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Why are exports not generating a positive effect on Colombian labor productivity? Evidence from the Colombian manufacturing sector (2005-2015)

¿Por qué las exportaciones no están generando un efecto positivo en la productividad laboral de Colombia? Evidencia empírica del sector manufacturero colombiano (2005-2015)

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Abstract

The following article presents the causal relationship analysis between labor productivity and exports in the Colombian manufacturing sector for 2005-2015, where the effect and consequences of the hypothesis of self-selection and learning by exporting are studied. The purpose of this research is to gather empirical evidence that proves the positive impact of foreign sales on the rise of labor productivity, through a data panel model with the microdata available for the Colombian manufacturing sector during the studied period. The results show significant empirical evidence that argues for the self-selection effect hypothesis in Colombian exporting firms, where only companies with better productivity indices can face entry costs to the international market. Finally, the conclusions and recommendations are centered on generating policies focused on export offer diversification and increased R&D investment.

Keywords: export, labor productivity, manufacturing sector, learning by exporting, self-selection.

Resumen

El presente artículo presenta un análisis de la relación causal existente entre la productividad laboral y las exportaciones en el sector manufacturero colombiano para el periodo 2005-2015, en donde se estudian los efectos y consecuencias de las hipótesis de *self-selection* y *learning by exporting*. El objetivo de la presente investigación es obtener evidencia empírica que argumente el impacto positivo de las exportaciones sobre el incremento en la productividad laboral a través de la implementación de un modelo de panel de datos con los microdatos disponibles para el sector manufacturero colombiano en el periodo descrito. Los resultados obtenidos muestran evidencia empírica significativa que argumenta el efecto de autoselección de las firmas exportadoras, en donde solo aquellas empresas con mejor índices de productividad son capaces de afrontar los costos de entrada presentes en el mercado internacional. Finalmente, se muestran recomendaciones para la generación de políticas enfocadas en la diversificación de la oferta exportadora del país y el incremento en las inversiones en I+D.

Palabras clave: exportaciones, productividad laboral, sector manufacturero, self-selection, learning by exporting.

JEL classification: F14; F16.

Introduction

The analysis of labor productivity and the export dynamic in the manufacturing sector has acquired a certain interest in economic research, due to the rise of the sector and its incursion in the evolution of technological industry on the economies of developed countries, allowing for a clearer picture of the development level in terms of productivity, industrialization, and export index (World Bank, 2019).

In general terms, the objective of this research is to show the impact generated by exports on the dynamics of labor productivity in the Colombian manufacturing sector, to analyze the behavior of productivity and the process of technology transfer in the manufacturing industry, and to stimulate the economic policy generation focused on the export supply diversification, which enables increasing the manufacturing industry participation in the output of the economy.

Considering the objective of the research, it is necessary to analyze the differentiation in the labor productivity index between exporting and non-exporting firms, by using the hypothesis test of Learning by Exporting and Self-section, which describe the causal relationship between labor productivity and international sales in the manufacturing sector, to encourage the growth of foreign trade of industrial establishments. Besides, the 2005-2015 period is studied due to the external shocks that significantly affect the productivity index and the export dynamic of the Colombian manufacturing sector.

The research added value lies in obtaining significant results that support the studied hypotheses, due to the fact that the research carried out for the causal relationship analysis between productivity and exports in the Colombian manufacturing sector focuses on macroeconomic aspects and the geographical locations of industrial activity (Barrientos & Lotero , 2010); on the other hand, Fernandez (1998) studies the impact of exports on the agglomeration processes of the Colombian industry, as he analyzes the effect of internal logistics costs, and their impact on the entry cost to international markets. Finally, the research approach developed by Giraldo (2015), regarding sunk costs and market entry to the Colombian manufacturing sector.

For the testing process of the learning by exporting and Self-selection hypotheses, certain techniques will be used for a data panel analysis, through the fixed effects methodology and the estimator developed by Arellano & Bond (1991) for dynamic panel data, where the instrumental variables estimator is integrated. The purpose of applying the panel data model is to capture the unobservable heterogeneity between individuals throughout the study period, since heterogeneity cannot be detected with time series studies. For this reason, this technique allows for a more dynamic analy-

sis, by incorporating the temporal dimension of the data, which generates added value to the study, particularly over long periods (greater than 10 years) (Mayorga & Muñoz, 2000).

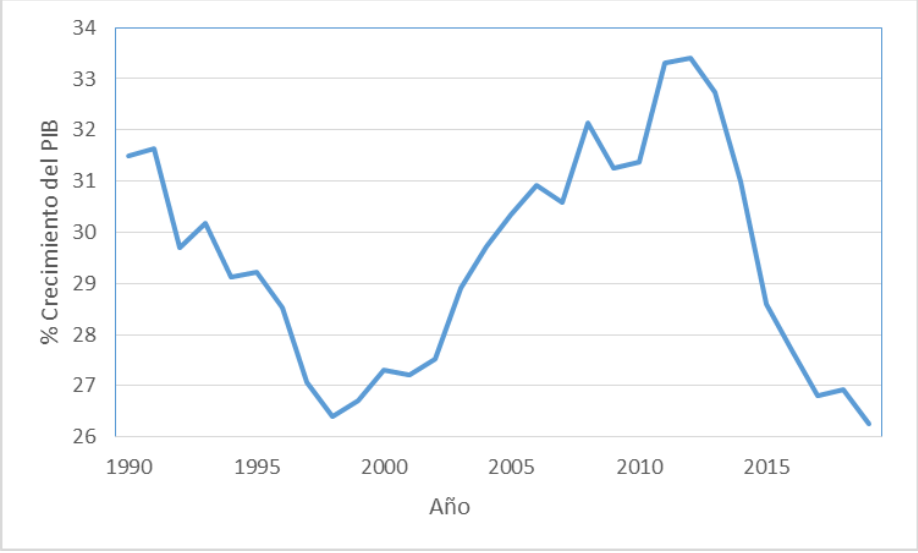
The empirical evidence supports the positive effect that the export effect has on the increase in labor productivity indices of firms, where it is observed that the levels of labor productivity increase in Colombian manufacturing firms that decide to export, compared to firms that only focus on the domestic market.

Finally, the document is structured as follows: the first part corresponds to the introduction; the second part analyses the Colombian manufacturing generalities, a brief literature review, and the methodological framework. In the third part, the results of the empirical model are analyzed, and the conclusions are presented.

Colombian manufacturing sector overview

The Colombian manufacturing industry has presented a significant drop in the industrial growth index from the economic opening experienced of the 1990s (Garcia, 2002). In graph 1, the dynamics of the added value of Colombian industry is showed, where it can be observed that the year 2009 stands out, as it registers a considerable fall, caused by the global financial crisis at the end of 2008, the moderate growth of the economy of the United States and China, a decrease in the real average rate of manufacturing industry net production around -3.5%, and a fall in the exports index of -3.6%.

Graph 1: Value Added Index (% of GDP) for Colombia

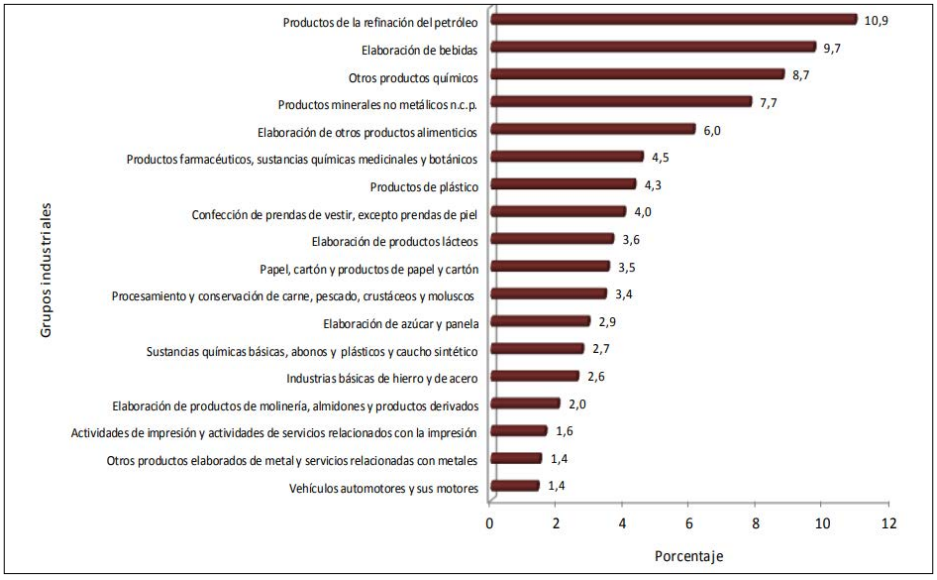


Source: National Accounts World Bank. Open data panel.

The slowdown in the Colombian manufacturing industry was accentuated due to external shocks, which drastically affected the dynamics of the national economy through different transfer mechanisms, of which the most relevant was the abrupt fall in international prices of commodities, especially the Brent oil reference price, which stood at less than $50 USD/barrel in 2014. This implies a significant decrease in national income from exports and foreign direct investment that generated a fiscal deficit in the Colombian economy (Banco de la República, 2016).

On the other hand, graph 2 shows the industrial groups with the highest share of industrial added value in Colombia, on average, for the 2005-2015 period. It can be inferred that the subsectors associated with the transformation of natural resources are those with the best added-value index, the best index of labor productivity, and the highest investment rate in capital stock.

Graph 2: Participation of industrial subsectors in the added value for Colombia (average 2005-2015)



Source: Boletín Técnico. Encuenta Annual Manufacturera (DANE, 2015)

Besides, it is evident that the industrial subsectors with high technological incorporation, such as the basic iron and steel industry, the chemical and pharmaceutical subsector, as well as the assembly and manufacture of motor parts, vehicles and engine manufacturing, present a low rate in the industrial added value participation and a significant loss in productivity rates (Clavijo, et al., 2012). This loss of dynamism is product of financial resources migration towards the mining and oil industry experienced by the Colombian economy.

Taking into account the current situation of the Colombian manufacturing sector, the National Government *and Ministerio de Comercio, Industria y Turismo* seek to promote public policy strategies focused on promoting a change in the productive structure of the economy and export diversification towards the goods of the manufacturing industry which have higher added value.

To achieve this objective, the Colombian government proposes the development of the manufacturing industry through the implementation of public spending policy reform, starting in 2012, where the goal is to stimulate investment in research and development (R&D) and to increase the capital stock through Law 1530 of 2012 (Secretaria del Senado, 2020). This law corresponds to the budget regulation of the *Sistema Regional de Regalías*, which is the mechanism for investment in physical infrastructure and connectivity, R&D, and investment in education and production process innovation, where the priority of this public policy is to increase the development of scientific knowledge and the implementation of technological development in the national industrial sector.

Regarding the Colombian manufacturing exports, they presented a deficit in their trade balance; in graph 3, it is possible to appreciate the dynamics of Colombian exports.

Graph 3: Export growth rate by industrial sector in Colombia (2006-2015)

Source: *Base de datos de exportaciones Departamento Nacional de Estadística de Colombia* (DANE) .

According to the export report of the *Departamento Nacional de Estadística* (DANE, 2015), Colombian manufacturing sector international sales presented a fall of -11%, equivalent to $1,135 million dollars in 2015, as a result of the moderate growth of the Chinese and the European Union economies, specifically the German economy, which

presented a decrease of 2.3%. On the other hand, exports to Latin America showed a loss in their dynamism, due to the lower growth of the aggregate demand for manufactured and intermediate goods from Brazil, Chile, and Argentina, which had a drop of 8%, on average.

In general terms, Colombian foreign sales decreased by 32.5% in 2015, where oil and gas exports registered a 46.8% drop (DANE, 2016), the largest fall in the past decade, caused by external shocks, which generated a fiscal deficit of 3.73% of the GDP in 2015, which forced the National Government to process a long-term tax reform with the aim of reducing the vulnerability of public finances.

In summary, the Colombian manufacturing exports for the 2010-2015 period presented a contraction of -13%, where the international sales of non-metallic minerals fell by 50.3%. Additionally, there was a decrease in exports of chemical products, food, and beverages, which represented 30%. This situation caused a significant deficit in the trade balance of the national industry.

Background studies

In economic literature, the causal relationship between productivity and exports is analyzed by taking, as a point of reference, the research work of Bernard & Bradford (1999), where they demonstrate, with empirical evidence, that exporting companies in the United States manufacturing sector increase their productivity and capital stock levels before exporting, to face the costs related to the insertion of their products in the international market.

The hypotheses that describe this type of behavior are learning by exporting and self-selection. Learning by exporting explains the positive relationship between productivity and exports, caused by the positive impact generated by technology transfer on the productivity of manufacturing companies, carried out by the interaction process that companies have with international market players (suppliers, customers, marketers, and others) (Bernard & Bradford, 1999).

The self-selection hypothesis indicates that only firms which show the best productivity and quality index in their final or intermediate good can carry out international sales to markets that present social and economic characteristics similar to the country of origin (Bernard & Bradford, 1999).

Regarding the aforementioned hypotheses, three research lines that analyze the causal relationship between exports and labor productivity in the manufacturing sector are identified. The first research line focuses on analyzing Learning by exporting and

self-selection. The second research line focuses on the "entry cost" of the international trade of manufactured goods. The third research line studies the geographic characteristics associated with the industrial agglomeration of exporting firms in the manufacturing sector.

From the first research line regarding the analysis of the Learning by exporting and self-selection hypotheses, the work of Bernard & Bradford (2004) for the manufacturing industry in the United States stands out, where the empirical evidence is overwhelming in arguing that only the most productive firms are capable of entering the international market. On the other hand, the empirical evidence of the positive effect of technology transfer indicates that there is an increase in the productivity index in the short term, but this effect tends to disappear in the long term.

To carry out the estimates, they propose a panel data analysis with random effects that allow for predicting the causal relationship between the variables. Besides, they quantify the decision to export through a dummy variable, which establishes the condition of having a higher income than the international market entry cost. Finally, the transition period that exists when a firm sells abroad and decides to leave the international market is taken into consideration.

The conclusion of Bernard & Bradford) (2004) is that exporting firms in the North American manufacturing sector increased their productivity rates in an average range of 12-19%, compared to non-exporting firms, for the 1984-1992 period. Surprisingly, the evidence that argues the effect of Learning by Exporting tends to be not statistically significant, due to the difficulty of modeling the decision to export made by firms in the manufacturing sector.

On the other hand, De Loecker (2007) presents empirical evidence that supports the Learning by Exporting hypothesis for the Slovenian manufacturing sector for the 1994-2000 period. hey use labor productivity as an approximate measure of the total factor productivity index of the manufacturing sector, and they conclude that exporting companies are, on average, 29.59% more productive than non-exporting companies.

To obtain statistically significant results, he proposes the creation of control groups, which quantify the decision to export, in terms of the expected probability of starting their sales abroad. For this reason, they use Propensity Score Matching (PSM), where a probit model is estimated. The results show that, on average, the companies that start to export are 8.8% more productive due to firms increasing their participation in the international market, which indicates a positive effect of the learning-by-exporting hypothesis.

In the case of Latin America, Alvaréz & García (2010) analyze the causal relationship and the impact that exports and technological innovation have on the productivity index of the Chilean manufacturing industry, where the empirical evidence favors the hypothesis that only the most productive firms are capable of exporting. The implemented econometric model is based on the one developed by De Loecker (2007).

The methodological approach of Alvaréz & García (2010) focuses on the Matching technique in the context of differences in differences, which allows for obtaining more precise estimators, because it is possible to control for unobservable heterogeneity between the signature groups. The results of the estimates are consistent in arguing an increase in the productivity index of 10%, on average, of firms that begin to export, which indicates that only firms that previously improved their productivity and installed capacity can enter the international market.

The second research line regarding "entry costs" refers to the transactions carried out by firms before entering international market. For the case of Colombia, the research of Giraldo (2015) estimates the export determinants of the Colombian manufacturing sector through a macroeconomic model of simultaneous equations, where the supply and demand of exports, and the costs of entry to the international market (freight, international physical distribution, tariffs, among others) are taken into account in order to estimate the price and income elasticity of the Colombian manufacturing sector. The results show that exports from the Colombian manufacturing sector are focused on food products, textiles, industrial chemicals, basic iron and steel metals, and non-ferrous metals; being food products the exports mainline, with an average participation of 25% of total exports for the 1998-2013 period.

Finally, the third research line focuses on the analysis of variables associated with economic geography and industrial agglomeration. The research of Greenaway & Kneller (2008) studies the geographic agglomeration effect of the United Kingdom manufacturing industry, and its relationship with the export potential, as well as examining the empirical evidence of the Spillover[2] between exporting and non-exporting firms. For this reason, the analysis focuses on demonstrating the impact of the size of the firm, productivity, and geographic agglomeration.

Taking these antecedents into consideration, the goal of this article is aimed at carrying out an analysis of the causal relationship between productivity and exports in

2 The Spillover effect was presented in the economic literature by Marshall in 1920, where he defines this phenomenon as the set of events that take place when the knowledge, know-how, technological innovations, and organizational process are created or developed by an agent and can be used by another agent with similar characteristics, such as firms belonging to an industrial conglomerate; without any compensation, or lesser value compensation than the corresponding one in the market (Delgado, Correa, & Conde, 2013).

the Colombian manufacturing sector. The main objective of this research is to establishing inputs for the generation of economic policy that enables improving the productive processes of the national manufacturing sector, to increase competitiveness and international sales of manufactured goods, which stimulates the growth of this sector, which has lost dynamism in the last 30 years, in terms of share of the GDP,.

The added value of this research is analyzing the process of technological transfer existing in foreign trade operations, which is measured through the acquired knowledge from the international market and foreign direct investment, in order to promote investment in R&D projects that allow increasing the implementation of new technologies in the productive system of the Colombian manufacturing industry.

Currently, Colombia has one of the lowest rates in R&D investment, as well as investment in scientific activities, of the OECD member countries. Colombian investment in these types of activities is less than 0.5% of the GDP, compared to developed economies such as Japan, China, the United States, Germany, and France, which have percentages of investment in R&D activities of more than 3% of its GDP, on average (Observatorio Colombiano de Ciencia y Tecnología, 2016).

For this reason, the Colombian Government approved Law 2190 of 2016, corresponding to the budget regulation of *Sistema Regional de Regalías*, whose purpose is the creation of equity conditions in the income distribution from the exploitation of non-renewable natural resources, to promote the development of productivity and competitiveness of the different departments, in the form of decentralized budgets for investment in physical infrastructure and connectivity, investments in R&D, education, and in research groups; which would increase the capital stock of the national industry and improve the export offer diversification.

Methodology

To carry out the estimates, the micro-data available from the *Encuesta Anual Manufacturera* (EAM), gathered by the *Departamento Administrativo Nacional de Estadística* (DANE) of Colombia, is used, which has a census of more than 3,000 industrial establishments, and disaggregated information regarding the industrial subsector, production levels, investment in assets, employment level, among other economic variables. Additionally, the micro-data from the *Encuesta de Desarrollo e Innovación Tecnológica* (EDIT), carried out by DANE, is used. With the same census of industrial establishments, it collects information regarding investment in scientific activities, investments in the technology transfer process, and investments in research and development.

Another fundamental aspect is that the DANE micro-data counts with a complete series for the 2005-2015 period, which allows us to analyze the impact generated on economic growth and the industrial production index in Colombia by external shocks, such as the world financial crisis of 2008, the moderate growth of the Chinese economy, and the drop in international commodity prices.

Under these precedents and micro-data characteristics, a model based on the panel data technique is developed, which enables capturing the unobservable heterogeneity between individuals throughout the study period, since this heterogeneity cannot be detected neither with time-series nor cross-sectional studies.

For this reason, this technique allows for a more dynamic analysis by incorporating the temporal dimension of data, which generates added value to the study, particularly in the long term (t ≥ 10) (Mayorga & Muñoz, 2000).The general specification of the model with panel data regression analyzed by Baltagi (2005) is the following:

$$Y_{it} = \alpha_{it} + \sum_{j=1}^{k} X_{it}^{j} \beta^{j} + u_{it} \quad (1)$$

Panel data models are interpreted through the error component term (Parra, 2016), from equation (1), the error term is decomposed as follows:

$$u_{it} = u_i + \lambda_t + e_{it} \quad (2)$$

Where the term represents the unobservable effects that differ between study units, which do not vary over time; represents non-quantifiable effects that vary over time, but not between study units; and, finally, is the purely random error.

The estimation of and is carried out by ordinary least square, considering that this model presents a significance loss on its degree of freedom. The F test [3] is a great help in this type of model to check if for any *i*. On the other hand, it should be noted, that when you want to include a constant term you only have to enter N-1 dummy variables. The estimator of the fixed effects model has the following representation:

3 It is the global significance test of the regression, which is carried out from the hypothesis test used to measure the goodness-of-fit of the model. This test determines the existence of a linear relationship between the dependent variable and the explanatory variables (Baltagi, 2005). The statistical hypothesis is:

$$H_0 = \beta_1 = \beta_2 = \cdots = \beta_k = 0$$

$$H_a = \beta_i \neq 0 \; for \; at \; least \; one \; i, with \; i = 1,2,\ldots j$$

By rejecting the null hypothesis, it is concluded that at least one of the estimators associated with the explanatory variables is significant to the model.

$$\hat{\beta} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T}(X_{it} - \bar{X}_i)(X_{it} - \bar{X}_i)'\right]^{-1}\left[\sum_{i=1}^{N}\sum_{t=1}^{T}(X_{it} - \bar{Y}_i)(X_{it} - \bar{Y}_i)'\right] \quad (3)$$

Within the analysis of the causal relationship between productivity and exports, it is common to find endogeneity between the error term and the explanatory variables of the model, because there is evidence of a common tendency relationship and self-selection between productivity and exports, corresponding to a selection bias in the empirical model.

In addition, a double causality relationship is observed, and it indicates that there is a relationship between the unobservable characteristics of productivity, such as managerial skills, externalities, and opportunities in the international market, competitive advantages, among other factors, that affect the behavior of the exporting companies of the Colombian manufacturing sector.

Consequently, this endogeneity condition triggers a bias problem in the estimation of the parameters, and, for this reason, the estimator β_{MRE} by generalized least squares and β_{MRE} by ordinary least squares are no longer consistent, unbiased, and with a lesser variance.

To solve the endogeneity problem, the methodology developed by Arellano & Bond (1991) is used; the difference generalized method of moments used the first differences to control unobservable heterogeneity and internal instruments, specifically the lag of the dependent variable, and another group of variables such as capital and labor input, and lags regarding export status, which helps to solve the problem.

The estimator developed by Arellano & Bond is the product of a modification to the random effects model where the matrix representation refers to a dynamic panel data model represented in equation (4), and whose assumptions are:

$$y_{it} = X'_{it}\beta + \delta y_{i,t-1} + c_i + \varepsilon_{it} \quad (4)$$

However, the presence of lags of the dependent variable in the model shows a correlation between and , of the form. Therefore, the estimator of OLS and CGM remain inconsistent and biased. To face this correlation Arellano & Bond (1991) propose an approach based on implementing the first differences.

$$y_{it} - y_{i,t-1} = (X_{it} - X_{i,t-1})'\beta + \delta(y_{i,t-1} - y_{i,t-2}) + (\varepsilon_{it} - \varepsilon_{i,t-1}) \quad (5)$$

$$\Delta y_{it} = (\Delta X_{it})'\beta + \delta(\Delta y_{i,t-1}) + \Delta\varepsilon_{it} \quad (6)$$

Additionally, the instrumental variable estimator is used under the panel data structure, which is represented by equations (7) and (8):

$$Z'\tilde{X} = \sum_{i=1}^{N}\sum_{t=1}^{T} z_{it}\tilde{x_{it}} = \sum_{i}^{n} Z_i'\tilde{X_i} \quad (7)$$

$$\widehat{\theta_{IV}} = \left[\left(\sum_{i=1}^{n} \tilde{X_i}' Z_i\right)\left(\sum_{i=1}^{n} Z_i' Z_i\right)^{-1}\left(\sum_{i=1}^{n} Z_i'\tilde{X_i}\right)\right]^{-1}\left[\left(\sum_{i=1}^{n} \tilde{X_i}' Z_i\right)\left(\sum_{i=1}^{n} Z_i' Z_i\right)^{-1}\left(\sum_{i=1}^{n} Z_i'\tilde{X_i}\right)\right] \quad (8)$$

From equations (7) and (8), it is possible to execute the least squares method in two stages, taking, as a reference, the characteristics of the and matrices, and the estimator of instrumental variables is obtained in equation 8, which is unbiased and of less variance, and enables correcting the endogeneity problem in the initial model, thus, developing the estimates that describe the impact of exports on the productivity growth in the Colombian manufacturing sector.

Empirical model

Thanks to the structure of the micro-data from the EAM and EDIT industrial census, it is possible to create a panel data for the 2005-2015 period, where 96.214 observations were preliminarily obtained. However, after imputing the missing data to obtain a balanced panel, 35.230 observations, corresponding to 3,523 firms in the Colombian manufacturing sector are set.

The dependent variable of the model corresponds to Labor Productivity (LP) as an approximate measure of Total Factor Productivity (TFP), because the use of TFP as a dependent variable of the model generates autocorrelation bias, since to obtain the TFP index, it is necessary to perform a linear regression for panel data with fixed effects and it generates a severe problem of autocorrelation and endogeneity between the error term and the explanatory variables of the model, which seriously affects the results of the estimates for the Colombian manufacturing sector (Camacho , 2011).

On the other hand, within the explanatory variables of the model, we find the gross investment as an approximate measure of the capital stock of the firms, the cost and expenses of the employed personnel as an approximate measure of the salary, the amount invested in internal and external R&D, the investment in technology transfer, and, finally, the variable related to exports. The labor productivity Index is expressed as follows:

$$PL_{it} = \frac{Y_{it}}{L_{it}} \quad (9)$$

Where is the labor productivity of firms, refers to the added value of the industry, and corresponds to the number of workers employed in the industry. In this way, the

index assesses the performance of a company, and, at a macro level, the performance of the industry within the study period.

In terms of methodology, there is the reference framework developed by Bernard & Bradford (1999), Newman, et al. (2017), and Isgut (2001). Additionally, those firms that have exported in all periods are eliminated from the data panel, because this behavior generates a bias in the results of the estimates. For this reason, the number of observations went from 35,230 to 31,588, which represents the elimination of around 400 companies that have this characteristic.

To evaluate the self-selection and learning by exporting hypotheses, equation (10) is used, and the exporting company[4] category is conditioned to capture the effect generated by investment in technology transfer that allows increasing productivity and competitiveness of the Colombian manufacturing sector, which presents a significant loss in its growth.

$$\begin{aligned}\text{Log}(LP_{it}) = \alpha + \beta_1 LagPL_{it-1} + \beta_2 export_{it} + \beta_3 LagExport_{it-1} + \beta_4 Logwage_{it} \\ + \beta_5 Logkapital_{it} + \beta_6 RDi_{it} + \beta_7 Tteansfer_{it} + \beta_8 ExporExp_{it} \\ + \beta_9 ExportStop + \mu_{it}\end{aligned} \quad (10)$$

The empirical results of equation (10) are summarized in table 1, where we find variables created to capture the effect of technology transfer and the learning by exporting effect, derived from the entry of firms to the international market, as well as variables that describe wages, capital stock, and investment in R&D.

On the other hand, the variables that capture the effect of learning by exporting are: *LagExport*, which is a dummy variable that indicates whether the firm made exports in the previous period, this variable is related to the effect of the hypothesis, since it allows to measure the impact of exports on the productivity index. Likewise, the *ExportExp* variable refers to the years of experience that companies have in the international market, measured as the number of consecutive years that the company exports. Finally, *ExportStop* is a dummy variable that indicates a company's exit from the international market.

The expected results for the estimators associated with these created variables must be positive and significant to argue the presence of learning by exporting in the Colombian manufacturing sector. A positive and significant value of the coefficient associated with the *LagExport* variable shows the presence of this effect in the firms,

4 Within the present investigation, the condition of exporting company is specified to those firms that have at least two consecutive years with sales in the international market, to measure the variation in the labor productivity index of exporting firms with non-exporting firms (Bernard & Bradford, 2004).

through the relationship between productivity and the export status of the firm, measured by consecutive years of exporting.

Table 1. Empirical results. Panel Data model under Fixed Effects methodology.

Dependent Variable: Labor Productivity (Log LP)	Ordinary Least Squares Fixed Effects (1)	Ordinary Least Squares Fixed Effects for Self-Selection (2)	Ordinary Least Squares Fixed Effects for Learning By exporting (3)
Export		0,155***	0,155***
		(0,0011)	(0,0011)
Lag Export	-0,021	-0,0431***	-0,0429**
	(0,010)	(0,010)	(0,010)
Lag LP	0,276***	0,274***	0,274***
	(0,0055)	(0,0055)	(0,0055)
ExportExp			0,00162
			(0,0028)
ExportStop			0,00675
			(0,025)
ExportExp / ExportStop			-0,0058
			(0,0066)
Log Lab	-0,186***	-0,224***	-0,224***
	(0,009)	(0,0010)	(0,0010)
Log Kap	0,233***	0,213***	0,212***
	(0,0055)	(0,0056)	(0,0056)
Technicians Salary		-0,0000031***	-0,0000035***
		(0,00000041)	(0,00000072)
Workforce Salary		0,0000041***	-0,0000042***
		(0,00000068)	(0,00000068)
Administrative staff salary		0,0000044***	0,0000044***
		(0,00000059)	(0,00000059)
Import		0,0212*	0,0212*
		(0,0088)	(0,0088)
Internal R&D investment		-0,0000077*	-0,0000077*
		(0,00000035)	(0,00000035)
External R&D Investment			
Technology Transfer		-0,0000069*	-0,0000068*
		(0,00000033)	(0,00000033)

Continúa...

R2	0,1462	0,1578	0,1578
F Test of Global Significance	409, 42	1215,79	332,69
Number of Companies	3170	3170	3170
Number of Observations	31588	31588	31588

Source: *Encuesta Anaual Manufacturera* (2005-2015)

Note: They have a balanced data panel. This table only shows estimators with statistically significant results. Columns (1), (2) and (3) include control variables associated with the CIIU Rev. 3 a.c[5] industrial subsector, geographic region and period. The F test of significance is specified. Robust standard errors are in parentheses. Significance levels *** p <0.01, ** p <0.05, * p <0.10.

The empirical evidence of this research agrees with the results of Bernard & Bradford (1999) for the United States manufacturing industry, Alvaréz & García (2010) for Chilean manufacturing industry, and Camacho (2011) for the Mexican manufacturing industry; that the effect of learning by exporting does not generate significant results, since the increase in productivity generated by technology transfer process is not constant or observable in the long term.

In table 1, the results of column (3) stand out, where the coefficient of the variable **Export** is statistically significant, and it indicates a positive impact on the levels of labor productivity of exporting firms. The results argue that firms with at least two consecutive years of presence in the international market have an increase in their labor productivity index of 15.5%, on average.

On the other hand, the coefficient associated with the variable of investment in R&D and investment in technology transfer present in column (3) shows a negative impact on the labor productivity of firms in the manufacturing sector, which indicates a deficiency in investments in scientific activities, investments in R&D, and implementation of new technology in the productive process of companies. Originating a limited implementation of economies of scale that enable increasing the competitiveness levels in the Colombian manufacturing industry.

In the same way, the coefficient associated with the *LagLP*[6] variable presents a positive and statistically significant behavior, which indicates the presence of an increase in the labor productivity of the firms before exporting, which implies that companies experience an increase on average of 27.4% in their labor productivity before entering to the international market, which supports the self-selection hypothesis in the Colombian manufacturing sector.

5 Clasificación Industrial Internacional Uniforme (CIIU) Rev. 3 a.c.is the economic activities classification of economic activities by production process that classifies statistical units based on their main economic activity in Colombia.

6 Due to the nature of using a lag in the dependent variable, the labor productivity variable LagLP forces the model to lose a period.

From another point of view, the results obtained by Newman et al. (2017) for the Vietnam manufacturing industry supports the positive and significant effect of the learning by exporting hypothesis in the manufacturing sector. For the estimations, they use the Arellano-Bond Difference Generalized Method of Moments, and the empirical evidence shows that there is an improvement in labor productivity through an increase in investment in R&D and technology transfer.

In table 2 column (2), it shows the results of the estimations under the difference generalized method of moments, where the value of the coefficient associated with the **LagExport** is surprisingly negative and statistically significant, the similar result obtained through the fixed effects method, which is evidence that Colombian manufacturing industry is not generating an increase in its labor productivity index from the experience in the international market, instead, there is a loss of -4.6%, on average.

This negative behavior is generated by the low optimization of production factors, the low index of qualified labor, and the absence of economies of scale that directly affect the competitiveness of the Colombian manufacturing sector.

The empirical evidence agrees with the results obtained by Alvaréz & García (2010) for the Chilean manufacturing industry, where firms classified as exporters show negative and not significant productivity index, indicating that the effect of learning and technology transfer is not generating any impact on the productivity of firms that decide to export for the first time during the study period.

On the other hand, when applying the dynamic panel estimator of Arellano & Bond (1991), it is observed that the coefficient of the variables **ExportExp** and **ExportStop** show negative and non-significant values. This leads to the conclusion that the learning effect and productivity growth originated by international trade operations tend to disappear when firms leave the international market.

Table 2. Empirical Results. Panel Data Model with Difference Generalized Method of Moments (Arellano-Bond)

Dependent variable: Labor Productivity (Log LP)	**Difference Generalized Method of Moments (Arellano-Bond) (1)**	**Difference Generalized Method of Moments (Arellano-Bond) (2)**
Export		0,135***
		(0,0177)
Lag Export	-0,0846***	-0,0460***
	(0,016)	(0,01823)

Continúa...

Lag PL	0,269***	0,264***
	(0,0254)	(0,026)
ExportExp		-0,00140
		(0,0049)
ExportStop		-0,03814
		(0,2629)
ExportExp / ExportStop		0,0040
		(0,0052)
LogLab	-0,291***	-0,321***
	(0,0288)	(0,295)
LogKap	0,325***	0,3029***
	(0,0195)	(0,209)
Technician Salary		-0,0000037 ***
		(0,00000010)
Workforce Salary		-0,0000034***
		(0,00000093)
Administrative staff salary		0,0000039***
		(0,00000081)
Import		0,0608***
		(0,0136)
Internal R&D investment		-0,00000039**
		(0,00000012)
External R&D Investment		
Technology Transfer		-0,0000069*
		(0,00000033)
R2	N/A	N/A
Wald Chi Square Test	525,87	1035,68
Number of Companies	3167	3169
Number of Observations	25200	28388

Source: Encuesta Anaual Manufacturera (2005-2015)

Note: There is a balanced data panel. The present table only shows the estimators with statistically significant results. Columns (1) and (2) include control variables associated with the ISIC rev industrial subsector. 3 BC, geographic region and period. Chi-Square test is specified. Robust standard errors are in parentheses. Significance levels *** p <0.01, ** p <0.05, * p <0.10.

In contrast, the impact of the capital stock **LogKap** on productivity is positive and significant, which is an indicator that firms are investing in fixed assets that increase their productive capacity, and, therefore, there is an increase in the labor productivity index of 30.2%, on average. A result that agrees with the exogenous growth theory developed by Solow (1956), where he concludes that the productivity index depends on the level of capital per worker, which means that an increase in machinery and equipment investment generates increases in capacity and labor productivity.

Regarding the estimates of the labor factor **LogLab** in the Colombian manufacturing sector present in Table 2 column (3), it is inferred that the wages of workers and technical personnel are generating a negative effect on labor productivity of 32, 1%, on average. This result implies that factors such as low-skilled labor, economic slowdown, and the inflationary process affected the dynamics of wages in the Colombian economy and the labor productivity index (FEDESARROLLO, 2018).

According to the research of Gori & Sakamoto (2018), there is a relationship between wages and labor productivity for the different types of workers. The results show that there is a positive relationship between salary and the degree of economic development, which implies that external shocks can influence the salary rate and the productivity index. In the case of the Brazilian economy, the earnings initially grow much faster than productivity, and it caused a reduction in the quality of employment and socio-economic development.

The empirical evidence from Colombia is similar to the Brazilian economy, because there is a gap between the technical wage and the professional wage, which harms the labor productivity and the technological development of the economy. This situation affects the participation of the manufacturing sector in the GDP, due to the lack of new technologies and innovation implementation in the economy productive structure.

In conclusion, the solution of the endogeneity problem presented between the variables of labor productivity and exports does not change the level of significance, signs of the coefficients, and the general effect on the estimates of the learning by exporting hypothesis. This means that the effect of technology transfers existing in the international trade and interaction with international market agents are not generating a considerable increase in the labor productivity of the Colombian industrial sector.

Concluding remarks

The result indicates the existence of empirical evidence that supports the self-selection hypothesis, where it is observed that the levels of labor productivity increase in firms that decide to export by 27%, on average, compared to firms that only focus on the domestic market. Contrarily, the costs associated with employed personnel show a negative behavior, due to factors such as inflation, the lack of qualified labor, and the unemployment rate in the industrial sector, which affect the growth of labor productivity.

On the other hand, the capital stock reflects a positive and significant impact on labor productivity of 30%, on average; a result that is acceptable because of installed capacity, and capital goods are not showing the expected effect of economies of scale that enable maximizing production levels. This empirical evidence is relatively low compared to other similar economies in South America, such as Chile, Brazil, and Uruguay, which have percentages of greater than 40%, according to the Global Competitiveness Index published by the World Economic Forum (World Economic Forum, 2015).

Likewise, the results in terms of salary show a negative effect on labor productivity, which implies the level of wage and the job skills in the industrial sector are not generating the expected effect. For this reason, the private and public sectors must formulate strategies to improve employment generation and investment in education, and training in areas of technological development that are the most added-value subsector to diversify the export offer in Colombia and promote growth in the national manufacturing sector.

Based on the empirical evidence, it is possible to connect the negative result in terms of technology transfer and learning by exporting hypothesis with the deindustrialization process that the Colombian industry is experiencing, where there is a migration of resources and capital to the mining and services sector, which distort the GDP growth due to the volatility of the income derived from the exports of commodities (Polline & Lourenço , 2013).

The recommendations in terms of economic policy that improve the productivity of the Colombian manufacturing sector are linked to the theories of increasing public spending as a factor that enhances economic development. The most relevant theory that argues the hypothesis of an increase in public spending is the macroeconomic theory developed by Keynes (Beneti, 2000), which argues that public spending has a positive effect on aggregate demand and the output of the economy. Additionally, he argues that public spending can be used as a countercyclical tool to reduce the gap in real production.

In consequence, the economic policy research in Colombia should turn towards an analysis of substantial increase in public and private investment in R&D; because this type of investment does not exceed 0.5% of GDP, well below developed economies (Yazgan & Yalçinkaya, 2018). Additionally, the creation of a public policy that promotes foreign direct investment in the Colombian industrial sector, focused on the long term, is suggested.

Finally, this type of initiative will stimulate the development of the manufacturing sector through the implementation of technological development and innovation

processes in the industrial productive structure, in order to increase the participation of the Colombian manufacturing industry in the GDP. Lastly, this is the best strategy for stopping the dependence on commodities exports of low added-value, which have caused a significant drop in the Colombian industry and the trade balance.

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