treatment effect. The first two specifications belong to the binary variable treatment, while the third to the continuous variable treatment, using a stata implementation developed by Cerulli (2015).

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 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).

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). 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. Firms are paired on their probability of receiving the treatment, conditional on covariates. This probability, called propensity score, is estimated for all firms, irrespective of their treatment status, from a logit regression:[9]

$$\Pr(\theta_{it} = 1/X) = F\left(X_{i,t-1}, \delta_t, \delta_j\right) \qquad (4)$$

where $X_{i,t-1}$ is a vector of lagged firm characteristics, and δ_t and δ_j are time and industry dummies, respectively. The set of firm characteristics includes (log) TFP in natural logarithm, profit-value added ratio, export intensity measured as the share of exports in total sales, number

[8] For a review of non-experimental methods used in the evaluation literature see Blundell and Costa Dias (2000) and Khandker et al. (2010).

[9] 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.

of employees in natural logarithm to proxy size, capital intensity measured by the capital-labour ratio, and average wage per employee in natural logarithm.

In the propensity score matching case, the comparison group for each treated firm is chosen with a pre-defined criterion of proximity. 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.

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. We try different specifications, one with an interaction term between the switching into imports and skills, as well as the interaction between import share and the share of skilled workers:

$$\ln(TFP_{it}) = \beta_1\theta_{it} + \beta_2 mshare_{it} + \beta_3 skill_{it} + \beta_4(skill_{it} \times \theta_{it}) + \gamma_k Z_{it-1} + \delta_j + \delta_t + \varepsilon_{it} \quad (5)$$

$$\ln(TFP_{it}) = \beta_1\theta_{it} + \beta_2 mshare_{it} + \beta_3 skill_{it} + \beta_4(skill_{it} \times mshare_{it}) + \gamma_k Z_{it-1} + \delta_j + \delta_t + \varepsilon_{it} \quad (5')$$

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, θ_{it} is the treatment variable (an indicator variable that takes the value one if firm i switches import status at t), δ_j are industry dummies, and δ_t are time dummies. We also include as controls a dummy variable indicating whether foreign capital is present in firm's total capital at time t.

The role of firms' absorptive capacity in affecting their benefits from import-related knowledge spillovers is evaluated in equation (5) and (5') by means of the interaction term between the proportion of skilled workers and starting importing and the interaction between the proportion of skilled labour 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 ($\beta_4 > 0$). Aside measuring the impact of skills when the firm starts importing, 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.[10]

An important issue regarding the difference-in-differences method is that it assumes that treatment assignment depends on time-invariant unobserved characteristics, so the selection bias cancels out through differencing. Thus, we also try a direct approach to check the robustness of the results.

From a programme evaluation perspective, it may be important not only the binary treatment status, but also the level of exposure or "dose" provided. To this end, we use a stata module developed by Cerulli (2015) for estimating a dose-response function when treatment is

[10] We also consider the effect of starting and continuing importing during all th sample period finding positive effects of this variable. Results are available upon request from the authors.

continuous and individual are heterogeneous.[11] We obtain a "dose-response function" which is equal to the Average Treatment Effect, given the level of treatment t. This is, we estimate the causal effect of the level of imports on productivity by assuming that treated and untreated individuals may respond differently both to specific observable confounders (collected in vector Zit) and the intensity of the treatment (t). The advantage of this model is that it does not need a full normality assumption, and it is well-suited when many individuals have a zero level of treatment (a "spike" at zero).

2.2. Direct Approach

In order to assess the robustness of our results we modify the OP and ACF methodologies, including the share of imported intermediates as an endogenous regressor in the production function. Thus, our production function equation for OP becomes:

$$y_{it} = \beta_{sl} sl_{it} + \beta_{ul} ul_{it} + \beta_m m_{it} + \phi_t (i_{it}, k_{it}, Mshare_{it-1}) + \eta_{it} \quad (6)$$

Where $Mshare_{it-1}$ is the share of imported intermediates in total intermediates used by the firm.

The augmented ACF method becomes:

$$y_{it} = \beta_m m_{it} + \phi_t (i_{it}, k_{it}, sl_{it}, ul_{it}, Mshare_{it-1}) + \eta_{it} \quad (7)$$

To analyse whether the effects of imported inputs on productivity depends on the firm´s absorptive capacity we test skill intensity. Additionally we analyse the effects of export intensity, profit growth, and output growth. We call these firm´s characteristics(z_{it}^k).

Following to Augier et al. (2013) for each characteristic of interest we define a cut off level (z_0^k), and an indicator function $High_{it}^k$ such that:

$$High_{it}^k = \begin{cases} 1 \text{ } if \text{ } z_{it}^k \geq z_0^k \\ 0 \text{ } otherwise \end{cases} \quad (8)$$

Thus, we use characteristic k to determine the high and low groups according to the characteristic of interest. Then our extended production function for the OP method is:

$$y_{it} = \beta_{sl} l_{it} + \beta_{ul} ul_{it} + \beta_m m_{it} + \phi_t \left(i_{it}, k_{it,} Mshare_{it-1} * High_{it}^k, Mshare_{it-1} * \left(1 - High_{it}^k\right)\right) + \eta_{it}$$
(9)

While for the extended ACF method we have:

$$y_{it} = \beta_m m_{it} + \phi_t \left(i_{it}, sl_{it}, ul_{it}, Mshare_{it-1} * High_{it}^k, Mshare_{it-1} * \left(1 - High_{it}^k\right)\right) - \eta_{it} \quad (10)$$

We estimate (9) and (10) for the whole sample and for the various groups defined by firm characteristic k. If a high value of z_{it}^k denotes a high absorptive capacity, we assume that

$\beta_{Mshare*High} > \beta_{Mshare*(1-High)}$, where $\beta_{Mshare*High}$, and $\beta_{Mshare*High*(1-High)}$ indicate

[11] Ctreatreg command. It also may be used when selection into treatment is endogenous.

the coefficients for $Mshare_{it-1} * High_{it}^{k}$ and $Mshare_{it-1} * (1 - High_{it}^{k})$, respectively.

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).[12] 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 with base year 1997.[13] It also includes data on employment discriminated in skilled and unskilled workers, 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 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.[14] 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.

[12] 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.

[13] 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 is recorded in the Census and the Surveys of Economic Activity, and we take the book value to estimate productivity.

[14] 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]	11.40	4.87	20.3	11.6
	(73.0)	(89.4)	(76.5)	(39.7)
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)
Foreign ownership of capital	0.129	0.048	0.208	0.123
	(0.335)	(0.214)	(0.406)	(0.328)
Age	27	21	32	31
	(17)	(14)	(18)	(17)
TFP ACF	11.219	10.877	11.486	11.280
	(0.9587)	(0.9476)	(0.8779)	(0.9492)
TFP OP	11.266	10.882	11.566	11.566
	(0.9643)	(0.9519)	(0.8684)	(0.9456)

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; TFP ACF: estimation of TFP by Ackerberg, Caves and Frazer (2006) technique; TFP OP: estimation of TFP by Olley and Pakes (1996) technique.

Source: Authors' calculations.

4. Results

Table 2 reports the parameter estimates for the production functions based on the OP and ACF methodologies with gross output as the dependent variable. In spite of some difference in the coefficients of both techniques the correlation between the estimated TFPs is high (0.95). The main difference lays on the coefficient of capital.

4.1. TFP estimation

We present the estimation of total factor productivity using the Olley and Pakes (1996) and Ackerberg, Caves and Frazer (2006) techniques.

Table 2. TFP estimation, period 1997-2008

	Olley and Pakes	Ackerberg, Caves and Frazer
Ln VBP	Coefficients	Coefficients
Ln(Capital)	0.165***	0.265***
	(0.0346)	(0.0114)
Ln(Unskilled Workers)	0.245***	0.265***
	(0.0287)	(0.0145)
Ln(Skilled Workers)	0.299***	0.317***
	(0.0223)	(0.0132)
Ln(inputs and materials)	0.168***	0.155***
	(0.0212)	(0.0164)
Trend	0.0422***	0.0365***
	(0.00269)	(0.0024)
Observations	5,745	5,745

Source: Authors' estimations.

Figure 1 show the evolution of the TFP estimated over the sample period for the three types of firms defined by their import status: permanent importers, never importing and switchers into importing. It can be observed that permanent importers have higher productivity than non-importing firms, while switchers have a TFP that lies between permanent importers and non-importing firms, except for the last year of our sample. Moreover productivity increases steadily over the period mainly for permanent importers, while non-importing firms seems to be more sensitive during the crisis period (2001-2003).

Figure 1. Unweighted average TFP by import status
Figure 1.a. Ackerberg, Caves and Frazer technique

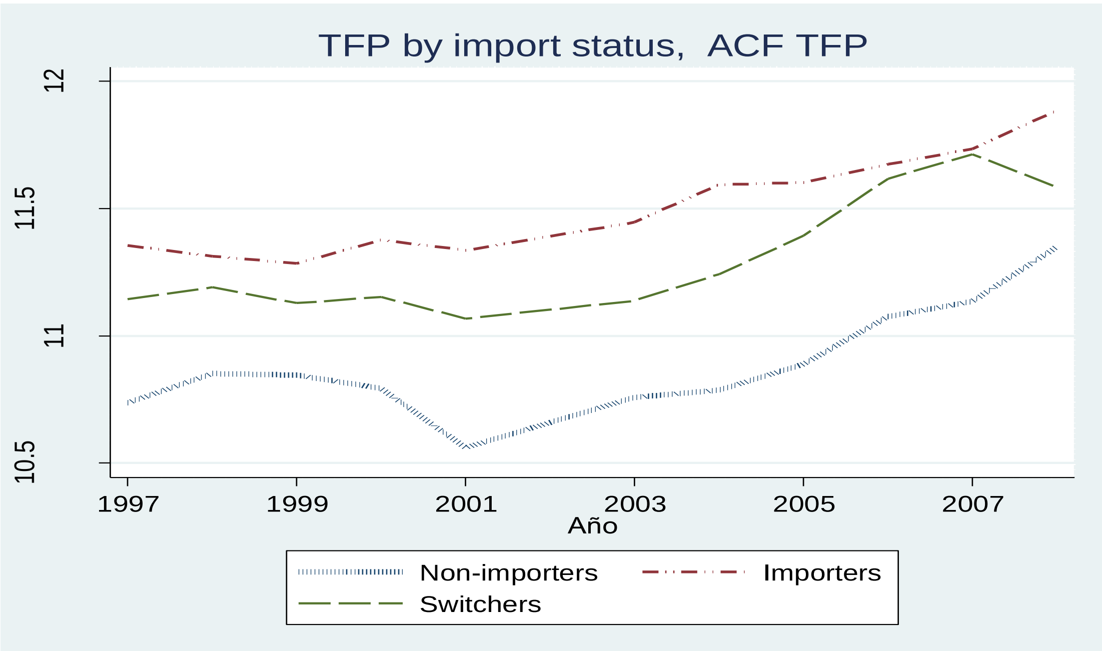
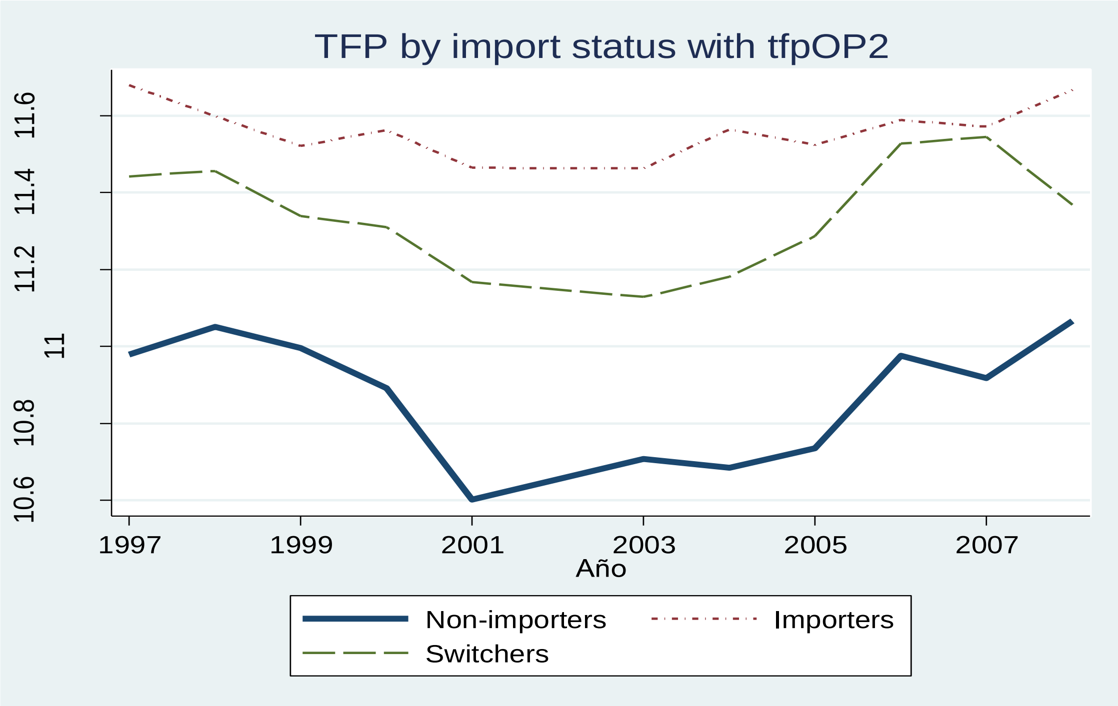


Figure 1.b. Olley and Pakes' technique.



Source: Authors' estimations

4.2. Impact evaluation techniques

4.2.1. Treatment effect: binary and continuous treatments

Returning to the binary case difference-in-difference estimation, in Table 3 we report the balancing-score test, which verifies the correct performance of the propensity score matching procedure. Thus, after matching, the distribution of observable characteristics is not statistically different between the treated and control groups.[15]

Table 3. Balancing score tests (propensity score matching)

	Mean			t-test	
Variable	Treated	Control	% bias	t	p>t
TFP	11.224	11.21	1.5	0.14	0.888
Labour	4.0339	4.0145	1.8	0.18	0.855
Capital-Labour ratio	10.684	10.626	3.5	0.35	0.724
Average wages	11.178	11.157	2.7	0.29	0.775
Export Share	0.44	0.43765	0.5	0.04	0.965
Profit-value added ratio	0.10329	0.11574	-0.6	-0.05	0.957

Source: Authors' estimations.

In Table 4a we present the results for the binary case: switching into imports, considering once-time switchers as well as multiple switchers. We find that starting to import has not a significant

[15] For the sake of brevity, we do not report the results on the industry and time dummies.

impact on productivity, while skilled labour has a positive and significant effect. Regarding to the interaction terms while the interaction between skilled labour and switching into imports is not significant the interaction of the skilled workers with import share is positive and significant (Model 2). This could be pointing out that the amount of imports plays some role in enhancing productivity.

Regarding to the control variables we find that the ratio of profit to value added, export share, foreign ownership of capital and firm size has a positive and significant effect.

Table 4a: Impact evaluation: effect of starting importing inputs, binary case

VARIABLES	(1) Model 1	(2) Model 2	(3) Model 3
Treatment variable (Θ)	0.0543	-0.0316	0.0545
	(0.0528)	(0.0545)	(0.0574)
Skilled-labour share (skill)	3.421***	2.495***	3.422***
	(0.491)	(0.319)	(0.519)
Import share (mshare)		0.400***	
		(0.0679)	
Skill*mshare (skill_i)		2.807**	
		(1.344)	
Profit-value added ratio, lagged	0.0326**	0.0322**	0.0326**
	(0.0162)	(0.0159)	(0.0162)
Export share, lagged	0.115***	0.0811**	0.115***
	(0.0365)	(0.0358)	(0.0366)
Size (total employment), in logs and lagged	0.166***	0.155***	0.166***
	(0.0192)	(0.0190)	(0.0192)
Capital-labour ratio, lagged	0.0112	0.00237	0.0112
	(0.0121)	(0.0119)	(0.0121)
Foreign capital, lagged	0.565***	0.492***	0.565***
	(0.0673)	(0.0630)	(0.0671)
Skill*treatment			-0.0109
			(0.996)
Constant	9.965***	10.05***	9.965***
	(0.161)	(0.158)	(0.161)
Observations	2,475	2,461	2,475
R-squared	0.394	0.417	0.394

Notes: i) Dependent variable is log TPF estimated using the Ackerberg, Caves and Frazer (2006) method. ii) FE by year and industry. Skilled: share of skilled workers in total employment; VA: value added. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Source: Authors' estimations.

In order to shed more light on the effect of importing on productivity some years after starting this activity, we consider alternative treatment variables, studying the studying the impact on importing on productivity for various years after starting importing.

In Table 4b we present the results for our treatment variables defined according to different years after starting importing. Stay1 takes the value one at time t if the firm started importing at t-1 and remain importing at t, i.e. after one year of starting importing, stay2 takes the value one at time t if the firm started importing at t-2 and remain importing at t, i.e. two years after starting importing, and stay3 which takes the value one at time t if the firm started importing at t-3 and remain importing at t, i.e. 3 years after starting importing.

We analyse two different specifications for each treatment variable (stay1, stay2 and stay3). In one specification we consider the interaction of the share of skilled workers with the share of imported inputs, and in the second the interaction of the share of skilled workers with the treatment variable. We find that stay1, stay2 and stay3 are positive and significant in the second specification (the one that includes the interaction between skilled workers and the treatment), while the interaction term (treatment*skills) is not significant for stay1 and stay3, but negatively significant for stay2, contrary to our priors.

The share of skilled workers and of imported inputs has always a positive and significant effect, while the interaction term is positive and significant for stay2 and stay3.

Table 4.b. Matching and Difference-in-Difference estimation

VARIABLES	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4	(5) Model 5	(6) Model 6
Stay1	0.0479	0.167**				
	(0.0665)	(0.0743)				
Stay2			0.0757	0.212***		
			(0.0703)	(0.0784)		
Stay3					0.0308	0.201*
					(0.102)	(0.117)
Skill	2.807***	3.663***	2.232***	3.621***	2.145***	3.391***
	(0.388)	(0.613)	(0.417)	(0.835)	(0.346)	(0.704)
Mshare	0.457***		0.439***		0.553***	
	(0.0821)		(0.0880)		(0.0977)	
Skill_mshare	2.204		4.072**		3.534*	
	(1.569)		(1.913)		(1.884)	
Lagged Profit-VA ratio	0.0695	0.0747	0.0512***	0.0531***	0.0282*	0.0296**
	(0.0576)	(0.0596)	(0.0180)	(0.0192)	(0.0145)	(0.0135)
Lagged Profit-VA ratio	0.0818*	0.114**	0.124**	0.156***	0.239***	0.290***
	(0.0433)	(0.0443)	(0.0485)	(0.0498)	(0.0541)	(0.0564)
Lagged Size (Ln Employment)	0.143***	0.153***	0.145***	0.153***	0.160***	0.164***
	(0.0219)	(0.0223)	(0.0265)	(0.0278)	(0.0270)	(0.0289)
Lagged Capital-Labour ratio	-0.0189	-0.0124	-0.0108	-0.00484	-0.0313**	-0.0205
	(0.0142)	(0.0146)	(0.0162)	(0.0173)	(0.0158)	(0.0167)
Lagged Foreign Ownership	0.646***	0.717***	0.618***	0.703***	0.586***	0.655***
	(0.0762)	(0.0834)	(0.0828)	(0.0914)	(0.0884)	(0.100)
Skill_stay1		-0.894				
		(1.918)				
Skill_stay2				-2.551**		
				(1.202)		
Skill_stay3						-2.303
						(1.438)
Constant	10.32***	10.26***	10.23***	10.10***	10.26***	10.14***
	(0.177)	(0.183)	(0.201)	(0.207)	(0.207)	(0.211)
Observations	1,662	1,681	1,292	1,306	1,133	1,147
R-squared	0.456	0.429	0.485	0.450	0.492	0.451

Notes: i) Dependent variable is log TPF estimated using the Ackerberg, Caves and Frazer (2006) 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

In Table 5 we present the estimation results for import share consider as a continuous variable, applying the technique developed by Cerulli (2015) as we commented before. We consider heterogeneous effects due to skilled workers (model 1) and in skills and the interaction of skills with import share in model 2, in model 3 we consider lagged skills instead of contemporaneous skilled labour on productivity.

We find positive effects of the treatment, with a good fit show by the R-squared. Thus, there is a positive effect of imports on productivity. This means that on average all values taken by the share of imported inputs have a positive effect on productivity.

In Figure 2a we present the dose response function for Model 1, in Figure 2b for Model 2 and in 2c for Model 3. All the dose response functions show a continuous increasing effect of imported intermediates on TFP.

Table 5. Continuous Treatment (Cerulli)

	(1)	(2)	(3)
VARIABLES	Model 1	Model 2	Model 3
Import Dummy	0.140***	0.147***	0.117***
	(0.0388)	(0.0390)	(0.0405)
Skilled-labour share (skill)	3.213***	3.201***	3.222***
	(0.391)	(0.389)	(0.393)
Profit-Value Added ratio (lagged)	0.0419**	0.0420**	0.0420**
	(0.0187)	(0.0187)	(0.0187)
Export Share (lagged)	0.0620**	0.0586**	0.0587**
	(0.0275)	(0.0275)	(0.0275)
Size (Ln total employment, lagged)	0.123***	0.123***	0.124***
	(0.0158)	(0.0157)	(0.0157)
Capital-Labour ratio (lagged)	-0.0269***	-0.0263***	-0.0271***
	(0.00975)	(0.00975)	(0.00971)
Foreign Ownership (lagged)	0.432***	0.434***	0.430***
	(0.0384)	(0.0384)	(0.0380)
Lagged Skill*Import Share			2.281*
			(1.227)
Industry Dummies	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes
_ws_skill	-0.491	-2.622***	-1.835**
	(0.549)	(0.792)	(0.837)
_ws_skill_mshare		3.205**	
		(1.325)	
Tw_1	0.00839*	0.00816*	0.00822*
	(0.00487)	(0.00483)	(0.00482)
Tw_2	-0.000129	-0.000133	-0.000132
	(0.000112)	(0.000111)	(0.000111)
Tw_3	1.01e-06	9.77e-07	9.81e-07
	(7.21e-07)	(7.12e-07)	(7.10e-07)
Constant	10.63***	10.62***	10.63***
	(0.128)	(0.127)	(0.128)

Observations	3,728	3,728	3,728
R-squared	0.456	0.458	0.458

Import dummy: variable equal 1 if the firm imports and zero otherwise; _ws_skill, and ws_skill_mshare: variable: are additional regressors used in model's regression when we allow for heterogeneous effects; Tw_1, Tw_2 and T2_3are the three polynomial factors of the dose-response function. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Figure 2a. Dose-response function, Model 1

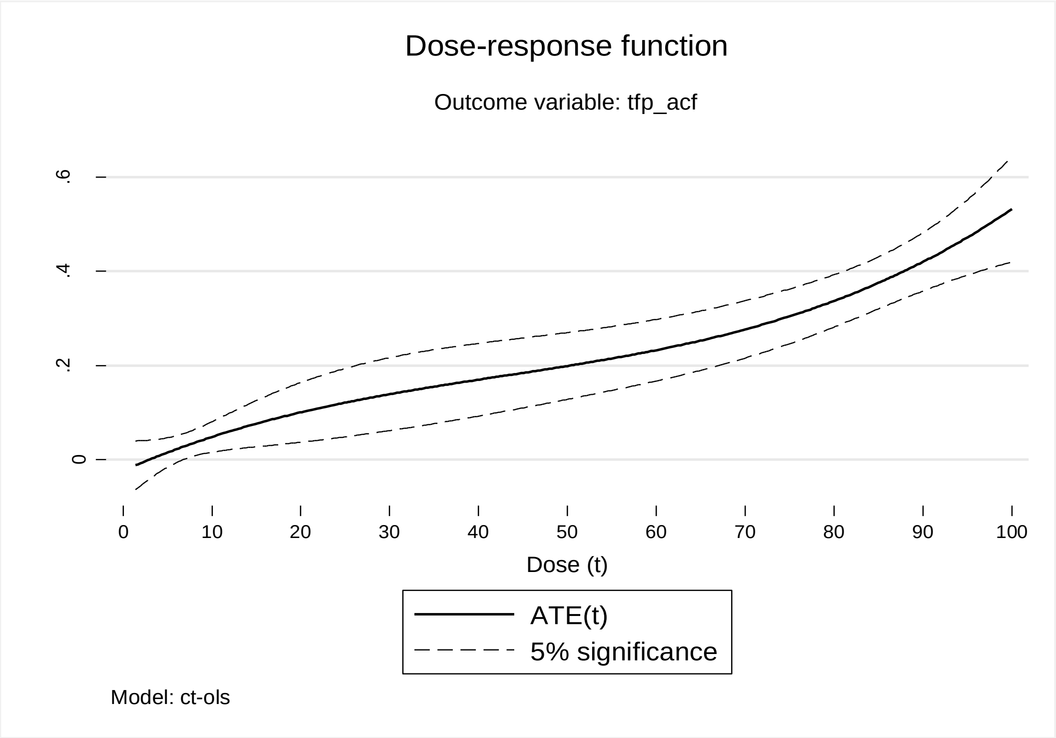


Figure 2b. Dose-Response function, Model 2

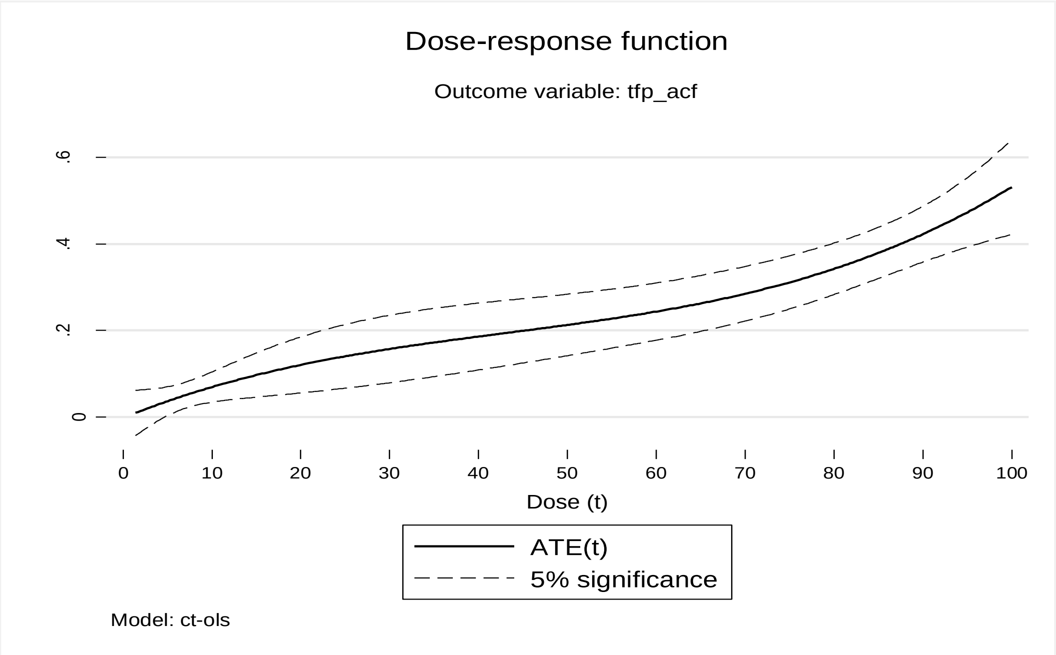
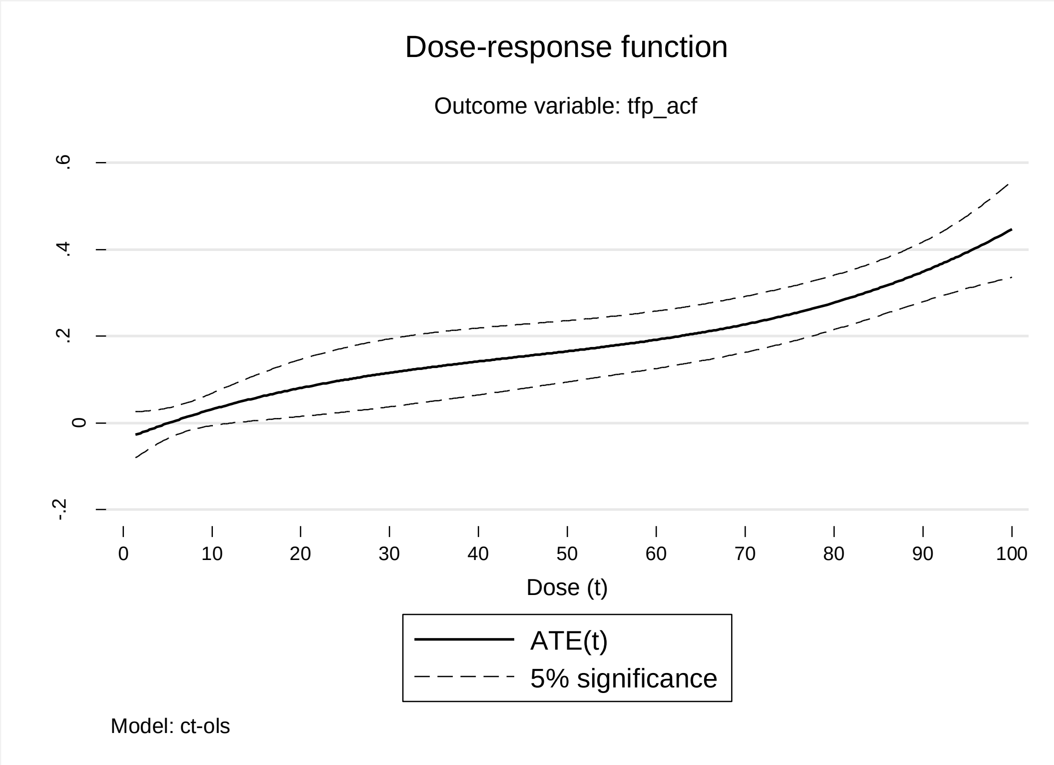


Figure 2c: Dose-Response Function, Model 3



Source: authors' estimation

4.3. Direct Estimation

As a robustness check we re-estimate the production function augmented by the share of imported inputs, for the OP as well as for the ACF methodology.

In Table 6 and 7 we extend the OP and the ACF approach to accommodate the share of imported intermediates. We estimate TFP using gross output as well as value added as our dependent variable. Rivers et al. (2013) argue that using value added overestimates the coefficient of the variable. As can be seen from Table 6 for the OP approach the lagged share of imported inputs has a positive and significant effect on TFP, with a lower coefficient for current values of the variable. Furthermore, we note that the coefficients for the share of imported intermediates are higher when we use value added as our dependent variable, nevertheless, this variable is significant for gross output too. Thus, though the claim of Rivers et al. (2013) seems to be well grounded, so using value added seem to show a higher impact of imported inputs than using gross output.

Table 6. Direct Approach using Olley and Pakes (1996) methodology

	Ln Gross Output			Ln Value Added		
Ln VBP	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
Ln(Capital)	0.165***	0.161***	0.169***	0.215***	0.259***	0.210***
	(0.0346)	(0.0381)	(0.0353)	(0.0760)	(0.0587)	(0.0560)
Share of imported inputs		0.185***			0.426***	
lagged one year		(0.0531)			(0.0867)	
Share of imported inputs			0.0862			0.238**
			(0.0700)			(0.0951)
Ln(Unskilled Workers)	0.245***	0.204***	0.241***	0.271***	0.255***	0.286***
	(0.0287)	(0.0320)	(0.0277)	(0.0341)	(0.0347)	(0.0310)
Ln(Skilled Workers)	0.299***	0.266***	0.281***	0.406***	0.352***	0.360***
	(0.0223)	(0.0280)	(0.0220)	(0.0266)	(0.0290)	(0.0241)
Ln(Inputs and materials)	0.168***	0.234***	0.173***			
	(0.0212)	(0.0415)	(0.0241)			
Time trend	0.0422***	0.0431***	0.0421***	0.0547***	0.0637***	0.0574***
	(0.00269)	(0.00340)	(0.00264)	(0.00377)	(0.00476)	(0.00372)
Observations	5,596	5,596	5,596	5,596	5,596	5,596

Notes: Robust standard errors in parentheses; *** significant at 1%, ** significant at 5%, * significant at 10%. Source: Authors' estimations.

Table 7. Direct Approach using Olley and Pakes (1996) methodology

	Ln Gross Output			Ln Value Added		
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
Ln(Capital)	0.265***	0.247***	0.244***	0.374***	0.321***	0.320***
	(0.0114)	(0.007)	(0.0127)	(0.0136)	(0.0122)	(0.0131)
Share of imported inputs		0.354***			0.6729***	
lagged one year		(0.025)			(0.0359)	
Share of imported inputs			0.199***			0.658***
			(0.0212)			(0.0304)
Ln(Unskilled Workers)	0.265***	0.256***	0.242***	0.338***	0.341***	0.345***
	(0.0145)	(0.010)	(0.0132)	(0.0173)	(0.0163)	(0.0174)
Ln(Skilled Workers)	0.317***	0.287***	0.275***	0.407***	0.408***	0.375***
	(0.0132)	(0.010)	(0.0127)	(0.0126)	(0.0164)	(0.0128)
Ln(Inputs and materials)	0.155***	0.214***	0.236***			
	(0.0164)	(0.006)	(0.0175)			
Time trend	0.037***	0.040***	0.031***	0.051***	0.049***	0.046***
	(0.0024)	(0.003)	(0.0020)	(0.0024)	(0.0039)	(0.0031)
Observations	6183	4671	6088	6183	4671	6088

Notes: Robust standard errors in parentheses; *** significant at 1%, ** significant at 5%, * significant at 10%. Source: Authors' estimations.

Results for the extended ACF approach are in line with the results for the OP method A 10 percent increase in lagged import share raises TFP by 1.85 percent for the OP approach and 3.5 percent for the ACF method when we use gross output. Thus, the ACF approach shows a higher effect. Augier et al. (2013) find coefficient of 1.5 and 1.4 for the OP and ACF approach respectively, while Halpern et al. (2009) for Hungerian exporting firms find that a 10 % increase in the share of imports raise firm productivity in GMM in 1.8 % and had no impact on a fixed effect estimator. Amiti and Konings (2007) found that a 10 percent reduction in input tariffs raise TFP of importing Indonesian firms by 12 % which is in line with the results of Goldberg et al. (2010) for Indian data. While Kasahara and Rodrigue (2008) using augmented production functions for Chilean plants, find that switching from being a non-importer to being an importer of foreign intermediates can improve productivity by 2.3 to 22 percent.

In what follows we check whether there are different effects of imported intermediates according to firm´s characteristics, by interacting the lagged import share with a dummy indicator for the "High" group as explained above in Section 3.

In Table 8 we present the direct approach for OP methodology with gross output as our dependent variable. In the first column we proxy absorptive capacity using the share of skilled labour, and in the second column we present the results for investments in R&D. We can observe positive and significant coefficients for the interaction of lagged import share with both variables that proxy absorptive capacity with a higher coefficient for the high skilled and high R&D groups compared to the low ones. This shows the importance of absorptive capacity to take advantage of external knowledge. These results differ from the previous evaluation techniques use, probably due to the fact that now we are taking into account firms with a high level of absorptive capacity.

For the low skilled workers and low R&D groups of firms the coefficients are much lower than for the high skill group, though the impact is also positive. For instance for the high skill workers group a 10 percent increase in the share of imports raise TFP by 2.8 percent and in the low skilled group a 10 percent increase translate into 1.68 percent. While in the high R&D group this figure is 2.9 percent and 1.61 for the low R&D group of firms.

In the third column we define groups of firms according to their export intensity. We observe a higher positive effect for the group of firms with export intensity in the 75^{th} upper percentile of the distribution of export intensity. This confirms the complementarity between imports and exports found in several works.

Table 8. Direct approach function according to different firm´s characteristics, Olley and Pakes method

VARIABLES	Skill intensity	R&D intensity	Export intensity	Profit growth intensity	Output growth intensity
Ln(Capital)	0.147***	0.153***	0.159***	0.182***	0.171***
	(0.0365)	(0.0339)	(0.0392)	(0.0418)	(0.0343)
Lagged Mshare*High	0.279***	0.285***	0.211***	0.211***	0.228***
	(0.0845)	(0.0820)	(0.0751)	(0.0626)	(0.0631)
Lagged Mshare*(1-High)	0.168***	0.161***	0.156***	0.166***	0.156***
	(0.0539)	(0.0549)	(0.0603)	(0.0546)	(0.0524)
Ln(Unskilled Workers)	0.245***	0.209***	0.205***	0.206***	0.205***
	(0.0316)	(0.0325)	(0.0331)	(0.0316)	(0.0317)
Ln(Skilled Workers)	0.228***	0.258***	0.267***	0.266***	0.267***
	(0.0309)	(0.0274)	(0.0281)	(0.0279)	(0.0280)
Ln(Inputs and materials)	0.232***	0.233***	0.232***	0.234***	0.232***
	(0.0411)	(0.0413)	(0.0415)	(0.0415)	(0.0414)
Time trend	0.0431***	0.0423***	0.0423***	0.0430***	0.0417***
	(0.00346)	(0.00351)	(0.00328)	(0.00338)	(0.00335)
Observations	5,596	5,596	5,596	5,596	5,596

Notes: Robust standard errors in parentheses; *** significant at 1%, ** significant at 5%, * significant at 10%. Source: Authors' estimations.

In the fourth column we check the effect of growth in profits. We observed that the group with higher profit growth takes more advantage of imported input, which could be the result of a pricing strategy by the firm, either because of lower prices of imported inputs or due to a higher quality of the final good produced. In the last column we present the results for firms with higher market share. It can be observed a higher effect on productivity for firms with higher market share.

In the fifth column we take output growth intensity to check for scale economies. Since importers are also big sized firms, one hypothesis could be that as firms grow they increase their probability to become an importer. Thus, productivity growth could be associated to increasing returns to scale. In fact, we observe a higher effect of imported inputs for the group of firms with higher output growth than for the lower one. Nevertheless, the impact of imported intermediates is much more enhanced when firms have higher absorptive capacities than higher firm´s growth. In fact our estimations of the effects of imported input are higher for the group of high skilled labour and high R&D intensity than for the other characteristics considered.

Table 9. Direct approach function according to different firm´s characteristics, Ackerberg, Caves and Frazer (2006) methodology

VARIABLES	Skill intensity	R&D intensity	Export intensity	Profit growth intensity	Output growth intensity	Market Participation
Ln(Capital)	0.244***	0.249***	0.253***	0.252***	0.254***	0.248***
	(0.011)	(0.014)	(0.014)	(0.014)	(0.249)	(0.013)
Lagged Mshare*High	0.484***	0.560***	0.290***	0.330***	0.567***	0.463***
	(0.037)	(0.045)	(0.046)	(0.044)	(0.393)	(0.048)
Lagged Mshare*(1-High)	0.193***	0.254***	0.378***	0.203***	0.286***	0.194***
	(0.025)	(0.030)	(0.030)	(0.026)	(0.238)	(0.026)
Ln(Unskilled Workers)	0.294***	0.255***	0.254***	0.261***	0.252***	0.263***
	(0.022)	(0.017)	(0.017)	(0.019)	(0.241)	(0.023)
Ln(Skilled Workers)	0.265***	0.280***	0.281***	0.287***	0.286***	0.282***
	(0.018)	(0.016)	(0.017)	(0.014)	(0.294)	(0.011)
Ln(Inputs and materials)	0.215***	0.220***	0.215***	0.225***	0.216***	0.223***
	(0.030)	(0.031)	(0.031)	(0.032)	(0.287)	(0.033)
Time trend	0.036***	0.039***	0.048***	0.0345***	0.041***	0.031***
	(0.002)	(0.003)	(0.003)	(0.003)	(0.037)	(0.003)
Observations	4,659	4,659	4,659	4,659	4,659	4,659

Notes: Robust standard errors in parentheses; *** significant at 1%, ** significant at 5%, * significant at 10%. Source: Authors' estimation.

Summing up, we analyse the impact of switching into imports and staying importing afterwards from one to three years using a binary treatment effect, as well as the effect of import intensity using continuous treatment effect techniques. The most robust findings are that imports impact positively on productivity, as well as skilled labour. Moreover, it seems that importing takes some time to translate into productivity gains, and there is a positive interplay between the share of imported inputs and skilled labour, pointing out that absorptive capacity matters. The continuous treatment effect also reveals a positive impact of importing with an increasing effect.

Finally, the augmented production function approach shows a positive effect of skilled labour and R&D intensity on productivity.

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 foreign 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 a two-stage approach by first estimating firms' TFP and then using impact evaluation techniques to analyse 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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Serie Documentos de Trabajo

Marzo, 2019

DT 03/2019

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