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Are importing and exporting complements or substitues in an emerging economy? The case of Colombia.

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Abstract

The aim of this paper is investigating the impact of two firm trading strategies (exporting and importing) on total factor productivity (TFP) and the potential complementarity/substitutability effects of these strategies. To assess these effects, we obtain robust estimates of TFP using a GMM approach that explicitly reckons the ability of firms' trading experience to affect productivity. We use data for Colombian manufacturing firms from the Annual Manufacturing Survey spanning from 2007-2016. Our estimations results suggest that, regardless of the technological intensity of the industry in which the firm operates, active trading strategies (only exporting, only importing, both importing and exporting) pay positive rewards in terms of productivity. Nevertheless, whilst we find positive synergies (complementary) between exporting and importing for firms in med-high tech sectors, for firms operating in low-tech and med-low tech sectors, importing and exporting appear to be substitutes.

Keywords: imports, export, productivity, complementarity, substitutability
JEL classfication: F14, D24

1 Introduction

The impact of trade activities on manufacturing firms' productivity has been extensively analyzed, mainly for developed countries, both in the theoretical and empirical trade literatures. Most of the studies analyze either the possibility that exporting boosts firms' productivity or the impact of importing intermediate inputs on firms' productivity.[1] This paper attempts to contribute to the existing literature by investigating the effects of trading strategies on firm's productivity for Colombia, a developing country. In particular, we aim at exploring the effect of different firms' trading strategies (only importing, only exporting and both importing and exporting) upon total factor productivity and testing for the possible existence of complementarity/substitutability relationships between importing and exporting (in terms of productivity).

To test for complementarity/substitutability between the exporting and importing strategies, we use a two-stage procedure. In the first stage, we use a modified version of the generalized method of moments estimator proposed by Wooldridge (2009) to jointly estimate the parameters of the production function and the coefficients capturing the effects of firms' internationalization strategies on productivity. More specifically, in line with De Loecker (2007, 2013) (for exports) and Kasahara and Rodrigue (2008) (for imports) or Máñez et al. (2020b) (for exports and imports), we consider a more general law of motion of productivity in which we include a set of dummy variables fully characterizing firms' past internationalization strategies. In the second stage, we use the coefficient estimates of the internationalization strategies to test for complementarity/substitutability between internationalization choices (importing and/or exporting) using the structural methodology suggested by Carree et al. (2011) and applied in Añón et al. (2018). Moreover, we aim to analyze whether the effect of firms' internationalisation strategies on productivity depends on the technological regime in which the firm operates. Thus, we break down our analysis by the technological intensity of the sectors, according to the OECD classification (Hatzichronoglou, 1997).

We perform the empirical analysis using an unbalanced sample of Colombian manufacturing firms extracted from the Annual Manufacturing Survey (EAM) for the period 2007-2016. Analyzing the impacts on productivity of firms' trading strategies for an emerging country like Colombia is especially interesting. Typically, in emerging countries

[1] See Silva et al. (2012), Martins and Yang (2009), Singh (2010) for evidence on exports; and Kasahara and Rodrigue (2008), Amiti and Konings (2007) and Halpern et al. (2015) for evidence on imports.

a disproportionate proportion of firms are SMEs (91% in the case of Colombia). Since these firms are more likely to suffer from financial constraints and probably from other limitations, the need of detracting resources from a trading strategy (either importing or exporting) when starting another one, may give rise to a pattern of substitutability between exporting and importing.

Analyzing complementarity/substitutability between exporting and importing requires to acknowledge that both trading activities may have direct and indirect effects on productivity and both are subject to sunk costs. We introduce direct and indirect effects in turn. We consider as direct effects of exporting on productivity, the potential gains in productivity that stem from export participation. These productivity gains are usually associated to growing sales that allow firms to profit from economies of scale, from knowledge flows from foreign customers (in the form of innovations that help reducing costs and/or improving the quality of the firm's products), and also from increased competition in export markets, forcing exporters to become more efficient (Máñez et al., 2010; Manjón et al., 2013; Crespi et al., 2008). We consider now the direct effects of importing inputs on productivity. Importing intermediates can result in productivity increases if it allows firms to access to a wider variety of inputs, and/or to higher quality inputs and lower price inputs (mainly in developed countries), adopt or imitate new technologies from foreign markets, and to obtain knowledge embodied in imported inputs (Halpern et al., 2015; Bekes and Altomonte, 2009). This last possibility is especially relevant for firms in emerging economies. The empirical evidence on the impact of importing intermediates on productivity is scarce and mixed. Van Biesebroeck (2008) using Colombian data, finds that productivity growth is correlated more strongly with firm's export status than with the use of imported inputs; and, similarly, Muendler (2004) finds a small contribution of foreign materials and investments goods on output, for Brazil. In contrast, Kasahara and Rodrigue (2008), Amiti and Konings (2007) and Halpern et al. (2015) find that importing intermediates has a positive effect on firms' productivity for Chile, Indonesia and Hungary, respectively.

We understand for indirect effects, the effects of firms' exporting (importing) strategies that accrue to productivity through their possible enhancing effects on the probability of importing (exporting). Should exporting (importing) results in productivity gains and reduces the sunk costs associated to start importing (exporting), exporting (importing) firms will be more likely to start importing (exporting) than firms without previous ex-

porting (importing) experience.

As for the sunk costs, Aristei et al. (2013) points out that some of these costs may be common to both activities. The acquisition of knowledge obtained in the import/export activities, through contacts with providers or customers, learning from international laws, government regulations, taxation, among others, allows firms gaining expertise in the international markets that very likely will contribute to reduce the sunk costs to start selling output abroad or importing intermediates (Kasahara and Lapham, 2013). Additionally, as raised by Aristei et al. (2013) or Albornoz and Garcia-Lembergman (2019), the new contacts among exporters might create new information channels that incentive importing high quality inputs to improve the characteristics of the products firms sell abroad.

With respect to the increase in productivity associated to exporting (importing) that may increase the probability of importing (exporting), it is related to the process, put forward by Melitz (2003), that only the more productive firms might engage into importing (exporting). Complementarities between firm's importing and exporting activities (in terms of higher productivity) stem from these indirect effects, which contribute to reinforce the possible positive effects on productivity of performing already only one of the two trading strategies considered.

Nevertheless, becoming a two-way trader when the firm is only-exporting or only-importing is not without risk.[2] For a firm, starting to export when it is already importing might suppose detracting resources devoted to efficiently importing. It might imply that the firm devotes less resources to access lower price and/or high-quality inputs, that it has less possibilities to learn about new technologies from foreign markets, and it might make more unlikely to obtain knowledge embodied in foreign inputs. The consequence is that the possibilities of profiting from importing get diluted. Furthermore, if even detracting resources from importing, the firm is not able to allocate enough resources to establish an efficient exporting activity, then the opportunities of the firm to profit from the productivity enhancement associated to exporting substantially decrease.

Analogously, if a firm that is already exporting needs to withdraw resources from the export activity to start importing, possible consequences are that foreign sales may suffer (reducing the possibilities of profiting from economies of scale) and knowledge flows from foreign customers would be less likely. Therefore, withdrawing resources from exporting to allocate them to start importing might imply a reduction in the firm's possibilities of

[2]We will refer as two-way traders to the firms that both export and import.

benefiting from exporting. Moreover, if even after withdrawing resources from exporting, the firm is not able to obtain enough resources to start a successful importing activity, then it will find difficult to profit from the possible productivity improvement associated to importing. In those cases in which a firm needs to withdraw (financial or other) resources from a trading strategy to start another, may arise a substitutability relationship between exporting and importing.

Limited availability of resources to start importing (exporting) when the firm is already exporting (importing) or the need of withdrawing resources from exporting (importing) to start importing (exporting) may be quite common among SMEs operating in emerging countries. SMEs in emerging countries are very likely to be short of internal resources and face difficulties to access to external financing.

In recent years, some studies like Bernard et al. (2009), Bernard et al. (2007), Muûls and Pisu (2009), Aristei et al. (2013) or Máñez et al. (2020b) recognize the linkages between firms exporting and importing activities. However, only a scarce number of empirical studies explore simultaneously the effects of importing intermediates and exporting on productivity at the firm level. Among them, it is worth mentioning, Kasahara and Lapham (2013) and Máñez et al. (2020b). Kasahara and Lapham (2013) propose a model with heterogeneous final good producers who simultaneously choose whether to export their output and to use imported intermediates. They estimate a structural model with Chilean plant-level data that confirms that there are aggregate productivity and welfare gains due to trade in both final goods and intermediates. Máñez et al. (2020b) estimate total factor productivity (TFP, hereafter) using a modified version of the control approach method (see Olley and Pakes, 1996; Levinsohn and Petrin, 2003), in which they allow past import and export experience to affect productivity. Then, they use this estimated TFP as the dependent variable of an equation in which they analyze the impact of import and export on productivity while explicitly recognizing the existence of productivity persistence. Their results suggest that, whereas SMEs benefit both from performing export and imports activities in terms of productivity, large firms only benefit from importing.

To anticipate our main results, our analysis uncovers that whether export and imports are complements or substitutes (in terms of productivity) depends upon the technological regime in which the firm operates. Whereas in low tech and low-med tech sectors exports and imports appear to be substitutes in terms of productivity, in the med-high tech sector our estimations suggest that they are complements. A reason behind this differential result

is that most of the companies in the low tech and med-low tech sectors do not have access to the necessary resources to efficiently start a second trading strategy; or, even, to start the new trading activity they have to reduce the volume of resources devoted to that trading activity they were already carrying out. Nevertheless, firms in the med-high tech sector may have better access to the resources needed to implement a second trading strategy.

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

2 Empirical strategy

2.1 Production Function

To capture substitutability and complementarity among different trading strategies, we assume assume that firms produce a homogeneous good using a Cobb-Douglas production technology. Thus,

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \omega_{it} + \eta_{it} \tag{1}$$

where y_{it} denotes the natural log of firm's i output in period t; l_{it} is the natural log of the effective hours worked; k_{it} is the log of capital stock; and, m_{it} is the log of the consumption of materials. Finally, ω_{it} is firm's productivity that is not observable to the econometrician but observable or predictable by the firm, and η_{it} is a standard *i.i.d.* error term that is neither observed nor predictable by the firm. We also assume that capital is a state variable, whereas total hours of labour and intermediate materials are variable factors.

To obtain consistent estimates of the inputs elasticities and estimates of TFP residuals, we follow Wooldridge (2009), who argues that both Olley and Pakes (1996) and Levinsohn and Petrin (2003) semiparametric estimation methods can be reconsidered as consisting of two equations that can be jointly estimated by GMM. The first equation deals with the problem of endogeneity of the variable inputs; and, the second one, deals with the issue of the law of motion of productivity.

In the first equation, to solve the problem of endogeneity of labour and materials, we

follow Levinsohn and Petrin (2003) and use the demand of materials, $m_{it} = m_t(k_{it}, \omega_{it})$, to proxy for unobserved productivity. Under the *scalar unobservable* and the *monotonicity assumptions*, we can invert the demand of materials and express productivity in terms of observables:[3]

$$\omega_{it} = m_t^{-1}(k_{it}, m_{it}) = h_t(k_{it}, m_{it}) \tag{2}$$

where h_t is an unknown function of k_{it} and m_{it}. Substituting (2) in (1), we obtain the first estimation equation of the GMM system:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + h_t(k_{it}, m_{it}) + \eta_{it} \tag{3}$$

since h_t is proxied by a third-degree polynomial in its arguments, the parameters β_k and β_m in (3) cannot be identified. This problem is solved by the inclusion of a second equation in the GMM system that deals with the law of motion of productivity:

$$\omega_{it} = f(\omega_{it-1}) + \xi_{it} \tag{4}$$

where $f(\cdot)$ is an unknown function that relates productivity in period t with productivity in period t-1, and ξ_{it} is an innovation term uncorrelated by definition with k_{it}. Nevertheless, the exogenous Markov process in equation (4) neglects the possibility of firms' past export and import experience to affect current productivity. To solve this problem, similarly to Máñez et al. (2020a) and Máñez et al. (2020b), we consider a more general (endogenous) Markov process in which ω_{it} does not depend only on ω_{it-1} but also on firm's past import and export experience captured by a set of dummy variables fully characterising firms' trading strategies.[4] As stated by De Loecker (2013) and De Loecker et al. (2016) if one expects trading strategies to have an effect on productivity, then the theoretical consistent treatment is to include them directly in the law of motion of productivity. Omitting these variables may cause biased estimations of the production function coefficients. Nevertheless, it should be considered that allowing these variables to have an effect on productivity does not imply assuming that they actually have it. This procedure does

[3]The *scalar unobservable assumption* implies that the only unobservable in $m_t(\cdot)$ is ω_{it}. The *monotonicity assumption* implies that the demand of intermediate materials $m_t(\cdot)$ is strictly monotonic in unobserved productivity, ω_{it}.

[4]See Doraszelski and Jaumandreu (2013) or Kasahara and Rodrigue (2008) for similar approaches for R&D and imports, respectively.

not preclude an empirical estimation indicating that trading strategies do not have an effect on productivity. Thus, widening the law of motion of productivity to include firms' trading strategies does not imply assuming a particular effect of importing or exporting on productivity. Therefore, we consider the following law of motion of productivity:

$$\omega_{it} = f(\omega_{it-1}) + \gamma_{1,0} s(1,0)_{it-1} + \gamma_{0,1} s(0,1)_{it-1} + \gamma_{1,1} s(1,1)_{it-1} + \xi_{it}, \tag{5}$$

where $s(exp, imp)_{it-1}$ is an indicator of firm i trading strategy in $t-1$. There are four possible trading strategies: i) only-exporter, $s(1,0)$; ii) only-importer , $s(0,1)$; iii) two-way trader, $s(1,1)$; and, iv) non-trader, $s(0,0)$. Finally, substituting (5) in (1), we obtain the second estimation equation of the GMM system:

$$\begin{aligned} y_{it} =& \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + g_t\left(k_{it-1}, m_{it-1}\right) + \\ & \gamma_{1,0} s(1,0)_{it-1} + \gamma_{0,1} s(0,1)_{it-1} + \gamma_{1,1} s(1,1)_{it-1} + u_{it} \end{aligned} \tag{6}$$

where $g_t\left(k_{it-1}, m_{it-1}\right) = f(h_t\left(k_{it-1}, m_{it-1}\right))$ is a unknown function to be proxied by a third degree polynomial in its arguments and $u_{it} = \omega_{it} + \eta_{it}$ is a composed error term.

Following Wooldridge (2009), equations (3) and (6) can be estimated jointly under appropriate instruments and moment conditions for each equation. The instrumental variables for equation (3) are:

$$\mathbf{z}_{it(1)} = \left(1, l_{it}, k_{it}, m_{it}, c^1_{it}\right) \tag{7}$$

where c^1_{it} is a third-degree polynomial in k_{it} and m_{it} without including k_{it}. The instruments for equation (6) are:

$$\mathbf{z}_{it(2)} = (1, k_{it}, l_{it-1}, m_{it-1}, c_{it}, s(1,0)_{it-1} + s(0,1)_{it-1} + s(1,1)_{it-1}) \tag{8}$$

where c_{it} is a third-degree polynomial in k_{it} and m_{it}. This procedure allows us obtaining both the coefficient estimates of the production function (for the three technological intensity sectors considered) and the estimates for productivity, that are obtained as a residual:

$$\omega^j_{it} = y^j_{it} - \beta^j_l l_{it} - \beta^j_k k_{it} - \beta^j_m m_{it} \tag{9}$$

where ω_{it} is the estimated productivity in logs for firm i at time t belonging to technological intensity sector j.

2.2 Test for complementarity and/or substitutability

To test for complementarity/substitutability between importing and exporting, we use the production function approach explained in Carree et al. (2011).[5] Thus, for implementing the test, we take the set of parameters γ, introduced in the law of motion of productivity to characterize firms' past trading strategies. Following Carree et al. (2011) and Añón et al. (2018), and given that $s(0,0)$ is the reference category, the null hypothesis of complementarity between exporting and importing would require that the following inequality strictly holds:

$$\mathrm{H}_0 : \gamma_{(1,1)} - \gamma_{(1,0)} - \gamma_{(0,1)} > 0 \tag{10}$$

If inequality (10) holds, then a trading strategy that combines exporting and importing renders a larger positive effect on productivity than the sum of the results of only-exporting and only-importing. Conversely, the null of substitutability between importing and exporting would imply:

$$\mathrm{H}_0 : \gamma_{(1,1)} - \gamma_{(1,0)} - \gamma_{(0,1)} < 0 \tag{11}$$

Therefore, if inequality (11) holds the sum of the positive effect on productivity of exporting and importing individually is larger than that associated to combine importing and exporting.[6]

[5] As we include firms' import and export strategies as additional variables in the law of motion of productivity, as De Loecker (2013), and not as additional inputs in the production function, this procedure seems more adequate

[6] An alternative, less structural approach to test for complementarity/substitutability would be the "correlation" approach (see Carree et al. (2011)). This approach also consists of two stages. In the first stage, the researcher obtains an estimate of firms' TFP, as the residual of a production function estimation. The second stage is based on the estimation of a reduced form premium equation, in which the dependent variable is the estimated TFP from the first stage and the explanatory variables are a set of dummy variables capturing whether firm i in period t follows the strategy only-importer ($s(1,0)_{it}$), only-exporter ($s(0,1)_{it}$) or two-way trader ($s(1,1)$), and a vector of control variables (z_{it}). Thus the equation to estimate would be:

$$\hat{\omega}_{it} = \beta_0 + \beta_1 s(1,0)_{it} + \beta_2 s(0,1)_{it} + \beta_3 s(1,1)_{it} + u_{it}$$

A test for complementarity would amount to check whether the productivity premium associated to both import and export is higher than the sum of the productivity premium of only-importing and the premium of only-exporting. Nevertheless, it is important to note that the results obtained using a

3 Data and descriptive analysis

To analyse complementarity/substitutability between importing and exporting strategies on productivity, we use data for Colombian manufacturing extracted from the Annual Manufacturing Survey (EAM), for the period 2007-2016. Firms with missing data on key variables are removed from the sample, as well as some outliers.[7] We end up with an unbalanced panel data with 71,825 observations corresponding to 10,863 firms.[8] Further, due to the small number of observations in specific sectors, we merge some sectors as follows: industry 15 with industry 16; industry 17 with industry 18; and, industry 30 with industry 32.[9] Thus, we have 19 industries that are classified into three technological intensity sectors, according to the OECD technological intensity classification (ISIC Rev. 3) (Hatzichronoglou, 1997).[10]

Next, we focus on the patterns of firms' trading strategies. Table 1 displays some descriptive statistics for the trading strategies, by technological intensity sector and firm size.

In the top panel of Table 1, we report the descriptive statistics for the full sample of firms. We observe that the majority of firms are not actively involved in international trade activities (about 69% of the observations correspond to firms that neither export nor import). Further, for the full sample, observations that correspond to two-way traders (13.7%) exceed those that correspond to only-exporters and only-importers (10.8% and 6.8%, respectively). These figures are similar across the different technological intensity sectors except for the med-high one. For this sector, the percentage of observations corresponding to two-way traders (23.1%) more than doubles that corresponding to only-exporters (12.5%) and it is almost four times larger than the percentage corresponding to only-importers (7.9%).

In the middle panel of Table 1, we report the descriptive statistics for the SMEs

more structural production function approach (like the one we propose in this work) are not necessarily comparable to those of the alternative correlation approach.

[7] We have considered as outliers those firms in the upper and lower 1% of the productivity distribution and removed them from the complementarity analysis. This is quite standard in this literature. Nevertheless, including them would not have had any impact in the main results of the paper.

[8] We only consider those observations for the relevant variables that do not have missing data.

[9] We join these industries as they produce related outputs. After merging these sectors, industry 15 includes Beverage/Food and Tobacco; industry 17 includes Textiles, textile products, leather and footwear; and, industry 30 includes Manufacture of Office, accounting and computing machinery, Radio, TV and communications equipment.

[10] Due to low number of observations in the high tech sector, we merge it with the med-high tech sector. See Table A.1 in the Appendix to for the industry classification into technological sectors.

sample. Both in the low tech and med-low tech sectors, the percentage of observations that correspond to non-traders (more than 70%) is substantially larger than the percentage in the med-high tech sector. Furthermore, the percentages corresponding to firms involved in different active trading strategies are quite different across technological intensity sectors. In the low-tech sector, the percentage of observations that correspond to only-exporters (10.1%) almost doubles that corresponding to only-importers and two-way traders (5.2% and 5.7%, respectively). In the med-low tech sector, the percentages of observations that correspond to only-exporters, only-importers and two-way traders are quite similar (9.5%, 9.1% and 9.9%, respectively). Finally, in the med-high tech sector the percentage of observations corresponding to two-way traders (17.58%) is about 5 and 7 percentage points higher than those corresponding to only-exporters and only-importers, respectively.

In the bottom panel of Table 1, we can observe that large firms are much more likely to participate in international trade than SMEs (whereas the percentage of observations corresponding to non-traders for small firms is 73.5%, for large ones is 20.47%). Among large firms actively involved in international trade, regardless of the technological intensity sector, the prevalent trading strategy is both to import and export (for small firms involved in international trade, except in the med-low tech sector, the most common strategy is only-exporting). Further, it is interesting to highlight three interesting observational facts that relate firms' international trade strategies to the technological intensity sector in which firms operate: i) the percentage of observations corresponding to non-traders decreases as technological intensity increases; ii) the percentage of observations corresponding to two-way traders increases with technological intensity; and, iii) the percentage of observations corresponding to only-exporters and only-importers decreases with technological intensity.

All in all, we can conclude that internationalisation is not a widespread phenomenon among Colombian manufacturing firms, as less than one third of firms are involved in these activities. Moreover, it is interesting to note that the active participation in international trade is much more common among large firms than among small firms and that firms' trading strategies seem to be related to the technological intensity sector in which they operate.

Next, we use a simple regression analysis to identify some stylised facts about only-exporters, only-importers and two-way traders. The aim of these regressions is to investigate the link between firms' trading strategies and some basic firm's characteristics. With

Table 1: Share of trading strategies by technological intensity sectors

	All firms	Low	Med-Low	Med-High
All firms				
Only-exporter	10.75%	10.47%	9.91%	12.53%
Only-importer	6.83%	5.63%	8.96%	7.90%
$Two-way\text{-}trader$	13.74%	9.97%	15.27%	23.08%
Non-trader	68.68%	73.93%	65.86%	56.48%
SMEs				
Only-exporter	10.53%	10.13%	9.53%	12.58%
Only-importer	6.67%	5.23%	9.10%	10.02%
$Two-way\text{-}trader$	9.06%	5.73%	9.91%	17.58%
Non-trader	73.75%	78.91%	71.46%	59.83%
Large firms				
Only-exporter	14.87%	13.85%	13.72%	9.55%
Only-importer	9.73%	9.81%	7.47%	5.83%
$Two-way\text{-}trader$	69.79%	53.25%	68.89%	72.80%
Non-trader	20.47%	23.09%	9.92%	11.82%

this objective, we estimate the following reduced form equation:

$$log(y_{it}) = \beta_0 + \beta_{1,0}s(1,0)_{it} + \beta_{0,1}s(0,1)_{it} + \beta_{1,1}s(1,1)_{it} + \alpha log(size_{it}) + \sum_{j=2}^{19} \lambda_j ind_j + \sum_{t=2008}^{2016} \lambda_t year_t + \epsilon_{it} \quad (12)$$

where the dependent variable can be alternatively: output per worker, capital per worker, materials per worker and size (measured as the number of employees).[11] The variables $s(0,1)_{it}$,$s(1,0)_{it}$ and $s(1,1)_{it}$ represent firms' trading strategies, as defined above. We also include size, industry and year dummies as controls.[12]

The differences, in percentage, between only-exporters/only-importers/two-way traders and non-traders, computed from the estimated coefficients β_I (for $I = (1,0), (0,1), (1,1)$) as $100 \times (exp(\beta_I) - 1)$, indicate the average percentage differences for each of the four characteristics under analysis, once we control for industry, year and firms' size. Results of this regression analysis, shown in Table 2, suggest that firms actively involved in international trade are larger, more productive (in terms of output per worker) and more capital and materials intensive than non-traders. These significant differences provide empirical support to our decision of endogenizing the law of motion of productivity, to allow past trading experience to affect current productivity, when estimating productivity.

[11] See Table A.2 for the definition of the variables used in the analysis.

[12] We exclude size from the set of control variables when size is the dependent variable.

Table 2: Differences between exporters and importers

	Difference in % (Only exporters)	Difference in % (Only importers)	Difference in % (Both)
Output per worker	50.61***(0.012)	78.86***(0.013)	140.181***(0.012)
Capital per worker	36.98***(0.017)	72.27***(0.021)	167.56***(0.018)
Materials per worker	51.68***(0.014)	93.15***(0.015)	164.36***(0.014)
Size	136.37***(0.014)	143.28***(0.017)	617.05***(0.013)

Notes: 1. Robust standard errors are reported in parenthesis. 2. ***, **, * denote level of significance at 1%, 5% and 10 %, respectively.

4 Empirical results

In Table 3 we report the estimates of the revenue production function (1) together with the parameters associated to firms trading strategies (in the Markov process) that determine the evolution of firm's productivity (see equation 5). The top panel of Table 3 shows the elasticities of labour, materials and capital. The estimated elasticities are in line to those obtained in the literature, see Hall et al. (2010).[13]

The main objective of this paper is to explore the effects of different trading strategies on firms' productivity. As explained in the methodological section, the estimates of these effects are obtained directly from the Markov process coefficients of the corresponding trading strategy. The bottom panel of Table 3 presents the estimates of these effects. In column (1) we report the results for the full sample, and in columns (2) to (4) the breakdown by technological intensity sector. Since the omitted category is not trading ($s(0,0)$), the estimates for the trading strategies dummies should be interpreted taking this category as the reference category.

Results for the full sample provide evidence of a positive and significant effect of active trading strategies on productivity (in comparison to non-traders). Whereas the positive impact of only-exporting and only-importing is quite similar (6.4% and 5.9%, respectively), being a two-way trader pays higher rewards in terms of productivity (11.4%). These aggregated effects are concealing the differential effects we find when we analyse the impacts of trading strategies by technological breakdown. The breakdown by technological sector suggests that whilst in the low-tech sector the trading strategy that pays higher rewards in terms of productivity is only-importing (6.3%), in the med-low tech and

[13]Further, these elasticities are also similar to previous estimates using similar methods. See for example Añon et al. (2021), who estimate productivity using six different methods (a TFP Index, OLS, Cobb-Douglas assuming an exogenous and endogenous Markov process and Translog assuming an exogenous and endogenous Markov process). If anything is worth to be mentioned from our estimates is that the elasticities for capital, and especially those in the med-low sector, are somehow lower than expected.

in the med-high tech sectors the strategy that pays higher rewards is both exporting and importing (13% and 20%, respectively). It is also worth to note that the positive effect of only-exporting and both importing and exporting is increasing across the technological intensity of the industry in which the firm operates. Nevertheless, the highest effect of only-importing corresponds to firms operating in med-low tech industries.

Table 3: Effect of the trading strategies on firm productivity

	Full sample	Low	Med-Low	Med-High
Labour	0.274***(0.001)	0.250***(0.001)	0.236***(0.002)	0.263***(0.003)
Materials	0.871***(0.011)	0.830***(0.015)	0.865***(0.018)	0.948***(0.023)
Capital	0.063***(0.004)	0.061***(0.005)	0.045***(0.007)	0.082***(0.011)
trading strategies				
Only-Exporter, s(1,0)	0.064***(0.003)	0.042***(0.004)	0.069***(0.007)	0.120***(0.008)
Only-importer, s(0,1)	0.059***(0.004)	0.063***(0.006)	0.080*(0.007)	0.044***(0.010)
Two-way traders, s(1,1)	0.114***(0.003)	0.038***(0.005)	0.130***(0.006)	0.200***(0.007)
Observations	56,900	32,764	12,873	11,263

Notes: 1. The dependent variable is (log) gross output. 2. Robust standard errors are reported in parenthesis. 3. ***, **, * denote level of significance at 1%, 5% and 10 %, respectively.

Next, we use the estimated coefficients for firms' trading strategies (shown in Table 3) to formally test for complementarity/substitutability between trading strategies. With this aim, we define:

$$\hat{\delta} = \hat{\gamma}_{1,1} - \hat{\gamma}_{1,0} - \hat{\gamma}_{0,1} \tag{13}$$

where $\hat{\delta}$ measures the difference between the returns (in terms of productivity) of combining exporting and exporting (returns for two-way traders) and the sum of the returns of only-exporting and only-importing. Following Añón et al. (2018), we test for complementarities/substitutabilities using a two-step procedure. In the first step, we test whether $\hat{\delta}$ is statistically different from zero (two-sided test). If we reject the null of $\hat{\delta} = 0$, then we proceed to the second stage: if $\hat{\delta}$ is positive we test for complementarity (one-sided test); and, if it is negative, then, we test for substitutability (one-sided test). A positive and significant estimate for $\hat{\delta}$ should be considered as a sign in favour of the existence of complementarity between exporting and importing, i.e. the productivity returns of combining exporting and importing (as two-way traders do) are higher than the sum of the returns of only-importing and only-exporting. In contrast, a negative and significant estimate for $\hat{\delta}$ should be interpreted as evidence in favour of substitutability between exporting and importing: the sum of the productivity returns of only-importing and only-exporting outweigh those of combining exporting and importing.

Table 4: Testing for complementarity and substitutability

	Full sample	Low	Med-Low	Med-High
Complementary test				
$\hat{\delta}$	-0.009	-0.067	-0.021	0.035
$\chi^2(1)$	2.870	69.530	3.740	6.940
Two-sided test p-value	0.090	0.000	0.053	0.008
One-sided test p-value	0.045	0.000	0.026	0.004

Results of the tests of complementarity/substitutability are shown in Table 4. First, we show the value of $\hat{\delta}$ and the p-value corresponding to the null that $\hat{\delta} = 0$ (two-sided test). Second, dependent upon $\hat{\delta}$ being positive or negative, and statistically significant according to the p-value of the corresponding one-sided test, we will obtain evidence of complementarity or substitutability. In column (1) we report the result of the test for the full sample, and in columns (2) to (4) the breakdown by technological sectors.

For the full sample of firms, we find evidence of substitutability since $\hat{\delta}$ is negative and statistically significant. As for the technological intensity breakdown, we find also evidence of substitutability for the med-low and low tech intensity sectors. Nevertheless, in the med-high tech sector we find evidence of complementarity. Therefore, our results suggest that in Colombian manufacturing the existence of complementarity/substitutability between exporting and importing depends on the technological regime in which the firm operates: only in the med-high tech sector, importing and exporting are complementary activities, in terms of productivity.

As already pointed out in the introduction, the result of substitutability, between exporting and importing, in the low and med-low technological industries in Colombian manufacturing is not surprising. Many firms operating in these sectors in an emerging country, such as Colombia, are very likely to be short of internal resources and with difficulties to access external financing. This may imply that when a firm is already involved in a trading activity (exporting or importing), it may lack the ability to generate enough resources to efficiently set up a second trading activity. It may be even the case that they need to detract resources from the ongoing activity in order to start the new activity. This may bring forth negative consequences on firm productivity: on the one hand, without securing enough resources to perform a second trading strategy, it is difficult to profit from the benefits of importing, in case this second activity is importing, or from the benefits of exporting, in case it is exporting; on the other hand, detracting resources from the ongoing trading activity may halt the positive effects of this activity

on productivity.

Nevertheless, it seems that firms operating in Colombian med-high tech industries are less likely to have to detract resources from one trading activity when starting another. This would allow them to fully profit of productivity enhancement linked to exporting and importing.

To assess to what extent these results might be driven by firms being or not financially constrained, we have calculated a measure capturing indirectly if the firm is financially constrained. This measure is the proportion of the firm's operating income (or generated cash) to cover debts and profits. If the measure is negative, it means that the firm does not have cash availability to pay its debts or distribute profits, and if it is positive, quite the opposite. The higher the index, the more attractive the company is to financial creditors and shareholders, and therefore the higher will be the capacity of the firm to access to external finance too. Using this measure, we observe that both firms in the low and med-low sectors are more likely to suffer from financial constraints, as for both sectors the mean value of our financial index is negative (the mean value of this index for low and med-low tech sectors is -0.007 and -0.015, respectively). Contrarily, firms in the med-high tech sector are less likely to suffer from financial constraints as the mean value of our financial index for this sector is positive (0.006).[14] Therefore, this evidence gives support to the argument that being financially constrained seems to play a role in what are the international activities firms get involved, although we should recognise that there might exist other reasons.[15]

[14]Further, using a t-test we find that the values for the low and med-low sectors are not statistically different between them, but they are statistically different from the value of the med-high tech sector.

[15]Using the alternative (correlation) approach to test for complementarity/substitutability, mentioned above, we find evidence in favour of complementarity (regardless the technological intensity of the sector considered and whether firms are financially constrained), i.e. the productivity premium associated to two-way trading is significantly larger than that corresponding to the sum of the productivity premium of only-exporting and the premium of only-importing. In the low-tech sector we should necessarily find evidence in favour of complementarity since neither only-exporting nor only-importing render a positive productivity premium. The same happens with financially constrained firms in the med-high tech sectors. Notwithstanding, it is worth to remark that complementarity seems to be much stronger in the med-high tech sector than in the other two sectors. These results are somehow in agreement with the results presented in the paper following a more structural approach, in which we find evidence of substitutability for low-tech and med-low tech and of complementarity for med-high tech.

5 Concluding remarks

This paper sheds light on the existence of complementarities/substitutabilities between exporting and importing in the manufacturing sector of an emerging economy, namely Colombia. Our results suggest that whereas importing and exporting are substitutes (in terms of productivity) for low-tech and med-low tech industries, they are complements for med-high industries.

Our results suggest that Colombian firms operating in low and med-low tech sectors lack the resources to adequately combine exporting and importing. Should these firms start a second trading activity when they are already performing one, might imply that they lack the necessary resources to start up efficiently this second activity. In many cases, these firms will need to withdraw resources from the ongoing trading strategy. This poses two problems that may give rise to the observed substitutability between exports and imports: on the one hand, under investing in setting up the second activity may prevent firms from profiting from the benefits associated to importing, if the second activity is importing, or from the benefits associated to exporting, if it is exporting; on the other hand, detracting resources from the ongoing trading strategy may halt the productivity enhancement effects associated to this activity.

Firms in med-high tech sectors seem to be better suited to combine importing and exporting activities. Very likely for these firms it is easier to access the necessary resources to perform both activities efficiently. This would allow them to profit from the productivity enhancement effects of both activities, and would contribute to explain the pattern of complementarity between exports and imports observed for this group of firms.

With respect to the policy recommendations and managerial implications, our results suggest that firms operating in low and med-low tech sectors should concentrate their efforts in a single-activity trading strategy. Unless they are able to secure the minimum resources to efficiently start up a second trading strategy without withdrawing resources from the ongoing one, they should not get involved in a second trading strategy. Otherwise, it could have negative effects on productivity. The role of public policy is to ease these firms the access to the necessary resources to efficiently perform both activities. Evidence suggest that firms operating in med-high tech sectors that are endowed with these resources are able to profit from performing both trading activities jointly.

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Appendix

Table A.1: Industry classification by technological sector

Low tech industries
Food/Beverages/Tobacco
Manufacture of textiles
Tanning and Leather
Wood
Paper
Furniture
Publishing
Med-low tech industries
Coking of refined petroleum
Rubber and Plastic
Non-Metallic Mineral Products
Metallurgical Products
Metal products
Med-high tech industries
Chemical
Machinery and equipment
Manufactures of Office
Machinery and Electrical Appliance
Instrument Making Medical
Motor Vehicles
Ships and boats

Table A.2: Variables definition

Variable	**Definition**
Output	Production in revenue terms deflated using firm level price deflators.
Labour	The number of hired workers per year.
Capital	Real value of the stock of capital measured using the perpetual inventory method.
Materials	Real value of intermediate materials.
Only-exporter,$s(1,0)$	Dummy variable that takes the value of 1 if the firm exports output but does not import intermediate materials in period t, and 0 otherwise.
Only-importer,$s(0,1)$	Dummy variable that takes the value of 1 if the firm imports intermediates but does not export output in period t, and 0 otherwise.
Two-way trader,$s(1,1)$	Dummy variable that takes the value of 1 if the firm imports intermediates and exports output in period t, and 0 otherwise.
Non-trader,$s(0,0)$	Dummy variable that takes the value of 1 if the firm neither imports intermediates nor exports output in period t, and 0 otherwise.
TFP	Total Factor Productivity estimated as per equation (9)