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

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Abstract

The aim of this paper is to investigate the impact of two trading strategies (exporting and importing) on total factor productivity (TFP) and the potential complementarity/substitutability effects of these strategies. In order to assess these effects, robust estimates of TFP are obtained using a general method of moments approach that explicitly determines the ability of a firm's trading experience to affect productivity. Data from the Annual Manufacturing Survey spanning from 2007 to 2016 is used for Colombian manufacturing firms. Our estimation results suggest that, regardless of the technological intensity of the industry in which the firm operates, active trading strategies (exporting only, importing only, both importing and exporting) pay positive rewards in terms of productivity. Nevertheless, whilst positive (complementary) synergies are found 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
complementarity, export, imports, productivity, substitutability

1 | INTRODUCTION

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

In order to test for complementarity/substitutability between the exporting and importing strategies, a two-stage procedure is employed. In the first stage, a modified version of the generalized method of moments estimator is used as 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, Rochina-Barrachina, et al. (2020) (for exports and imports), a more general law of motion of productivity is considered in which a set of dummy variables that fully characterize the firms' past internationalization strategies are included. In the second stage, the coefficient estimates of the internationalization strategies are employed to test for complementarity/substitutability between internationalization choices (importing and/or exporting) while using the structural methodology suggested by Carree et al. (2011), which was previously applied in Añón et al. (2018). Moreover, we analyze whether the effect of firms' internationalization strategies on productivity depends on the technological regime in which the firm operates. Our analysis is thereby broken down into the technological intensity of the sectors, in accordance with the OECD classification (Hatzichronoglou, 1997).

The empirical analysis is performed with an unbalanced sample of Colombian manufacturing firms extracted from the Annual Manufacturing Survey (EAM) for the period 2007–2016. The analysis of the impacts on productivity of firms' trading strategies for an emerging country such as Colombia is especially interesting. Typically, in emerging countries, a disproportionate number of firms are SMEs (91% in the case of Colombia). Since these firms are more likely to suffer from financial constraints and probably from further limitations, the need to detract resources from a trading strategy (either importing or exporting) when starting another strategy, may give rise to a pattern of substitutability between exporting and importing.

The analysis of complementarity/substitutability between exporting and importing requires acknowledging that both trading activities may have direct and indirect effects on productivity and that both are subject to sunk costs. Direct and indirect effects are introduced in turn. The potential gains in productivity that stem from export participation are considered to be direct effects of exporting on productivity. These productivity gains are usually associated to growing sales that enable firms to profit from economies of scale, from knowledge flows from foreign customers (in the form of innovations that help to reduce costs and/or improve

the quality of the firm's products), and also from increased competition in export markets, thereby forcing exporters to become more efficient (Crespi et al., 2008; Máñez et al., 2010; Manjón et al., 2013). We first consider the direct effects on productivity of importing inputs. Importing intermediate inputs can result in productivity increases if they enable firms: to access a wider variety of inputs, and/or inputs of higher quality and lower price (mainly in developed countries); to adopt or imitate new technologies from foreign markets; and to obtain knowledge embodied in imported inputs (Bekes & Altomonte, 2009; Halpern et al., 2015). This last possibility is especially relevant for firms in emerging economies. The empirical evidence on the impact of importing intermediate inputs on productivity is both scarce and yields mixed results. Van Biesebroeck (2008) using Colombian data, finds that productivity growth is correlated more strongly with a firm's export status than with the use of imported inputs; similarly, Muendler (2004) finds a small contribution of foreign materials and investment goods on output, in Brazil. In contrast, Kasahara and Rodrigue (2008), Amiti and Konings (2007), and Halpern et al. (2015) find that importing intermediate inputs exerts a positive effect on firms' productivity in Chile, Indonesia, and Hungary, respectively.

As for indirect effects, these are assumed to be the effects of firms' exporting (importing) strategies that contribute to productivity through their possible enhancing effects on the probability of importing (exporting). Should exporting (importing) result in productivity gains and reduce the sunk costs associated to start importing (exporting), then exporting (importing) firms will be more likely to start importing (exporting) than firms without previous exporting (importing) experience.

As for the sunk costs, Aristei et al. (2013) point out that several 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, and taxation, among others, allows firms to gain expertise in the international markets that will probably contribute towards reducing the sunk costs when first selling output abroad or importing intermediate inputs (Kasahara & Lapham, 2013). Additionally, as pointed out by Aristei et al. (2013) and Albornoz and Garcia-Lembergman (2019), the new contacts among exporters might create new information channels that provide an incentive for high-quality inputs to be imported to improve the characteristics of the products that the 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 most productive firms might engage in importing (exporting). Complementarities between a firm's importing and exporting activities (in terms of higher productivity) stem from these indirect effects, which contribute towards reinforcing the possible positive effects on productivity of having already performed only one of the two trading strategies considered.

Nevertheless, the step of becoming a two-way trader when the firm is exporting-only or importing-only 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 fewer resources to accessing a lower price and/or higher-quality inputs and that it enjoys fewer possibilities to learn about new technologies from foreign markets. It might also reduce the likelihood of attaining knowledge embodied in foreign inputs. The consequence is that the possibilities of profiting from importing become diluted. Furthermore, if the detraction of resources from its importing activities means that the firm is unable 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, then the possible consequences include a reduction in the possibilities of profiting from economies of scale since foreign sales may suffer, and knowledge flows from foreign customers would be less likely. Therefore, withdrawing resources from exporting activities in order to allocate them to start importing might imply a reduction in the firm's possibilities of benefiting from exporting. Moreover, if, after withdrawing resources from exporting, the firm remains unable to obtain sufficient resources to start a successful importing activity, then it will find it 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, a substitutability relationship between exporting and importing may arise.

Experiencing a limited availability of resources to start importing (exporting) when the firm is already exporting (importing) or the need to withdraw resources from exporting (importing) to start importing (exporting) may be common occurrences among SMEs that operate in emerging countries. Small and medium-sized enterprises in emerging countries are very likely to be short of internal resources and to face difficulties in accessing external financing.

In recent years, several studies, such as Bernard et al. (2009), Bernard et al. (2007), Muûls and Pisu (2009), Aristei et al. (2013), and Máñez, Rochina-Barrachina, et al. (2020), have recognized the linkages between the exporting and importing activities of firms. However, only a scarce number of empirical studies have simultaneously explored the effects of importing intermediate inputs and exporting on productivity at the firm level. Among these, Kasahara and Lapham (2013) and Máñez, Rochina-Barrachina, et al. (2020) deserve mention. Kasahara and Lapham (2013) propose a model with producers of heterogeneous final goods who simultaneously choose whether to export their output and whether to use imported intermediate inputs. These authors estimate a structural model with Chilean plant-level data that confirms that there are aggregate productivity and welfare gains due to trading in both final goods and intermediate inputs. Máñez, Rochina-Barrachina, et al. (2020) estimate total factor productivity (TFP, hereinafter) by using a modified version of the control approach method (see Levinsohn & Petrin, 2003; Olley & Pakes, 1996), in which they allow past import and export experience to affect productivity. They subsequently incorporate this estimated TFP as the dependent variable of an equation in which they analyze the impact of importing and exporting on productivity while explicitly recognizing the existence of productivity persistence. Their results suggest that, whereas SMEs benefit both from performing exporting and importing activities in terms of productivity, large firms only benefit from importing.

In order to anticipate our main results, our analysis uncovers that it is the technological regime in which the firm operates that dictates whether exporting and importing are complements or substitutes in terms of productivity. In low-tech and med/low-tech sectors, exporting and importing appear to be substitutes in terms of productivity; in the med/high-tech sector however, our estimations suggest they are complements. One reason behind this differential result is that most of the companies in the low-tech and med/low-tech sectors have no access to the necessary resources to efficiently start a second trading strategy, or that in order to start the new trading activity, they have to reduce the volume of resources devoted to the current trading activity. 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 discusses estimation methods. Section 3 describes the data and Section 4 presents the empirical results. Finally, Section 5 presents the conclusions.

2 | EMPIRICAL STRATEGY

2.1 | Production function

In order to capture substitutability and complementarity among different trading strategies, it is assumed that firms produce homogeneous goods using 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 a 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 the firm's productivity that is not observable to the econometrician but remains observable or predictable by the firm, and η_{it} is a standard *i.i.d.* error term that is neither observed nor predicted by the firm. It is also assumed that capital is a state variable, whereas the total number of hours of labor and intermediate materials constitutes variable factors.

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

In the first equation, to solve the problem of endogeneity of labor and materials, we follow Levinsohn and Petrin (2003) and use the demand for materials, $m_{it} = m_t(k_{it}, \omega_{it})$, as a proxy for unobserved productivity. Under the *scalar unobservable assumption* and the *monotonicity assumption*, the demand of materials can be inverted and productivity can be expressed 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}. By substituting (2) in (1), the first estimation equation of the GMM system is obtained:

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

Since the proxy for h_t is 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 a firm's past export and import experience affecting current productivity. To solve this problem, in a similar way to that employed by Máñez, Mínguez Bosque, et al. (2020) and Máñez, Rochina-Barrachina, et al. (2020), we consider a more general (endogenous) Markov process in which not only does ω_{it} depend on ω_{it-1} but it also depends

on the firm's past import and export experience captured by a set of dummy variables fully character-ising the firm's 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 theoretically consistent treatment should be to include them directly in the law of motion of productivity. Omission of these variables may cause biased estimations of the production function coefficients. Nevertheless, it should be borne in mind that allowing these variables to exert an effect on productivity does not imply assuming that they do indeed exert any influence. Thus, widening the law of motion of productivity to include a firm's trading strategies does not imply the assumption of a particular effect of importing or exporting on productivity. We therefore consider the following law of motion of productivity:

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

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

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

where $g_t\left(k_{it-1}, m_{it-1}\right) = f(h_t\left(k_{it-1}, m_{it-1}\right))$ is an unknown function whose proxy is 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:

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

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

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

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

$$\omega_{it}^j = y_{it}^j - \beta_l^j l_{it} - \beta_k^j k_{it} - \beta_m^j m_{it} \tag{9}$$

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

In order to test for complementarity/substitutability between importing and exporting, we use the production function approach explained in Carree et al. (2011).[5] For the implementation

of the test, we take the set of parameters γ introduced in the law of motion of productivity to characterise 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 the following inequality to strictly hold:

$$H_0: \gamma_{(1,1)} - \gamma_{(1,0)} - \gamma_{(0,1)} > 0 \qquad (10)$$

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 exporting-only and importing-only. Conversely, the null hypothesis of substitutability between importing and exporting would imply:

$$H_0: \gamma_{(1,1)} - \gamma_{(1,0)} - \gamma_{(0,1)} < 0 \qquad (11)$$

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

3 | DATA AND DESCRIPTIVE ANALYSIS

In order to analyze complementarity/substitutability between importing and exporting strategies on productivity, Colombian manufacturing data extracted from the Annual Manufacturing Survey (EAM) for the period 2007–2016 is used.[7] Firms with missing data on key variables are removed from the sample, as well as several outliers.[8] We end up with an unbalanced panel data with 71,825 observations corresponding to 10,863 firms.[9] Furthermore, due to the small number of observations in specific sectors, we merge certain sectors as follows: industry 15 with industry 16; industry 17 with industry 18; and, industry 30 with industry 32.[10] There are therefore 19 industries that are classified into three technological intensity sectors, in accordance with the OECD technological intensity classification (ISIC Rev. 3) (Hatzichronoglou, 1997).[11]

We subsequently focus on the patterns of firms' trading strategies. Table 1 displays several descriptive statistics for the trading strategies, in terms of technological intensity sector and firm size.

In the top panel of Table 1, the descriptive statistics are reported for the full sample of firms. It can be observed that the majority of firms are not actively involved in international trade activities (approximately 69% of the observations correspond to firms that neither export nor import). Furthermore, for the full sample, observations that correspond to two-way traders (13.7%) exceed those that correspond to exporting-only and importing-only (10.8% and 6.8%, respectively). These figures are similar across the different technological intensity sectors except for the med/high-tech sector. For this sector, the percentage of observations corresponding to two-way traders (23.1%) more than doubles that corresponding to exporting-only (12.5%) and it is almost four times larger than the percentage corresponding to importing-only (7.9%).

In the middle panel of Table 1, the descriptive statistics for the sample of SMEs are reported. 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 the various active trading strategies differ across technological intensity sectors. In the low-tech sector, the percentage

TABLE 1 Share of trading strategies per technological intensity sector

	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-trader	13.74%	9.97%	15.27%	23.08%
Non-trader	68.68%	73.93%	65.86%	56.48%
SMEs				
Only-exporter	10.52%	10.13%	9.53%	12.58%
Only-importer	6.67%	5.23%	9.10%	10.02%
Two-way-trader	9.06%	5.73%	9.91%	17.58%
Non-trader	73.75%	78.91%	71.46%	59.83%
Large firms				
Only-exporter	13.23%	13.85%	13.72%	9.55%
Only-importer	7.57%	9.81%	7.47%	5.83%
Two-way-trader	61.88%	53.25%	68.89%	72.80%
Non-trader	17.32%	23.09%	9.92%	11.82%

of observations that correspond to exporting-only (10.1%) almost doubles that corresponding to importing-only and two-way traders (5.2% and 5.7%, respectively). In the med/low-tech sector, the percentages of observations that correspond to exporting-only, importing-only, and two-way traders are 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 approximately 5 and 7 percentage points higher than those corresponding to exporting-only and importing-only, respectively.

In the bottom panel of Table 1, it can be observed that large firms are much more likely to participate in international trade than are SMEs (while the percentage of observations corresponding to non-traders for small firms is 73.5%, for large firms this figure is 17.32%). For large firms actively involved in international trade, regardless of the technological intensity sector, the prevalent trading strategy is both to import and to export (for small firms involved in international trade, except in the med/low-tech sector, the most common strategy is exporting-only). Furthermore, there are 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 exporting-only and importing-only decreases with technological intensity.

All in all, we can conclude that internationalization is not a widespread phenomenon among Colombian manufacturing firms, since 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.

A simple regression analysis is now employed to identify certain stylized facts about exporting-only, importing-only, and two-way traders. The aim of these regressions is to investigate the link

between firms' trading strategies and several basic characteristics of a firm. To this end, the following reduced-form equation is estimated:

$$
\log\left(y_{it}\right) = \beta_0 + \beta_{1,0}s(1,0)_{it} + \beta_{0,1}s(0,1)_{it} + \beta_{1,1}s(1,1)_{it} + \alpha\log\left(\text{size}_{it}\right) +
$$
$$
\sum_{j=2}^{19} \lambda_j \text{ind}_j + \sum_{t=2008}^{2016} \lambda_t \text{year}_t + \epsilon_{it} \tag{12}
$$

where the dependent variable can be alternatively: output per worker, capital per worker, materials per worker, and size (measured as the number of employees).[12] The variables $s(0,1)_{it}$, $s(1,0)_{it}$, and $s(1,1)_{it}$ represent trading strategies of firms, as defined above. Size, industry, and year dummies are also included as controls.[13]

The differences, as a percentage, between exporting-only, importing-only, two-way traders, and non-traders, computed from the estimated coefficients β_I (for $= (1,0)$, $(0,1)$, $(1,1)$) as $100 \times \left(\exp\left(\beta_I\right) - 1\right)$, indicate the average percentage differences for each of the four characteristics under analysis, once we control for industry, year, and size of the firm. 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-intensive and material-intensive than non-traders. These significant differences provide empirical support to our decision to endogenize the law of motion of productivity, in order to allow past trading experience to affect current productivity, when estimating productivity.

4 | EMPIRICAL RESULTS

In Table 3, the estimates of the revenue production function (1) are reported together with the parameters associated to the trading strategies of firms (in the Markov process) that determine the evolution of a firm's productivity (see Equation 5). The top panel of Table 3 shows the elasticities of labor, materials, and capital. The estimated elasticities are in line with those obtained in the literature; see Hall et al. (2010).[14]

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

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

TABLE 3 Effect of the trading strategies on firm productivity

	Full sample	**Low**	**Med/-Low**	**Med/High**
Labor	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				
Exporting-only, s(1,0)	0.064*** (0.003)	0.042*** (0.004)	0.069*** (0.007)	0.120*** (0.008)
Importing-only, 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 parentheses. 3. ***, **, * denote levels of significance at 1%, 5%, and 10%, respectively

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), the results for the full sample are reported, while in columns (2) to (4), the breakdown is given for each technological intensity sector. Since the omitted category is not trading ($s(0,0)$), the estimates for the trading strategy dummies should be interpreted by 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 exporting-only and importing-only is similar (6.4% and 5.9%, respectively), a two-way trader is paid higher rewards in terms of productivity (11.4%). These aggregated effects conceal the differential effects found when the impacts of trading strategies are analyzed by technological breakdown. The breakdown by technological sector suggests that, in the low-tech sector, the trading strategy that pays the highest rewards in terms of productivity is importing-only (6.3%), whilst in the med/low-tech and in the med/high-tech sectors, the strategy that pays the highest rewards is that of both exporting and importing (13% and 20%, respectively). It is also worth bearing in mind that the positive effect of exporting-only and both importing and exporting increases across the technological intensity of the industry in which the firm operates. Nevertheless, the highest effect of importing-only corresponds to firms operating in med/low-tech industries.

The estimated coefficients for the trading strategies of firms (shown in Table 3) are now employed to formally test for complementarity/substitutability between trading strategies. To this end, 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 importing (returns for two-way traders) and the sum of the returns of exporting-only and importing-only. Following Añón et al. (2018), we test for complementarities/substitutabilities using a two-step procedure. In the first step, it is determined whether $\hat{\delta}$ is statistically different from zero (two-sided test). If the null hypothesis of $\hat{\delta} = 0$ is rejected, then we proceed to the second stage: if $\hat{\delta}$ is positive, then the complementarity is tested (one-sided test); and if it is negative, then the substitutability is tested (one-sided test). A positive and significant estimate for $\hat{\delta}$ should be considered as a sign in favor of the existence of complementarity between exporting and importing, that is, the productivity returns of combining

exporting and importing (as two-way traders do) are greater than the sum of the returns of importing-only and exporting-only. In contrast, a negative and significant estimate for $\hat{\delta}$ should be interpreted as evidence in favor of substitutability between exporting and importing: the sum of the productivity returns of importing-only and exporting-only outweighs the return of combining exporting and importing.

The results of the tests of complementarity/substitutability are given in Table 4. First, the value of $\hat{\delta}$ is shown together with the p-value corresponding to the null hypothesis that $\hat{\delta} = 0$ (two-sided test). Second, evidence is obtained regarding complementarity or substitutability, which is dependent upon $\hat{\delta}$ being positive or negative, and statistically significant according to the p-value of the corresponding one-sided test. In column (1), the result of the test for the full sample is reported, and in columns (2) to (4) the breakdown by technological sectors is given.

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, evidence is also found of substitutability for the med/low-tech and low-tech intensity sectors. Nevertheless, in the med/high-tech sector, evidence is found 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 are importing and exporting complementary activities in terms of productivity.

As pointed out in the introduction, the result of substitutability, between exporting and importing, in the low and med/low-technological industries in Colombian manufacturing comes as no surprise. Many firms operating in these sectors in an emerging country, such as Colombia, are very likely to be short of internal resources and to experience difficulties in accessing 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 sufficient resources to efficiently set up a second trading activity. It may even be 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 thereof; 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 from productivity enhancement linked to exporting and importing.

In order to assess to what extent these results might be driven by whether firms are financially constrained, we have calculated a measure which indirectly captures whether the firm

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	.090	.000	.053	.008
One-sided test p-value	.045	.000	.026	.004

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 lacks available cash to pay its debts or distribute profits; however, if it is positive, the opposite occurs. The higher the index, the more attractive the company is to financial creditors and shareholders, and therefore the higher the capacity of the firm will be to access external finance. Using this measure, that firms in both the low-tech and in the med/low-tech sectors are observed to be more likely to suffer from financial constraints, since the mean value of our financial index is negative for both sectors (the mean value of this index for low-tech and med/low-tech sectors is −0.007 and −0.015, respectively). In contrast, firms in the med/high-tech sector are less likely to suffer from financial constraints, since the mean value of our financial index for this sector is positive (0.006).[15] Therefore, this evidence gives support to the argument that being financially constrained apparently plays a role regarding the choice of international activities with which firms become involved, although it should be recognized that there might exist other reasons.[16]

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 that of 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 such activity, evidence suggests that they may lack the necessary resources to efficiently start up 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-investment in setting up the second activity may prevent firms from profiting from such an activity; 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 combining importing and exporting activities. It is highly likely that, 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 towards explaining 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-tech and med/low-tech sectors should concentrate their efforts in a single-activity trading strategy. Unless these firms are able to secure the minimum resources to efficiently start up a second trading strategy without withdrawing resources from the ongoing activity, they should not become involved in a second trading strategy, since it could trigger negative effects on productivity. The role of public policy is to facilitate access to the necessary resources so that these firms may efficiently perform both activities. Evidence suggests that firms operating in med/high-tech sectors that are endowed with these resources are able to profit from performing both trading activities jointly.

DATA AVAILABILITY STATEMENT

Microdata is available from the Colombian National Statistical System. https://www.dane.gov.co/index.php/en/statistics-by-topic-1/industry/annual-manufacturing-survey.

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ENDNOTES

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

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

[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.

[5] Since we include firms' import and export strategies as additional variables in the law of motion of productivity, as does De Loecker (2013), and not as additional inputs in the production function, this procedure appears to be more suitable.

[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 the firm's 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 importing-only strategy ($s(1,0)_{it}$), the exporting-only strategy ($s(0,1)_{it}$), or is a two-way trader ($s(1,1)$), and a vector of control variables (z_{it}). Thus the equation to estimate would be:

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

A test for complementarity would amount to verifying whether the productivity premium associated to both importing and exporting is higher than the sum of the productivity premium of importing-only and the premium of exporting-only. Nevertheless, it is important to note that the results obtained using a more structural production function approach (like the approach proposed in this work) are not necessarily comparable to those of the alternative correlation approach.

[7] Microdata are available from the Colombian National Statistical System. https://www.dane.gov.co/index.php/en/statistics-by-topic-1/industry/annual-manufacturing-survey.

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

[9] Only those observations for the relevant variables that have no missing data are considered.

[10] These industries are joined since 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 Manufacturers of Office Equipment, accounting and computing machinery, Radio, TV and communications equipment.

[11] Due to low number of observations in the high-tech sector, we merge it with the med/high-tech sector. See Table A1 in the Appendix for the industry classification into technological sectors.

[12] See Table A2 for the definition of the variables used in the analysis.

[13] Size is excluded from the set of control variables when size is the dependent variable.

[14] Furthermore, these elasticities are also similar to previous estimates using similar methods. See for example Añón 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). It is worth mentioning from our estimates that the elasticities for capital, and especially those in the med/low-tech sector, are somehow lower than expected.

[15] Furthermore, by means of a *t*-test, the values for the low-tech and med/low-tech sectors are not found to be statistically different from each other, although they are statistically different from the value of the med/high-tech sector.

[16] In the Online Appendix, we show the results obtained using the alternative correlation approach to test for complementarity/substitutability, based on the estimation of a translog production function (equation A1). Table A1 presents the estimates of the input elasticities and average log TFP for the 19 industries for which we estimate the Translog production function. Based on TFP estimates we estimate the productivity premia for financially and non-financially constrained firms in the low-tech, med/low-tech and med/high-tech industries using equation (A3). See results in Figure A1. Finally, using equation (A4) for non-financially constrained firms and (A5) for financially constrained firms, we test for complementarity/substitutability between trading strategies (see results in Table A2). We find evidence in favor of complementarity, regardless of the technological intensity of the sector considered and whether firms are financially constrained. In other words, the productivity premium associated to two-way traders is significantly larger than that corresponding to the sum of the productivity premium of exporting-only and the premium of importing-only. In the low-tech sector we should necessarily find evidence in favor of complementarity since neither exporting-only nor importing-only render a positive productivity premium. The same happens with financially constrained firms in the med/high-tech sectors. Notwithstanding, it is worth mentioning that complementarity seems to be much stronger in the med/high-tech sector than in the other two sectors. These results are 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 sectors, and evidence of complementarity for the med/high-tech sector.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

APPENDIX

TABLE A1   Industry classification per 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
Manufacturers of office equipment
Machinery and electrical appliances
Medical instrument manufacture
Motor vehicles
Ships and boats

TABLE A2 Variables and their definition

Variable	Definition
Output	Production in terms of revenue deflated using firm level price deflators
Labor	The number of hired workers per year
Capital	Real value of the capital stock measured using the perpetual inventory method
Materials	Real value of intermediate materials
Exporting-only, $s(1, 0)$	Dummy variable that takes the value 1 if the firm exports output but does not import intermediate materials in period t, and 0 otherwise
Importing-only, $s(0, 1)$	Dummy variable that takes the value 1 if the firm imports intermediate inputs but does not export output in period t, and 0 otherwise
Two-way trader, $s(1, 1)$	Dummy variable that takes the value 1 if the firm imports intermediate inputs and exports output in period t, and 0 otherwise
Non-trader, $s(0, 0)$	Dummy variable that takes the value 1 if the firm neither imports intermediate inputs nor exports output in period t, and 0 otherwise
TFP	Total factor productivity estimated as per Equation (9)