

# An empirical analysis of Colombia's trade liberalization process and its effect on the equilibrium of its structural trade deficit

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## Abstract

This article examines the extent to which Colombia's trade liberalization, as a government strategy to boost its exports, has helped to balance its structural trade deficit. Based on the trade gravity model theory, we derive two-way specifications (Colombian exports and imports) in order to analyze bilateral trade flows (fuels and non-fuels) between Colombia and 136 countries from 2005 to 2018. Additionally, we compare the real export performance of Colombia with its main partners through the trade potential index (TPI), to assess the effect of Colombia's openness on bilateral trade. The econometric approach indicates that the free trade agreement (FTA) factor has a negative net effect on Colombia's exports and a positive net impact on Colombia's imports. Finally, the TPI analysis allows us to infer that although there is an evolution towards the intensification of Colombian trade, this trend is greater in imports than in exports, which suggests a deepening of the Colombian trade deficit.

## KEYWORDS

Colombia, free trade agreement (FTA), international trade, trade balance, trade gravity model

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## 1 | INTRODUCTION

The past decade has witnessed the rapid development of trade liberalization as one of the most critical policies in enhancing international trade around the world. In this regard, empirical research has explored the effects of the free trade agreement (FTA) factor on bilateral trade, showing that FTAs improve bilateral trade among associated countries (Egger et al., 2011).

Colombia, as part of the Andean Community (AC) and one of the fastest-growing countries in the region, has developed a policy of trade openness in the last decades. This policy has been implemented through the signing of relevant trade agreements, which have different trade scopes and follow global trends in trade liberalization. However, there is no consensus about whether this process has had the expected effect on Colombia's exports and its trade balance, and therefore, on domestic production and welfare.

The purpose of this paper is to analyze the effects of Colombia's trade liberalization process and also to assess the impact of the signing of bilateral and regional trade agreements as an effective policy to reduce the Colombian trade deficit. Additionally, our study delves into the effect of FTAs on Colombia's trade in fuel and non-fuel-related goods, which allows us to determine the individual influence of FTAs on these types of products, which is essential due to the country's high dependence on its fuel exports. Furthermore, this study could be replicated in most of the Latin American countries, which are highly dependent on their commodity exports, as well as those countries whose exports depend particularly on fuels.<sup>1</sup> Moreover, this study will allow us to analyze, through an empirical approach, the performance of the trade balance of a country which, on the one hand, largely depends on its fuel exports and, on the other hand, whose oil reserves are about to run out. As far as we know, this is the first study to explore the determinants of Colombia's international trade (export and import flow) in terms of fuel and non-fuel flows. Consequently, the results of the study will allow us to make some trade policy recommendations focused on improving the efficiency of Colombia's trade openness.

Furthermore, we applied the trade gravity model to a cross-sectional data set of bilateral exports to 136 countries from 2005 to 2018. Subsequently, this study sets out to assess the effects of a group of variables on exports between the parties, where the FTA factor is a relevant variable. Additionally, a robust estimation of bilateral trade will allow us to compare the actual export performance of Colombia and its partners with the estimated export potential generated by the model through the trade potential index (TPI). This comparison will permit us to determine whether the signing of trade agreements by Colombian governments has had the expected effect on trade. The research also considers two aspects of recent empirical analysis of international trade. The first is the fact of the presence of many zeros in bilateral trade data and the need to estimate the model with an approach more suitable than that of a traditional log-linear form; this approach is called the Poisson pseudo maximum likelihood (PPML; Santos Silva & Tenreyro, 2006). The second is the application of fixed effects to capture unobservable determinants in trade flows (Gopinath et al., 2014; World Trade Organization 2012). Summing up, the proposed study will allow us to discern whether the Colombian trade liberalization process has helped to balance its trade deficit.

The paper is organized as follows. Section 2 describes the evolution of Colombia's trade liberalization strategy in the last few decades through the international economic integration policy initially called *Apertura Comercial*. Section 3 describes our methodological approach. Section 4 is concerned with the specification and data used for this study. Section 5 presents the findings of the research, focusing on the effects of the variables involved in bilateral trade and the results of the TPI. Section 6 provides a discussion. Section 7 concludes.

## 2 | Colombia's TRADE LIBERALIZATION PROCESS

Several authors state that trade liberalization has a positive impact on economic growth (Manwa & Wijeweera, 2016). In this vein, Baier et al. (2019) claim that more than 350 bilateral trade agreements have been notified to the WTO since 1986. Thus, there is evidence that the determination of the most recent Colombian governments to develop a trade policy of international economic integration is associated with global trends, following what other countries have already done to promote their exports. This process, which has been encouraged by the promotion of international trade and investment relationships, has helped to create what Sokolov-Mladenović et al. (2017) have called the global village. According to Lim and Breuer (2019), the pace of decreasing barriers to international trade has quickened in the last 30 years, strongly reflected in developing countries, where this factor has helped boost their economic growth.

Colombia's aim of trade openness was embodied through membership of the General Agreement on Tariffs and Trade (GATT, lately WTO), reached on October 3, 1981 (World Trade Organization, 2019). The WTO has promoted the liberalization of international trade in recent decades through agreements signed by its member countries.<sup>2</sup> More recently, continuing its process of international economic integration, Colombia joined the Organisation for Economic Co-operation and Development (OECD) in 2020 (Organisation for Economic Co-operation & Development, 2020).

Nevertheless, Colombia's openness was sluggish until 1991. Since then, trade liberalization has intensified, with the helping hand of the former president of the republic, Cesar Gaviria Trujillo. According to García et al. (2014), Gaviria declared the intention of opening the economic system to make it more productive and efficient. To do so, an unprecedented set of reforms were implemented to promote what Gaviria called *Apertura Comercial*. Consequently, Colombia began negotiations to sign a significant number of bilateral and regional trade agreements.

In Colombia's openness, two agreements stand out. According to Dirección Administrativa Nacional de Estadística (Dirección Administrativa Nacional de Estadística, 2019a), the FTA between Colombia and the United States and the Commercial Agreement between Colombia and the European Union are arrangements that, on average, accounted for more than half of Colombia's exports and imports from 2005 to 2018. Nevertheless, both agreements have shown a deficit in Colombia's trade balance in recent years (Ministerio de Comercio Comercio and Industria y Turismo de Colombia (2018a)). Likewise, it is essential to clarify that, although both markets are of great importance, there is a big difference in trade amounts (Ministerio de Comercio, Comercio, & Industria y Turismo de Colombia, 2018b), which is explained by the more robust background of the commercial relationship between Colombia and the USA. This is mostly elucidated by conditions such as their productive complementariness (most of Colombia's exports to the USA are oil, mining or agricultural goods, unlike the USA's exports, which are mostly goods with high added value); the income level of US citizens; the relatively short distance between the two countries; the degree of trade openness defined in their FTA; and their robust and historical cooperation in different and strategic areas for Colombia's economic development and social stability, which have also improved their bilateral relationship.

Another notable trade association for Colombia is the one reached with the Andean Community, within the framework of a customs union. This agreement is highlighted by the fact that Colombia's exports are mainly made up of manufactured products, unlike the USA and the EU. Colombia's agreement with the AC is the oldest one signed by Colombia, and it is a natural market for national products due to its contiguity. According Ministerio de Comercio Comercio and Industria y Turismo de Colombia (2018a), trade flows grew continuously from 2001 to 2018,

except for the slight drop registered in 2009. Likewise, trade relations with the AC countries reflect the fact that, from 2001 to 2018, Colombia had a surplus in its trade balance, wherein a vast majority of exports are not from the oil or mining sectors. In particular, Colombia's exports to AC countries are mostly composed (72%) of goods from basic and light industry. In contrast, imports from AC countries are mostly composed (65%) of raw materials, particularly agricultural products. This situation indicates, on the one hand, Colombia's specialization in the production and export of manufactured goods, and on the other hand, the promotion of the production of value-added goods in commercial relations with the AC countries. Additionally, the trade flows show that Colombia and its AC partners have a robust inter-industry trade pattern. However, it is essential to note that there is also intra-industry trade between them, mainly represented by machinery and transport equipment goods (Ramos & Toro, 2012). Nevertheless, trade agreements such as the Pacific Alliance, the Caribbean Community and Mercosur have taken on greater commercial importance in recent years due to the notable increase in Colombia's exports to these destinations.

Figure 1 shows Colombia's export performance in millions of constant US dollars (base year 2000) to central destination countries by type of product from 2005 to 2018 in annual average figures. It shows that Colombia's exports are mainly made up of fuels, and their relative importance in total exports continues to be noteworthy in each of the periods analyzed. In particular, Colombia's exports to the USA represent about a third of total Colombian exports in every period shown, showing the significance of the US market. Furthermore, exports exhibit an expansionary trend with countries with which a trade agreement is in force. Those countries are Ecuador, Mexico, Brazil, Spain and even Chile, although the latter fell slightly in the last period. However, according to Figure 1, the highest export growth rates occur with countries with which there is no signed trade agreement: China, Panama and Turkey. In this regard, Colombia's exports to China have shown an outstanding performance, explained by

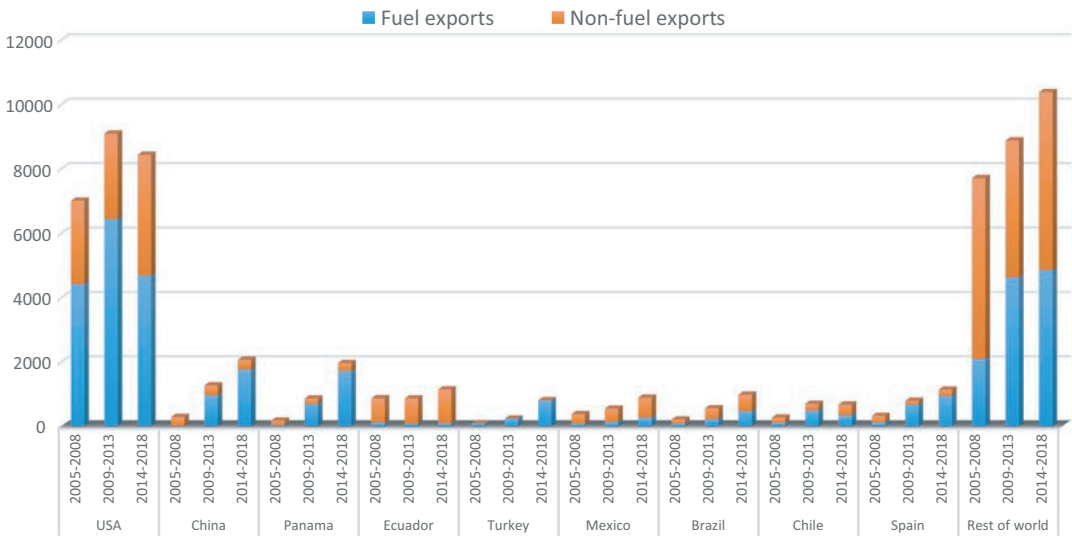


FIGURE 1 Main world destinations of Colombian exports in millions of constant US dollars (base year 2000) by type of product. Source: Authors' own calculations based on World Integrated Trade Solution (World Integrated Trade Solution, 2020a, 2020b). Deflated values based on the Export Price Index from Banco de la República de Colombia (Banco de la República de Colombia, 2020b) [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

the growth in its consumption of oil and mining goods. These types of exports represented 93.8% of Colombia's exports to China in 2018 (Ministerio de Comercio, Comercio, & Industria y Turismo de Colombia, 2020). Moreover, it is important to note that there is a trade agreement already signed with Panama and the legislative bodies of both countries are processing its approval, and also that another trade agreement is under negotiation with Turkey (Ministerio de Comercio, Industria y Turismo de Colombia, 2019).

Figure 2 shows Colombia's import performance in millions of constant US dollars (base year = 2000) by country of origin and type of product from 2005 to 2018 in annual average figures. It can be seen that the USA is the primary origin of Colombian imports. Nevertheless, this scenario may change shortly due to the notable increase in imports from China. Additionally, a remarkable growth in Colombian imports from most of the countries is evident. Unlike exports, Colombian imports consist almost entirely of non-fuel<sup>3</sup> goods. However, it is important to mention that the USA is a prominent supplier of refined petroleum products such as gasoline and light oils (Dirección Administrativa Nacional de Estadística, 2019b). Furthermore, it must be stated that even with a profound devaluation of the Colombian peso, which lost 42.3% of its value between 2005 and 2018 (Banco de la República de Colombia, 2020a), imports have shown an upward trend. Moreover, Colombia's international trade has been strongly influenced by the international price oscillation of fuel goods; according to Ministerio de Comercio Comercio and Industria y Turismo de Colombia (2018b), 63.3% of Colombian exports were composed of those types of products. This fact creates a substantial influence on the terms of trade, causing a constant and notable fluctuation in the USD/COL exchange rate. It is important to note that, although there is a general assumption about the symmetric effect of exchange rate changes on the trade balance (depreciation improves the trade balance and appreciation worsens it), this assumption is incorrect and is adequately explained through the concept of the asymmetric J-curve (Bahmani-Oskooee et al., 2020). Nevertheless, Bahmani-Oskooee et al. (2019) found that depreciation provokes an increase in price competitiveness and exports in the short run, but this

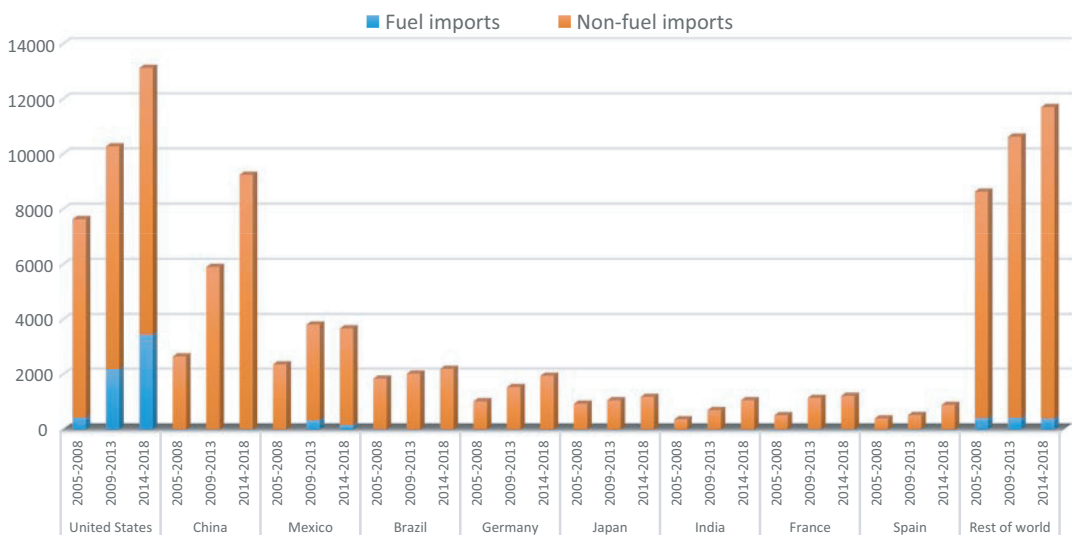


FIGURE 2 Main world origins of Colombian imports in millions of constant US dollars (base year 2000) by type of product. Source: Authors' own calculations based on World Integrated Trade Solution (2020a). Deflated values based on the Import Price Index from Banco de la República de Colombia (2020b) [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

positive effect must be accompanied by other measures such as an adequate monetary policy to have a long-term effect.

Considering all of this evidence, it seems that Colombian exports have an explicit dependence on the fuel industry. In this regard, Karabulut et al. (2020), in their study on the effect of global economic uncertainties on commodity prices, affirm that certain shocks such as the recent trade wars have increased their price volatility which can eventually generate lower growth for countries dependent on commodity production such as Colombia. Additionally, although the growth of non-fuel exports has been remarkable, an oil export substitution scenario is not feasible in the short term under current economic conditions. Moreover, Colombia has seen a deepening of its trade balance deficit, especially in the last period analyzed. It is imperative to highlight that the trade deficit scenario was intensified after the signing of some of the most prominent FTAs, questioning their effectiveness in reducing its deficit. Hence, it suggests that the income elasticity of imports appears to be greater than that of exports, resulting in the deterioration in terms of trade reflected in the expansion of the Colombian trade deficit. Finally, although Colombia's trade openness has had a positive influence on Colombian exports, the positive effect has been more significant on Colombian imports, deepening the country's trade deficit.

### 3 | METHODOLOGICAL APPROACH

To assess the determinants of Colombian trade flows, a robust and successful econometric method is implemented: the trade gravity model. The technique is commonly used in empirical studies to consider the factors that explain international trade among countries. Furthermore, it is a very good fit for predicting bilateral trade flows, and this property has been recognized in many papers (Fally, 2015). The model is proposed based on the theory called the *law of universal gravity* of the English physicist Sir Isaac Newton (Abidin et al., 2013). For Bergstrand (1985), the gravity equation states that trade between two countries can be explained by the economic forces of trade in the country of origin and by the economic forces of trade in the country of destination, and, additionally, through the economic forces that help or resist the flow of trade from origin to destination. Guo (2015) state that the volume of trade between two economies is directly proportional to the product of their economic masses, defined by their gross domestic products (GDPs), and inversely proportional to the physical distance between them.

Consistent with Anderson (1979), the gravity equation is ordinarily specified as

$$X_{ij} = \alpha_0 Y_i^{\alpha_1} Y_j^{\alpha_2} D_{ij}^{\alpha_3} n_{ij},$$

where  $X_{ij}$  denotes trade flows between country  $i$  and country  $j$ ,  $Y_i$  and  $Y_j$  denote the country incomes defined by their GDPs, and  $D_{ij}$  denotes the distance between  $i$  and  $j$ . Furthermore, the equation includes all the factors that might create resistance to trade. Likewise,  $n_{ij}$  represents an error factor statistically independent of the regressors. Finally,  $\alpha_0, \alpha_1, \alpha_2, \alpha_3$  are unknown parameters.

The first developments of the gravity model for the study of international trade were formulated by Tinbergen (1962) and Pöyhönen (1963). They analyzed the pattern of bilateral trade among European countries. Anderson (1979) claimed that the gravity equation was probably the most successful mechanism for the empirical study of international trade, although at that time part of its theoretical justification had not been identified. Deardorff (1984) affirmed that, despite this initial criticism of the theory, the gravity model has become popular due to its empirical success in predicting bilateral trade flows of various commodities in different situations.

The theoretical justification of the gravity model was mainly made by Anderson and van Wincoop (2003), who recognized that the prediction of the gravity model could be derived from the Ricardian approach, the Heckscher–Ohlin–Samuelson model and the New Theory of Trade based on increasing returns to scale (Gopinath et al., 2014; Kabir et al., 2017).

Furthermore, one of the most critical advances in the gravity model was the introduction of multilateral resistance terms (MRT), popularized by Anderson and van Wincoop (2003). They showed that controlling relative trade costs is crucial for a well-specified gravity model. Additionally, their theoretical results showed that bilateral trade is determined by relative trade costs (World Trade Organization, 2012). Furthermore, this statement was already supported by Krugman (1995), who stated that bilateral distance is a crucial empirical element in bilateral trade, and added that this could not be the sole factor that matters in the gravity equation.

Another important key in the development of the gravity model was the introduction of fixed effects. These are implemented to capture unobservable MRT in trade flows. Country-pair fixed effects are useful when econometric models lack plausible instrumental variables (Gopinath et al., 2014). Likewise, they are useful when there are specific MRT that affect trade between a pair of countries, but not with third parties (World Trade Organization, 2012). Moreover, individual country fixed effects effectively absorb all bilateral trade frictions, including any unobservable component of trade costs, which otherwise would enter the error term and potentially lead to inconsistent estimates (Baier et al., 2019). Furthermore, Gopinath et al. (2014) mention that these effects are used to control systematic tendencies to export or import large amounts relative to GDP and other observed trade determinants. Due to that, any unobservable determinants that contribute to change in the overall level of exports or imports of a country will be taken into account. Lastly, time-variant fixed effects are suitable for a database that spans many years.

## 4 | SPECIFICATION AND DATA

In the empirical study, 136 countries were selected. These countries accounted for 99% of Colombia's exports in 2018 (Dirección Administrativa Nacional de Estadística, 2019a). The period analyzed was from 2005 to 2018. The study period was chosen taking into account that since 2005 Colombia's trade integration process has intensified through the signing of trade agreements, and until 2018 due to the implementation of the latest economic data available at the time the research was complete.

The variables implemented in the model vary in economic, historical, geographical and trade characteristics. The specification follows the variable selection process made by Egger et al. (2011), which was adapted to our research, and contain the elements shown in Table 1. Consequently, six econometric specifications that follow the approach of Egger et al. (2011) are proposed to analyze, on the one hand, total export flows and export flows by type of products (fuels and non-fuels) from Colombia to its partners and, on the other hand, the total import flows and the import flows by type of products (fuels and non-fuels) from Colombia's partners to Colombia.

The first three econometric specifications include time fixed effects captured by  $\delta_t$ , time-invariant country fixed effects in the destination captured by  $\alpha_j$  and an identical set of explanatory variables. Model (1) represents the estimation of total Colombia's exports to its partners, model (2) the estimation of Colombia's fuel exports, and model (3) the estimation of Colombia's non-fuel exports. These models are summarized as.

TABLE 1 Variables implemented in the model

Variables	Description	Update date	Source	Expected sign
$X_{Total\ Colj}$	Colombia's exports to its partners in constant USD	June 19, 2020	World Integrated Trade Solution	
$M_{Total\ jCol}$	Colombia's imports from its partners in constant USD	June 19, 2020	World Integrated Trade Solution	
$X_{Fuels\ Colj}$	Colombia's fuel exports to its partners in constant USD	June 19, 2020	World Integrated Trade Solution	
$M_{Fuels\ jCol}$	Colombia's fuel imports from its partners in constant USD	June 19, 2020	World Integrated Trade Solution	
$X_{Non-fuels\ Colj}$	Colombia's non-fuel exports to its partners in constant USD	June 19, 2020	World Integrated Trade Solution	
$M_{Non-fuels\ jCol}$	Colombia's non-fuel imports from its partners in constant USD	June 19, 2020	World Integrated Trade Solution	
$LogDIST_{Colj}$	Log distance in kilometers between Colombia and country $j$	March 30, 2019	CEPII	-
$CONTIG_{Colj}$	Common physical border between Colombia and country $j$	March 30, 2019	CEPII	+
$COMLANG_{Colj}$	Colombia and country $j$ share a common legal language that is spoken by at least 9% of the population of both countries	March 30, 2019	CEPII	+
$COLONY_{Colj}$	Colombia and country $j$ ever in colonial relationship	March 30, 2019	CEPII	+
$LogGDP_j$	Log GDP of Colombia's partner in constant USD	July 1, 2019	World Bank	+
$WTO_j$	Colombia's partner is a member of the WTO	March 30, 2019	CEPII	+
$OECD_j$	Colombia's partner is a member of the OECD	June 30, 2020	OECD	+
$FTA_{Colj}$	Colombia and country $j$ with free trade agreement in force	May 8, 2019	WTO	+

Source: Own elaboration.



$$\begin{aligned}
 X_{Coljt} = & \exp(\beta_0 + \beta_1 \text{LogDIST}_{Colj} + \beta_2 \text{CONTIG}_{Colj} + \beta_3 \text{COLONY}_{Colj} \\
 & + \beta_4 \text{COMLANG}_{Colj} + \beta_5 \text{LogGDP}_{jt} + \beta_6 \text{WTO}_{jt} \\
 & + \beta_7 \text{OECD}_{jt} + \beta_8 \text{FTA}_{Coljt} + \delta_t + \alpha_j) n_{Coljt} \cdot
 \end{aligned} \quad (1)$$

The remaining econometric specifications also include time fixed effects captured by  $\alpha_t$ , time-invariant country fixed effects in origin captured by  $\alpha_j$  and an identical set of explanatory variables. In these models, the dependant variable varies from total imports from Colombia's partners in model (4), to fuel imports from Colombia's partners in model (5) and non-fuel imports from Colombia's partners in model (6). These models are summarized as.

$$\begin{aligned}
 X_{jColt} = & \exp(\beta_0 + \beta_1 \text{LogDIST}_{jCol} + \beta_2 \text{CONTIG}_{jCol} + \beta_3 \text{COLONY}_{jCol} \\
 & + \beta_4 \text{COMLANG}_{jCol} + \beta_5 \text{LogGDP}_{jt} + \beta_6 \text{WTO}_{jt} \\
 & + \beta_7 \text{OECD}_{jt} + \beta_8 \text{FTA}_{jColt} + \delta_t + \alpha_j) n_{jColt} \cdot
 \end{aligned} \quad (2)$$

Additionally, the latest studies have proposed estimating gravity models in multiplicative form instead of the usual log-linear estimation. Santos Silva and Tenreyro (2006) recommend Poisson pseudo maximum likelihood as a more suitable estimator in gravity models. They claim that this estimator is robust to different patterns of heteroskedasticity, providing a natural way to deal with zero values of the dependent variable when there are many elements and offer identical weight to the observations. In this regard, they noted that although there are pairs of countries that do not trade in some years (zero values), their inclusion in the gravity equation in its multiplicative form (PPML) does not pose problems. On the contrary, the inclusion of zero values strengthens the estimation and, therefore, the results of the study. Frankel (1997) described the different ways to deal with zero values in gravity models when a log-linear method is used in the estimations, but all of these procedures lead to inconsistent parameters of interest. Additionally, estimating with PPML instead of ordinary least squares (OLS) has an effect on the size of the coefficients. They state that the PPML estimator produces smaller and more suitable results in variables such as distance, colony, contiguity, and trade agreements among others than those provided by the OLS estimator. The authors also state that the PPML approach does not provide evidence of incorrect specification or puzzling results generated by the other approaches, which allows them to claim that the empirical methods conventionally used to estimate gravity equations are inappropriate. Considering all these facts, Fally (2015) affirms that more trust should be placed in those gravity model estimates that implement the PPML method. Gopinath et al. (2014) state that the differences in the coefficient are due to the existence of a nonlinear effect in the distance and, therefore, OLS estimates a more substantial trade for large economies and reduced trade for small economies. Moreover, Fally (2015) states that the PPML estimator leads to a perfect fit between the fixed effects and their MRT. Regarding MRT, Anderson and van Wincoop (2003) state that the traditional trade gravity model is incorrectly specified because this does not take into account MRT, which can be solved with the inclusion of exporter and importer fixed effects. However, it is important to note that, in some very specific and rare circumstances, the estimation results can be improved using country-pair effects (WTO, 2012). Given this, the models proposed in this study are estimated with the PPML approach, exporter or importer time-invariant fixed effects (depending on the model) to account for MRT and time fixed effects because the panel covers many years.

## 5 | RESULTS

Table 2 presents the results of the six proposed models based on the data described in Section 4. The models that estimate Colombia's exports to the world reflect some interesting results. In line with the theoretical and empirical approach, the distance factor harms exports. Likewise, according to the trade gravity model theory, the GDP of Colombia's partners has a substantial effect on Colombia's exports in each model. Additionally, control variables such as contiguity, common language, and colony are statistically significant only for the non-fuel model, except for the latter variable, which is also significant in the fuel estimate. Furthermore, if a Colombian partner is a member of the WTO, Colombia's non-fuel exports will increase considerably. Conversely, the variable corresponding to whether a Colombian partner is part of the OECD is insignificant in every model. Finally, regarding total exports, the coefficient reveals that when Colombia has an FTA with its partners, its total exports decrease by 28.2%. In the same vein, when Colombia has an FTA with its partners, its fuel exports decrease by 67.7%. However, if Colombia has an FTA with its partners, its non-fuel exports grow by 45.2%.

Turning to the models that estimate Colombia's imports from the world, some differences are observed concerning the previous specifications. The distance variable is significant only in the fuel imports model, and its effect is large and negative on these flows. Additionally, in each of the specifications, a directly proportional effect of the GDP values of Colombia's partners on its imports is observed. Concerning the control variables, the contiguity factor negatively and significantly affects fuel imports. Colonial ties are insignificant in these models. Furthermore, if a Colombian partner is a member of the WTO, total and non-fuel Colombian imports from such a partner will increase considerably. Moreover, if a Colombian partner is a member of the OECD, total and non-fuel Colombian imports from such a partner will be reduced. Additionally, the effect of an FTA between the parties on the models is positive, although its magnitude differs in each model. In particular, its effect on total imports will expand their flows to Colombia by 62.6%, by 101.2% for fuel imports, and by 61.6% for non-fuel imports.

Furthermore, related to the remarkable effect of the FTA factor on non-fuel exports and non-fuel imports, we performed a hypothesis test on means. Regarding the bilateral trade in non-fuel goods, the test result confirms that the difference between the two parameters is significantly different from zero. The test also confirms that the effect of the FTA on non-fuel imports is higher than on non-fuel exports with a significance level of 1%. This information allows us to infer that although the FTA has a significant influence on Colombia's non-fuel trade flows, the effect is greater in the case of these imports, which is in line with the regression values. The hypothesis test on means was also performed for total exports and total imports. The test result confirms that the difference between the two parameters is also significantly different from zero. The result also confirms that the positive effect of the FTA parameter on total imports is higher than the negative effect of this parameter on total exports with a significance level of 1%. Both test results suggest a deepening of Colombia's trade deficit and, therefore, an eventual impact on its economic growth.

Accordingly, the models are robust and fit well enough to use the predicted trade volumes of this model as a benchmark for discussing the potential trade of Colombia with its partners, and *vice versa*, through the trade potential index. According to Egger (2002), the TPI is calculated using the residual values of the estimated gravity equation. Hence, the TPI ratio is obtained by calculating the difference between the observed and the predicted values.

De Benedictis and Vicarelli (2005) calculate the TPI as

TABLE 2 Estimation results

Variables	Exports			Imports		
	Total (1)	Fuels (2)	Non-fuels (3)	Total (4)	Fuels (5)	Non-fuels (6)
$LogDIST_{Colj}$	-1.450 (0.314)***	-1.856 (0.403)***	-0.956 (0.147)***	-0.212 (0.372)	-4.088 (1.052)***	0.002 (0.319)
$CONTIG_{Colj}$	0.094 (0.446)	-0.689 (0.760)	0.840 (0.255)***	0.249 (0.540)	-4.012 (1.804)**	0.549 (0.488)
$COMLANG_{Colj}$	0.385 (0.426)	0.047 (0.578)	0.803 (0.226)***	0.763 (0.473)	-1.062 (1.420)	0.879 (0.455)*
$COLONY_{Colj}$	0.583 (0.370)	1.262 (0.552)**	-0.459 (0.194)**	-0.465 (0.486)	0.751 (1.290)	-0.514 (0.483)
$LogGDP_j$	0.813 (0.097)***	0.920 (0.152)***	0.721 (0.058)***	0.997 (0.112)***	1.470 (0.250)***	0.976 (0.117)***
$WTO_j$	-0.465 (0.667)	-0.931 (0.683)	0.884 (0.393)**	1.874 (0.455)***	-1.823 (1.386)	2.286 (0.469)***
$OECD_j$	0.235 (0.555)	0.349 (0.790)	0.237 (0.331)	-0.820 (0.446)*	-0.279 (1.064)	-0.777 (0.455)*
$FTA_{Colj}$	-0.331 (0.180)*	-1.131 (0.362)***	0.373 (0.118)***	0.486 (0.160)***	0.699 (0.301)**	0.477 (0.182)***
Constant	10.236 (3.232)***	11.068 (3.861)***	5.787 (1.720)***	-7.313 (3.344)**	13.711 (3.020)***	-9.191 (3.065)***
Observations	1,870	1,870	1,870	1,870	1,870	1,870
R <sup>2</sup>	0.846	0.752	0.909	0.894	0.911	0.884
Countries	136	136	136	136	136	136
Time-invariant country fixed effects	✓	✓	✓	✓	✓	✓
Time fixed effects	✓	✓	✓	✓	✓	✓

Notes: Robust standard errors, based on robust standard errors that have been adjusted for clustering by country pair, in parentheses.

\* $p < 0.1$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.01$ .

$$TPI_t = \frac{\hat{X}_{ijt}}{X_{ijt}}$$

where  $X_{ijt}$  is the observed value of exports from country  $i$  to country  $j$ , and  $\hat{X}_{ijt}$  is the estimated value of exports generated by the gravity model. Then the TPI is standardized so that it takes values between  $-1$  and  $1$ :

$$TPI_i = \frac{TP_{i-1}}{TP_{i+1}}$$

Positive values of TPI between  $0$  and  $1$  show an under-trading situation, while negative values between  $-1$  and  $0$  show an over-trading situation.

In this study, TPI is calculated for 2005 and 2018, taking into consideration that Colombia's trade integration process intensified from 2005 and that 2018 is the most recent year of available data. Colombia's TPI with its main partners is computed for every model proposed and is presented in Table 3. Model (1) reflects that, in terms of total exports, Colombia has an over-trading situation with the majority of its main partners (Chile, China, Ecuador, Panama, and Turkey), a situation that deepened by 2018. Likewise, its under-trading situation is decreasing with some of its partners (Brazil and Spain). This situation suggests that Colombia's exports to these countries have grown more than the estimate by the model according to the proposed specification, reflecting the intensification of Colombia's exports with these countries (see Figure 1). Conversely, Colombia's TPI level with the USA has increased during the same period. This is explained by the contraction of Colombia's exports after the entry into force of their FTA (see Figure 1). On the other hand, model (2) shows that, in terms of fuel exports, Colombia has notably reduced its TPI with most of its partners (Brazil, Chile, China, Panama, Spain, and Turkey). Nonetheless, Colombia's TPI has experienced an expansion with countries such as Ecuador, Mexico and the USA. Concerning Ecuador, this is explained by the fact that Colombia's fuel exports to Ecuador have remained relatively stable in the last period. In the case of the USA, fuel products exported to this destination have been partially replaced by non-fuel exports. Regarding Mexico, Colombian fuel exports to this destination have grown, although their growth rate has been lower compared to the advance of non-fuel exports. Furthermore, model (3) shows that, in terms of non-fuel exports, Colombia has seen a reduction of its TPI with its partners (Brazil, China, Ecuador, Mexico,

TABLE 3 Colombia's TPI with its main partners

Country	Total		Fuels		Non-fuels	
	2005	2018	2005	2018	2005	2018
Brazil	0.70	0.14	0.78	-0.75	0.66	0.02
Chile	-0.29	-0.45	-0.22	-0.63	-0.36	-0.27
China	-0.07	-0.59	NA	-0.57	-0.32	-0.34
Ecuador	-0.49	-0.17	-0.74	0.10	-0.22	-0.27
Mexico	0.16	0.16	0.06	0.16	0.31	0.10
Panama	0.22	-0.28	0.22	-0.48	0.20	0.27
Spain	0.38	0.05	0.65	0.01	-0.10	0.01
Turkey	-0.04	-0.64	-0.48	-0.66	0.80	0.65
USA	-0.08	0.09	-0.11	0.10	-0.10	0.07

Source: Authors' own calculations based on TPI estimates.

TABLE 4 Main Colombian partners' TPI with Colombia

Country	Total		Fuels		Non-fuels	
	2005	2018	2005	2018	2005	2018
Brazil	-0.09	-0.18	-0.26	-0.60	-0.05	-0.15
China	-0.08	-0.32	-0.74	-0.11	-0.06	-0.32
France	0.11	0.01	-0.68	0.35	0.13	-0.02
Germany	-0.12	-0.15	0.68	0.76	-0.13	-0.19
India	0.30	0.10	0.82	-0.29	0.33	0.11
Japan	0.16	0.04	-0.72	0.76	0.20	0.06
Mexico	-0.37	-0.48	0.91	-0.27	-0.44	-0.50
Spain	0.03	-0.07	0.84	0.47	0.05	-0.07
USA	0.06	0.16	0.29	-0.04	0.03	0.20

Source: Authors' own calculations based on TPI estimates.

Spain, and Turkey), some of which already reflected an over-trading situation. This is due to the notable growth of its non-fuel exports to these countries and the subsequent reduction of its export potential. However, Colombia's TPI with countries such as Chile (to which Colombia has increased its non-fuel exports and has reduced its fuel exports), Panama (where the largest proportion of Colombia's exports are fuels), and the USA (where non-fuel exports have gained in importance relative to fuel exports) reflect an expansion in Colombia's TPI in the period analyzed.

The TPI for Colombia's main partners is computed for every model proposed and is presented in Table 4. Model (4) shows that, in terms of Colombia's total imports, every partner has reduced their TPI level with the nation, except for the USA, although the latter's exports to Colombia are growing at a remarkable rate (see Figure 2). The evolution of Colombia's partners' TPI reflects that openness has boosted Colombian imports above the model's predictions. Additionally, model (5) shows that, in terms of Colombian fuel imports, the TPI level of Colombia's partners with Colombia is quite variable. Nonetheless, it is essential to state that of the partners presented, only the USA and Mexico export fuels to Colombia. In both cases, a noteworthy reduction of their TPI level with Colombia can be seen, although the USA experienced an increase in its fuel exports to Colombia in each period and Mexico presents a small decline in the last period (see Figure 2). Furthermore, model (6) reveals that, in terms of Colombia's non-fuel imports, the TPI performance of its partners was similar to that observed in model (4). This trend shows that openness has boosted Colombia's non-fuel imports above the model's predictions.

In summary, the data obtained allow us to infer that, in general, Colombia's TPI with its partners and Colombia's partners' TPI with Colombia reflect a trend towards the intensification of the over-trading situation or towards to achievement of this status. The evolution of Colombia's trade flows (exports and imports) reflects a clear trend towards over-trading in the period studied. However, there is higher growth in its import flows than in its export flows. Considering this, the consolidation of that trend over time would lead the country to suffer an intense exchange rate crisis due to a deepening of the national trade deficit. Additionally, if we complement this trend with the expected depletion of fuel products in the short term (Presidencia de la República de Colombia, 2020), the economic problems generated by the probable exchange rate crisis would be harmful to the Colombian economy.

## 6 | DISCUSSION

The proposed trade gravity model approach shows the influence of Colombia's trade integration processes on its bilateral trade, primarily through the signing of FTAs. Remarkably, most of the parameter values are consistent with similar latest studies (Baier et al., 2019; Egger et al., 2011; Fally, 2015; Melitz & Toubal, 2019; Santos Silva & Tenreyro, 2006).

Firstly, we want to highlight that the distance coefficient is not as large as in other studies (Santos Silva & Tenreyro, 2006). This is explained by the fact that we estimate the models through the PPML approach. However, the impact of the distance on bilateral trade is still high and adverse in the majority of the models. Despite all the improvements in transport, freight packaging, insurance and the like, the distance variable continues to be one of the critical factors that explain the volume of bilateral trade.

Regarding models that estimate Colombia's exports, it is appreciated that its trade openness has promoted the achievement of some objectives, for instance, the partial substitution of fuel exports by non-fuel exports. This encouraging effect is exhibited in Colombia's non-fuel export performance, where substantial growth is observed. Similarly, there is a notable influence on Colombia's non-fuel exports if a destination country is a member of the WTO. Additionally, the effect of the FTA variable on total and fuel exports is adverse, and this effect is more prominent in fuel than in total exports. The opposite effect of the FTA variable on Colombia's exports is contrary to that found by similar studies (Ahcar, 2018; Cárdenas & García, 2005; Serrano et al., 2015). Nonetheless, it is relevant to note that these studies were conducted in years prior to ours, which could explain the differences between our studies in the effects identified by the FTAs. The findings show that, on the one hand, Colombia's trade openness has helped promote non-fuel exports and, on the other hand, the amount of fuel exports has decreased with some partners. Nevertheless, due to the high dependence on fuel exports, the Colombian government should create an effective policy to promote non-fuel exports due to the reduced reserves of fuel-related products in the following years (Presidencia de la República de Colombia, 2020). Therefore, if Colombian policy-makers fail to replace fuel exports, the deepening of the trade balance deficit will damage the local currency to such a level that the Colombian peso may experience an unprecedented devaluation, affecting the entire economy.

Turning to the models that estimate Colombian imports, trade openness has helped to promote Colombian imports substantially. This is especially evident in the specifications for total and non-fuel imports. Notably, models for total and non-fuel imports reveal that distance is insignificant in these flows. This suggests that transportation costs do not restrict them, which explains why countries such as China and India are large suppliers of the country. In contrast, the model for fuel imports reflects that distance is a factor that profoundly and negatively affects fuel exports to Colombia. This explains that most of these imports come from nearby markets. However, having a common border with Colombia restricts its fuel exports. The situation implies that these exports are made by nearby countries with which a common border is not shared, such as the USA and Mexico (see Figure 2). Concerning the FTA factor in Colombian imports, its positive effect can be seen in every model with a predominance on non-fuel imports. Likewise, it is essential to highlight that if the Colombian partners belong to the WTO, their total exports and their non-fuel exports to Colombia tend to grow significantly. Nonetheless, if the Colombian partners belong to the OECD, their exports of the same type of products to Colombia will be negatively affected, the opposite result to that expected.

In accordance with the present results, we can affirm that there is a clear trend towards a deepening of Colombia's trade balance not only in the present day but also in the future.

These results are contrary to those found by Quansah and Ahn (2017), who in their study of sectoral trade found that the signing of the bilateral trade agreement between Korea and Australia helped to balance their bilateral trade. The deficit situation is reflected in the notable difference between the values of the FTA parameters generated for exports and imports. The results of the hypothesis test on means performed for total exports and non-fuel exports also confirm this tendency. These results suggest a greater positive influence of the FTA variable on imports than on exports for the referred models, which confirms the trend towards a deepening of the Colombian trade deficit. In this regard, it would be interesting to inquire into the degree of complementarity between Colombia and its trading partners, taking into account the results obtained in this respect by Vahalík (2014). Additionally, this trade deficit tendency is also easily perceived through the evolution of Colombian bilateral trade in recent years, confirming once again the expansion of Colombia's trade deficit and the very likely damage to its economy in the long term.

Regarding Colombia's TPI with its partners, the proposed models reveal a general trend towards an over-trading situation with most of its partners, although its performance varies in relation to the model analyzed. The results of Colombia's TPI allow us to identify a defined pattern with some of its strategic partners in every model proposed. For instance, Colombia's TPI with the USA reveals a trend towards an expansion of its under-trading situation, and this is evidenced in the notable decline in Colombian exports to the USA. Moreover, Colombia's TPI with China reflects a remarkable trend towards the intensification of its over-trading situation, which is reflected in a notable increase in its exports to this country. Likewise, there is a significant trend towards an over-trading situation with countries such as Brazil, Chile and Turkey. However, if the analysis focuses on the type of products, it is observed that there is a general trend towards an over-trading situation in fuel exports, unlike non-fuel exports, where there is no defined general trend. These deductions allow us to affirm that although Colombia's liberalization has had a positive impact on non-fuel exports, which is reflected in a general trend towards an over-trading situation, the evolution of total exports has been affected mainly by the reduction of fuel exports to the USA, and this reduction has not been balanced by the growth in non-fuel exports.

Turning to the TPI of Colombia's partners with Colombia, the models reflect an evident tendency towards a situation of over-trading (imports) greater than that reflected for the Colombian TPI with its partners (exports). This trend is mainly reflected in the models of total and non-fuel imports since fuel imports are relatively low and come principally from Mexico and the USA. However, a strategic supplier to Colombia such as the USA shows a trend towards an under-trading situation in the total and non-fuel imports models and a trend towards an over-trading situation in the fuel imports model, which is evidenced in a considerable increase in Colombia's imports from this country (see Figure 2). Conversely, the other Colombian supplier countries analyzed reflect a clear trend towards an over-trade situation in total and non-fuel imports (see Table 4), a tendency that is reflected in the strengthening of Colombian imports (see Figure 2). This scenario allows us to sustain that the Colombian openness has been successful for Colombia's partners due to the manifest tendency towards the over-trading situation reflected by most of the TPIs of its partners. This is also confirmed through the notable increase in Colombia's imports from each of its analyzed partners.

These findings suggest that the impact of Colombian trade liberalization carried out mainly through the signing of the FTA has deepened its trade deficit. Regarding this, as noted by Thirlwall (1979) in the balance of payments constrained growth theory, international trade can drive long-term growth through the interaction between trade and growth. Therefore, long-term growth will occur if national products are more attractive to foreigners and if foreign products are

less attractive to nationals; or through increased global growth (Setterfield, 2011). Consequently, our findings indicate a breach of what was indicated by Thirlwall since the objective of balancing Colombia's trade deficit, and eventually reaching a trade surplus through trade openness, has not been achieved, which calls into question Columbia's future economic growth under these circumstances. In the same vein, it is essential to remark that the expected increase in bilateral trade between Colombia and its main partners through the signing of FTAs, and the consequent liberalization of trade between the parties, was not as expected, at least for Colombia's exports. Finally, our findings on the FTA factor contrast with the results obtained in other studies, where a positive value of the FTA parameter is predominant (Anderson & Yotov, 2016; Baier & Bergstrand, 2009; Egger et al., 2011; Santos Silva & Tenreyro, 2006).

## 7 | CONCLUDING REMARKS

In this paper, we present the results of a gravity model approach applied to evaluate the trade performance by type of products between Colombia and its principal partners from 2005 to 2018. The study yields insights into the trade effects created by Colombia's trade openness and the TPI is implemented to assess its influence.

Although, as mentioned, the global effect of the FTA on Columbia's total exports to its partners is adverse, the analysis of its effect by type of goods yields two different outcomes. On the one hand, it is observed that an FTA in force between Colombia and its partners reduces the fuel exports of the former, and these tend to be partially replaced, although to a lesser extent, by non-fuel exports. This effect is in line with one of the purposes of Colombian trade policy: the substitution of fuel exports for non-fuel exports, which has been promoted through numerous government programs to boost exports of non-fuel goods (Procolombia, 2020). It should be noted that this purpose of Colombian trade policy is strategic to support greater diversification of the country's exports, since a recent report (Presidencia de la República de Colombia, 2020), stated that proven oil reserves were claimed to amount to 2,036 million barrels in 2019, which means that the oil reserves would be depleted within 6.3 years. Furthermore, concerning non-fuel exports, a noticeable positive influence is observed in their promotion if Colombian partners are members of the WTO. The effect of being a member of the WTO on Colombian exports is greater than that generated by the signing of bilateral or regional trade agreements framed in the FTA variable.

On the other hand, Colombia's imports from its partners have been promoted by the signing of FTAs with Colombia. Unlike Colombian exports, the encouraging effect of an FTA on Colombian imports prevails in each estimate. Additionally, the effect of being a member of the WTO for non-fuel imports is prominent. Moreover, if we compare the values of the FTA parameter and its influence on Colombian exports and imports, particularly of total goods and non-fuel goods through the results of the hypothesis test on means, a clear trend towards a deepening of the Colombian trade deficit is expected.

Additionally, the reduction of Colombia's TPI with its main partners, reflected in the proposed specifications, shows that the country should diversify its export destinations. Subsequently, the country should analyze the viability of deepening its trade integration with countries with which there is no traditional integration process, through integration mechanisms other than FTAs. Likewise, the possibility of deepening the agreements already established with some of its partners through the signing of new agreements could be studied, as is the case of the Pacific Alliance agreement. This policy has boosted Colombia's exports to the member countries of the alliance, with which Colombia previously had a trade agreement. Furthermore, although the evolution of



Colombia's TPI with its main partners shows a trend towards an over-trading situation, this is not reflected in the expected increase in national exports. On the contrary, the same trend reflected in the TPI of the Colombian partners with Colombia is established in a higher relative increase in Colombia's imports from its main partners. These facts reveal that the Colombian trade liberalization process has intensified the deficit in its trade balance. According to Dirección Administrativa Nacional de Estadística (2019a), Colombia's trade balance with most of these countries has become a deficit during the last period proposed (2015–2018). Consequently, these deductions question the Colombian trade liberalization policy focused on the signing of new trade agreements as an effective measure to increase its exports, and therefore reduce its trade deficit.

Furthermore, as noted, Colombia's trade pattern is mainly dependent on fuel goods, which means trading goods with little or no added value, and their prices and consumption depend on exogenous factors. In this regard, it is observed that the signing of trade agreements has partially supported the substitution of fuel exports for non-fuel exports, although the amount of this substitution has not offset the fall in fuel exports. Therefore, greater efforts are needed to ensure a proper conversion of Colombia's trade pattern. This challenge must be complemented by effective trade policies that promote the competitiveness of Colombian companies in global scenarios. For instance, although Colombia has seen its trade potential with its main partners reduced, its TPI with some countries is superior to others. Consequently, the Colombian government should create public policies that guide companies to trade with more suitable country destinations to take advantage of its TPI situation.

Finally, although our econometric approach contradicts the effect of other studies on the positive influence of signing FTAs on countries' exports (as is the case of its negative effect on Colombia's total and fuel exports), this positive effect of the FTA variable is reached only in Colombian non-fuel exports. Similarly, this positive effect is achieved by Colombian imports, regardless of the type of goods. Likewise, our findings reflect that the expected effect of boosting Colombia's exports through trade openness, and consequently reducing its trade deficit, has not been achieved; on the contrary, the deficit shows a tendency to expand. Hence, this information can be used to develop public interventions aimed at boosting Colombia's trade beyond the development of a trade policy focused on the signing of new trade agreements. These policies should be aimed at strengthening a more competitive national production, which promotes its exports and discourages its imports, to balance its trade deficit and promote its long-term growth (Thirlwall, 1979). Finally, future research should be focused on determining the reasons why this expected positive effect has not been adequately achieved in Colombia's trade liberalization process, evidenced in the structural and ascendant deficit of Colombia's trade balance.

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## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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## ENDNOTES

- <sup>1</sup> Fuel goods: products from code 321.1 to code 351.0, according to the Standard International Trade Classification (SITC 3; World Integrated Trade Solution, 2020).
- <sup>2</sup> It is important to note that although WTO rounds have reduced trade barriers among nations, they took longer to institutionalize it than through bilateral or regional agreements (Lim & Breuer, 2019).
- <sup>3</sup> Products other than those classified as fuels.

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