Mexico's Exports Attraction, 1995-2020: A Gravity Model Approach

La atracción de las exportaciones de México durante el período 1995-2020: análisis a partir de un Modelo Gravitacional

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Abstract

This paper analyzes Mexico's export activity from 1995 to 2020. It applies an augmented gravity model to test how economic size, the distance between countries, endowment factors differences, cultural closeness, and commercial rapprochement have affected Mexico's exports to other countries. The results suggest that Mexico's trading partners' economic size and distance largely explain Mexico's exports to the United States, Canada, China, Germany, Spain, Japan, and Brazil. However, differences in endowment factors, cultural closeness, and commercial rapprochement reasonably influenced Mexico's exports.

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Keywords: international trade; exports gravity model; Hausman-Taylor approach; Mexico.

Resumen

Este artículo analiza la actividad exportadora de México durante el período 1995 hasta 2020. De esta forma, se aplica un modelo gravitacional aumentado para probar cómo el tamaño de las economías, la distancia entre países, las diferencias en la dotación de factores, la cercanía cultural y el acercamiento comercial han afectado el nivel de las exportaciones de México hacía otros países. Los resultados sugieren que el tamaño de las economías y la distancia entre países explican en gran medida las exportaciones de México hacia los Estados Unidos, Canadá, China, Alemania, España, Japón y Brasil. Sin embargo, las diferencias en la dotación de factores, la cercanía cultural y el acercamiento comercial sólo influyeron de manera marginal las exportaciones de México hacia esos países.

Palabras clave: comercio internacional; modelo gravitacional de exportaciones; enfoque Hausman-Taylor; México.

Introduction

This paper analyzes how Mexico's trading partners' economic size and distance between countries influenced Mexico's export attraction from 1995 to 2020. In so doing, this analysis applies an export gravity model to determine the attraction forces behind Mexico's exports to other countries. In this regard, Mexico's export share in international markets is mainly distributed among seven trading partners: the United States, Canada, Germany, China, Spain, Japan, and Brazil. Typically, Mexico's exports to the United States have represented more than 80% of the total exports. In addition, from a theoretical perspective, this research is supported by both the neoclassical theory of international trade and the New Theory of Trade (NTT). Indeed, both theoretical approaches highlight the importance of trade to economic growth and development (Fratianni, 2009; Mayorga and Martínez, 2008; Krugman, 1979). This paper aims to test Mexico's export conditions and performance in international markets by applying an augmented gravity model. It is worth saying that although the study of international trade under the gravity model approach is widely spread in various empirical analyses, there are only a few studies in the case of Mexico. Hence, this paper applies the gravity model approach to analyze international trade in this country. Consequently, a gravity model from the Hausman-Taylor (HT) perspective is estimated to test the hypotheses stated in this research, namely economic size (i.e., real GDP) and Mexico's distance from its major trading partners (i.e., distance in kilometers/costs), on the one hand, and factor endowment differences (i.e., GDP per capita), cultural closeness (i.e., presence of a common language), and trade rapprochement between countries (i.e., the existence of trade agreements), on the other, may affect Mexico's export flows.

The results achieved in this paper suggest that the more similarity between Mexico's GDP and the GDP of its trading partners, the greater the trade potential between countries. In the same way, the more differences in GDP per capita between countries, the lower the levels of trade. Besides, the cultural similarity between countries plays a vital role in explaining trade flows. Indeed, cultural similarity shows a positive effect between this variable in other countries and Mexico's export flows. Finally, there is a positive relationship between bilateral agreements and Mexico's export flows. Notably, in this research, there is evidence of the greater distance between trading partners (i.e., transport costs), the lower international trade flows.

This paper is organized into six sections. Section 2 contains the literature review discussing the theoretical developments and empirical analyses developed from the perspective of the gravity models. Section 3 discusses the empirical methods that allow estimating the panel gravity equation. Section 4 analyzes the econometric procedures regarding the Hausman-Taylor estimation. Section 5 presents the main results from the econometric estimation in this research. Finally, Section 6 concludes with some remarks concerning the discussion of trade and Mexico´s export gravity model.

Literature review

Theoretical Perspective

The very beginning of the gravity model in international trade goes back to the interaction hypothesis proposed by Stuart Dodd (1950) that suggested how to know the number of interactions of any kind between groups of people from their dimensions of time, space, population, and productive activity (1950, p. 245). More recently, this approach proposed that the number of families moving between separate areas varies inversely with distance (Bergstrand, 1985). Certainly, Shahriar *et al.* (2019) discussed the development of the gravity model of the trade from a historical perspective. This analysis explored the roots and advances of the gravity model approach achieved through the last centuries identifying four different phases (Shahriar *et al.*, 2019). First, the development of the historical roots of the gravity equation from 1885 to 1962. Second, the beginning of the traditional gravity model approach from 1962 to 1966). Third, the mature phase of the theoretical foundations of the gravity model from 1966 to 2003). Finally, the revival of the gravity model in international trade from 2003 to 2017. Nevertheless, Tinbergen's (1962) pioneering work proposed a novel specification of a gravity model to determine the standard flow of international trade in the absence of trade barriers.

Tinbergen's (1962) work was soon further extended to an augmented gravity model of trade that allowed including other variables. For example, Linnemann (1966) added population as a proxy for market size, Rose and van Wincoop (2001), and Rojid (2006) measured the effects of exchange rate fluctuations. Leamer (1988), Feenstra (1995), and Wang (2001) explored the influence of average tariffs on bilateral trade. However, the gravity equation proved to be helpful in explaining international trade between countries but with no solid theoretical foundations.

In this way, Anderson (1979) was one of the first economists who contributed to develop the theoretical economic foundations for the gravity model under the Armington (1969) assumption of constant elasticity of substitution. Other theoretical contributions drawn from Bergstrand (1985, 1989, 1990) who established the microfoundations for the gravity model inquiring on the relationship between bilateral and trade theory. Finally, Helpman (1987) established a linkage between monopolistic competition and the gravity model of trade by investigating eighteen industrial countries. In summary, the gravity model approach gradually gained momentum in international economics incorporating the trade's demand and supply sides, and the capacity to explain intra-industry trade in monopolistic competition (Leamer and Stern, 1970).

Nowadays, the discussion around the gravity model is mainly focused on the best methods for estimation. In this regard, recent studies propose to account for several factors and agree on using panel datasets to obtain more robust results. For example, Shahriar *et al.* (2019) and Gómez-Herrera (2012) show some of the main advantages and disadvantages of each method, identifying some nonlinear methods: Nonlinear Least Squares (NLS), Feasible Generalized Least Square (FGLS), Gamma Pseudo Maximum Likelihood (GMPL), and Poisson Pseudo Maximum Likelihood (PPML). However, to determine the relevance of the gravity model proposed in this research, it is essential to stress the theory of reciprocal demand that states when two nations have equal economic size, each nation's demand would have a remarkable effect on market prices (Mill, 1848). Shortly speaking, countries' economic size significantly affects international trade flows.

On the other hand, from the neoclassical perspective, Heckscher (1919) and Ohlin (1933) emphasize the differences in country's factor endowments to determine the patterns of international trade (Arapova and Isachenko, 2019). Accordingly, to get full benefits from international trade, a country must specialize in producing and exporting goods where it has a comparative advantage (Ohlin, 1933). Accordingly, Deardorff (1998) demonstrated that the gravity model was consistent with many trade models, such as the Heckscher-Ohlin model with increasing returns to scale.

Nevertheless, the New Theory of Trade (NTT) states that under the assumptions of constant returns to scale and imperfect competition, it is possible to understand intra-industry trade and not the complete patterns of specialization proposed by Heckscher-Ohlin (Jiménez, 2011; Krugman, 1997). From this perspective, an expected advantage of free trade between industrialized and non-industrialized countries is that the former obtains an expansion of its market and thus takes advantage of economies of scale (Gómez, 2013). Hence, from the NTT theoretical perspective, intra-industrial trade shows another general pattern that may describe the development of international markets (Fratianni, 2009; Krugman,1981, 1997).

In a different way, Linder (1961) suggests that international trade is typically linked to comparative advantages. This author focuses on the similarities in income and consumer tastes to explain the trade patterns. Additionally, Linder also includes the demand structure in the analysis of international trade, as it is done in the gravity model underlying approach that measure the "force of attraction" between economies (Linder, 1961). In this regard, Linder's hypothesis states that countries with similar demand structures (i.e., similar income) are more likely to exchange. Importantly, this perspective on trade became the first explanation aiming to reveal Leontieff's paradox and intra-industry trade.

A gravity model sought to provide the measurement of the level of exchange that can be useful in explaining the presence of inter- and intra-industry trade. In this regard, the classical trade models ignore the presence of two determinants that characterize the New Trade Theory (NTT), namely economies of scale combined with product differentiation, and transportation costs (Helpman and Krugman, 1985; Krugman, 1980). Although gravity models do not account for transportation costs in their basic formulation, the specification by Helpman and Krugman (1985) and Helpman (1987) proved to be helpful since it is derived from the recent NTT advancements.

Empirical literature

The determinants of international trade flows have become the subject of a comprehensive set of economic studies aiming to determine the influence of different factors on foreign trade by applying qualitative and quantitative instruments. In this sense, the gravity model has become a helpful tool in empirical research. For example, Fratianni (2009) applies an augmented gravity model to explain North-South trade. This author finds that income and distance influence bilateral trade explanations. She demonstrates that since the distance elasticity is around unity, distance alone can inhibit the entire value of bilateral trade flows. Accordingly, distance captures more than transportation costs, which is a helpful explanation of the quantitative importance of distance. Krugman and Obstfeld (2002) discuss the obstacles limiting international trade. Kabir *et al.* (2017) examine the development and application of the gravity model into the four broad themes: 1) generalized gravity model; 2) intra-industry trade; 3) homogeneous and heterogeneous products; and 4) structural gravity model. Finally, Arapova and Isachenko (2019) apply an augmented gravity model to analyze trade in economic development, the impact of tariffs on Russian foreign trade, and the evolution of the trade policy on the development in a broader regional perspective. Table 1 shows some of the most relevant studies concerning gravity models.

Table 1. Selection of some empirical gravity model applications

Author	Article	Variables	Metodology
Egger and Pfaffermayr (2004)	Distance, trade, and FDI: A Hausman-Taylor SUR approach	Exports, Distance, FDI, Factor endowment	Hausman-Taylor SUR estimation
Serlenga and Shin (2007)	Gravity Models of Intra-EU Trade: Application of the CCE-HT in heterogeneous panels with unobserved common time-specific factors	GDP, Populatión, Distance, Language, Common Border, Free trade agreements, Currency Exchange Rate, Factor Endowments	Hausman-Taylor CCE estimation in heterogenous panels
Kabir and Salim (2010)	Can the Gravity Model explain BIMSTEC's Trade?	Trade flows, GDP similarity, Exchange rate, Distance, Border, Language, Government, and Trade agreements.	Prais-Winsten Regression in Panel-specific AR (1) with Hausman-Taylor estimators
Arapova and Isachenko (2019)	Russian trade policy: main trends and impact on bilateral trade flows	Exports, Imports, GDP Russia, GDP Part, Distance, Tariff, Exchange Rate	Augmented Gravity Model estimation with random effects
McPerson and Trumbull (2008)	Rescuing observed Fixed Effects: Using the Hausman Taylor method for out-of-sample trade projections.	GDP Per capita differences, trade agreements, distance, language, communist history	Hausman-Taylor estimation
Suresh, K. and Aswal, N. (2014)	Determinants of India's manufactured exports to south and north: a Gravity Model analysis	Exports, GDP similarity, GDP per capita, Exchange rate, Distance, Language, Border, Common Colonizer, Trade agreements	Augmented Gravity Model with random effects.
Egger and Staub (2015)	GLM estimation of trade gravity models with fixed effects	Ei exporter-specific factors and Mj are importer-specific factors, and Tij is bilateral pair-specific.	GLM fixed effects estimation
MartínezZarzoso, and Chelala (2021)	Trade agreements and international technology transfer	"The model differentiates between provisions relating to technology transfer, technical cooperation, research and development, and patents and intellectual property rights. It includes estimations of a structural gravity model for a panel of 176 countries from 1995 to 2015.	PPML estimator

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Author	Article	Variables	Metodology
Chen, Chen and Yao (2020)	Trade development between China and countries along the Belt and Road: A spatial econometric analysis based on trade competitiveness and complementarity	GDP of China and the countries along the B&R, the land area of countries along the B&R, trade complementarity, common language, and free trade agreements (FTA).	Generalized method of moments (GMM).
Ismail (2020)	Digital trade facilitation and bilateral trade in selected Asian countries	Three digital dimensions (DD), namely, digital infrastructure, digital usage and digital security on trade using selected Asian countries and 20 selected trade partners.	Hausman and Taylor estimation is used to allow the time-invariant model to be included and at the same time to remove correlations between the error terms.
Egger, Larch and Yotov (2021)	Gravity Estimations with Interval Data: Revisiting the Impact of Free Trade Agreements	Free Trade Agreements	Dynamic-adjustment effects
Irshad, Wu, Xin and Khan (2021)	The application of the gravity equation while accessing the environment of Pakistan-ASEAN technological trade flows	Trade in Exports, bilateral exchange rates, Investment in High, Medium, and Low Tecnological Firms, WTO subscription, FTAs.	PPML estimation technique

Source: From the literature review.

General specification for gravity models

The gravity model is estimated under the assumption that there are no barriers to trade so that trade can be directly obtained as a function of the size of each country's economy and indirectly as a function of the distance between countries (Arapova and Isachenko 2019; Tinbergen, 1962):

$$TRADE_{ij} = (GDP_i, GDP_j, DIST_{ij})$$

Where trade from the country of origin (i) to the country of destination (j) is given by the function of the country of origin's GDP by the GDP of the destination country and the distance (Dist) that separates these countries. One alternative to specifying a linear model is by expressing the equation in its log-log form as follows (Tinbergen, 1962):

$$\ln(TRADE_{ij}) = \ln(GDP_i), \ln(GDP_j), \ln(DIST_{ij})$$

Two main features characterize this transformation. Firstly, it converts the initial equation to the linear form, simplifying the calculations. Secondly, it clarifies the interpretation of the results, as the coefficients show the elasticity of the trade flows to explanatory variables (Arapova and Isachenko 2019).

This model links trade between two countries with their income and the distance that separates them (Deardorff, 1998), representing an analogy to the theory of universal gravitation proposed by Isaac Newton and stating that the force with which two celestial bodies are attracted is proportional to the product of their masses divided by the distance between them squared (Kleppner and Kolenkow, 1973) and expressed in logarithm to allow uniformity of variables and marginal analysis of the model.

Implementing dummy variables is commonly used (Salvatici, 2013). An example is using dichotomous variables for the effect that occurs on trade when two countries share common borders, resulting in an equation for the augmented gravity model in the form:

$$lnX_{ijt} = \propto + \beta_1 lnY_{it} + \beta_2\, lnY_{jt} + \delta lnD_{ij} + \beta_3 N_{ij} + \beta_4 V_{ij} + \varepsilon_{ijt}$$

Where N corresponds to the dummy value of the attribute for countries with shared borders and V corresponds to the variable's value that measures the effect of the presence or absence of other commercial policies named trade agreements (Salvatici, 2013). Furthermore, where $\propto$, $\beta 1, \beta_2, \beta_3, \beta_4$ are coefficients to be estimated. Finally, the error term captures any other shocks, events, and unobserved factors that may affect bilateral trade between the two countries.

General Hausman–Taylor specification

The selected methodology of this research is based on the contributions of Egger and Pfaffermayr (2004). They entitled their research "Distance, Trade, and FDI," using an econometric technique of the Hausman-Taylor estimator (1981) to obtain estimates of the proposed model with variables invariant over time.

The random effect estimator gives the first insight into the econometric estimation, implying that the error term is independent and distributed identically. This implies homoscedasticity, non-autocorrelation, and non-temporal correlation within the panel (Serlenga and Shin, 2007).

Regressors may be correlated with the unobserved error term in the fixed effects. In the presence of such autocorrelation, the generalized least squares (GLS) and least squares (LS) techniques produce biased and inconsistent estimators for the parameters of the equation, and the standard procedure for solving this problem is through the transformation of fixed effects. However, this transformation eliminates the invariant elements over time, which is a severe problem when the interest of the research is based on such invariant elements over time (Hausman and Taylor, 1981). Therefore, the Hausman-Taylor estimator's approach solves both the use of fixed effects and the use of random effects, other applications of these estimators can be observed in Cornwell and Rupert (1988) and Serlenga and Shin (2007).

Hausman and Taylor (1981) suggest an instrumental variable approach using the time-variant exogenous variables in random effects as instruments for the time-invariant endogenous variables. Consequently, the Hausman-Taylor estimator is a multistep process that approximates the time-invariant variables. The Hausman-Taylor estimator then estimates a weight for a feasible generalized least squares (FGLS) estimator using the estimated variances.

The HT estimator approach allows combining the random and fixed effects methodologies to estimate the coefficients since static panel data models that include endogenous time-invariant variables correlate with individual effects (Chatelain & Ralf, 2021). The Hausman-Taylor (HT) estimator groups variables into four primary categories named time-variant exogenous (X1), time-variant endogenous (X2), time-invariant exogenous (Z1), and time-invariant endogenous (Z2), where the following equation can be derived:

$$\text{(HT)} \qquad Y_{it} = X1_{it}\beta_1 + X2_{it}\beta_2 + Z1_i\delta_1 + Z2_i\delta_2 + a_i + u_{it}$$

Where (i) is the unique country identifier, (t) is time, commonly the reference year, (Y) is the bilateral trading quantity, (β) and (δ) are vectors of coefficients, and (u) are the residuals. So, the endogenous variables are those correlated with the individual effects. As a result, this approach can estimate the model using non-time varying variables with non-biased results (Montero, 2011).

Gravity model for México´s exports

This research applies an econometric approach and proposes a Hausman-Taylor model to estimate Mexico's gravity model of exports to its trading partners from 1995 to 2020. The economic data for this research is organized in panel data consisting of seven cross-sections for the countries corresponding to Mexico's main trade associates.

Even if there is no consensus about the proper econometric estimation methods of the model (Shahriar, S *et al.*, 2019), the main advantage of this arrangement in panel data is that it could use regression coefficients that cannot be estimated with cross-sectional data or time-series data (Arellano and Bover, 1990). Consequently, the empirical specification for the variables of this work follows the analysis proposed by Egger and Pfaffermayr (2004), who states that the analysis of the impact of invariant variables over time as the distance is more appropriately estimated with Hausman-Taylor's econometric technique (1981) which has been discussed in the corresponding section.

In another line of thinking, the model used for this research has the logarithm form, which provides the estimators, and measures of Y elasticity relative to X, which means that the results may be interpreted as the percentage of change in Y from a unit percentage increase in X (Jiménez and Gea, 1997).

Under these specifications this research proposes an econometric model with the equation of the form:

$$lnEXP\_R_{ijt} = \beta_0 + \beta_1 lnGDP\_T_{ijt} + \beta_2 lnGDP\_SIM_{ijt} + \beta_3 \, lnGDPpc\_DIF_{ijt} + \beta_4 lnDIST_{ijt} + \beta_5 FTA_{ijt} + \beta_6 LANG_{ijt} + e_{ijt}$$

This research follows the econometric specification proposed in Egger gravity models (2002; 2004) and the form proposed by Serlenga and Shin (2007). From both perspectives, it can be derived the following strategy that resumes the operationalization work for the variables used in this research.

Table 2. Research variables

Name	Variable	Operationalization	Description
Real exports	EXP_R		Real total exports logarithm
Total real GDP	*GDP_T*		Real GDP sum from the origin and destination country logarithm.
GDP Similarity	*GDP_SIM*		Similarity index: (SIM = 0) complete divergence (SIM = 0.5) complete similarity
GDP per capita difference	GDPpc_DIF		The absolute value of the difference in GDP between origin and destination country
Distance	DIST	Geographic (physical) distance.	The physical distance between capital from origin and destination country in kilometers.
Trade agreements	FTA	Dummy variable	1 –Presence of a shared condition 0 –Absence of shared condition
Language	LANG	Dummy variable	1 –Presence of a shared condition 0 –Absence of shared condition

Source: From the literature review.

In the original estimation by Tinbergen (1962), as well as in all subsequent analyses (Linnemann, 1966; Anderson, 1979; Krugman, 1980; Leamer, 1988; Feenstra, 1995; Anderson and van Wincoop, 2003; Kimura and Lee, 2006; Helpman *et al.*, 2008) the coefficients by GDP and distance resulted relevant and significant and had 'the typical signs' following the classical economic theory. The coefficients by country size were positive, while the ones by distance variable were negative.

Econometric testing

The panel gravity model needs to address the CSD to avoid bias, inefficiency, and inconsistency due to unobserved heterogeneous time-specific factors that lead to biased estimates of the conventional gravity coefficients, Harris *et al.* (2012) suggest applying two second-generation panel unit root tests that allow for Cross Section Dependence (CSD) Pesaran (2007) and Dumitrescu *et al.* (2006).

This research adopts an estimation strategy based on formal econometric tests for data panels. In this sense, econometric tests were carried out to validate the consistency of the model with econometric theory, obtaining for the Cross-Section Dependence test that in all variables, there is cross-country independence, and the variables within each country are not related to others.

The econometric estimates from the panel data commonly assume that bilateral trade flows and the non-dummy explanatory variables are all stationary. Econometric literature suggests that unit root tests show greater power in panel data analysis. The Levin–Lin–Chu (LLC, 2002), Im–Pesaran–Shin (IPS, 2003), and Fisher-type (Choi 2001) tests are commonly used unit-root tests to examine the stationarity of the heterogeneous panel data with logarithms for bilateral export flows. However, for this research, the unit root test suggested by Pesaran (2007) is applied, confirming that the variables are integrated into order one since the series have unit root at levels but are stationary in first differences to 1% significance.

Also, Fisher-Johansen's cointegration test, which uses the trace test and the maximum eigenvalue test (MVP), indicates at least two cointegration relationships since the null hypothesis is rejected at a significance level of 1%, confirming the existence of a relationship between variables.

Results

In the analysis of the coefficients obtained in the estimation of the model, it is essential to recall that the results are best interpreted in terms of the marginal change in the variables. In this way, the coefficients indicate the percentage effect caused by the percentage change of a unit in the variables.

Within the results of econometric estimation, it is possible to divide the analysis into three different dimensions of the effect of the variables. First, the statistical significance of the marginal effect of variables can commonly be measured by probabilistic value at 95% confidence. Second, the analysis of the expected signs in the variables allows concluding the perspectives of the behavior of the variables that make up the model; finally, the net effect of the variables is measured by the coefficient obtained in the estimation.

In the results obtained in estimating the econometric model for Mexico's exports, the first component to be highlighted is that probabilistic value produces significant values, taking as reference a value of 95% confidence, in the variables selected for the study. In addition, it should be noted that for the total GDP and Distance variables, probabilistic values are also significant at the level of 99% confidence, so this result allows us to see the greater importance of the effect of distance and GDP on Mexico's export flow determination.

Table 3. Hausman-Taylor estimation

EXP_R	Coefficient	st. error	Prob.
Time varying			
GDP_T	1.253431	.2129928	0.000
GDP_SIM	.2307141	.3884886	0.553
GDPpc_DIF	-.1597459	.0604522	0.008
FTA	.0876538	.1218492	0.472
Time-invariant			
LANG	.5135838	.460877	0.265
DIST	-2.170203	.4552668	0.000
Constant	-.7309718	7.109855	0.918
sigma_u	.56043063		
sigma_e	.37200913		
rho	.69414594		

Source: own elaboration.

The individual analysis of the variables allows noting that the results obtained show that the coefficient sign is positive in the GDP_T variable, which is consistent with the expected results according to economic theory and literature review. Therefore, the coefficient obtained for this variable allows insight into the marginal change in total GDP Mexico's exports would increase by 1.25%.

The index of the similarity of GDP indicates that the more significant the difference in countries' GDP is, there will be a lower level of trade. Therefore, the results show that for this variable, the coefficient obtained indicates that when the similarity of GDP shows a marginal change, thus Mexican exports benefit by 0.23%. This result indicates that trade responds almost proportionally to changes in GDP. The nature of the index indicates that joint growth in economies generates synergies that strengthen international trade. These results confirm Linder's Hypothesis and the New Theory of Trade approach.

Contrary to the GDP per capita ratio, a negative sign is observed, indicating that when countries show an increase in their differences, or when they move away in the similarity of their GDP per capita, there is a negative impact on the attraction of Mexican exports of 0.1% in the face of a marginal change in the difference in similarity.

The main advantage of the Hausman-Taylor estimator is the separation into the group of variant variables over time. For example, it is observed that the existence of agreements benefits international trade and has an influence of 0.08% on the determination of the attraction of Mexican trade in this same sense. However, in the variables that represent the variables invariant over time, the common language benefits from trade, and when the same condition is present, trade benefits 0.5%. Finally, it should be noted that while the language in a region is not fixed in the long term, the language has not undergone significant changes during the studied period.

The hypothesis refering to the decrease of trade among physical separated countries confirms that distance inhibits export performance. In the estimation of the model, a negative coefficient of -2.1% was obtained. In absolute terms, this coefficient is the highest obtained in the estimation. This concludes that the distance between countries is no small issue in international trade. Although globalization increasingly influences global behavior and brings international markets closer, transportation costs arising from a distance between countries strongly influence Mexico's business activity.

Elasticity analysis

Given the use of logarithm to estimate the model, it is possible to summarize the analysis of export performance and elasticity in Table 4. Elasticity tells us what proportion dependent variable is sensitive to a marginal change in explanatory variables.

Table 4. Elasticity test

Variable	Result
GDP	Significant coefficients at 1%, positive and elastic
Per capita GDP	Significant coefficients at 5%, negative effect, less than proportional (this result is as expected regarding the behavior of the index that captures this variable).
Distance	Significant coefficients at 1%, negative and elastic.
Trade agreements	Significant coefficients at 5%, positive effect and less than proportional.
Common language	Significant coefficients at 5%, positive effect with an almost elastic behavior.

Source: From the estimation results.

Elasticity exists when the impact on the dependent variable is more significant than proportional, whether the measured impact at absolute values of 1% on one of these variables results in a change greater than 1% in Mexican exports.

In this way, exports are elastic concerning GDP and the distance between countries. Since the estimate shows an impact of 1.25 and -2.1%, respectively, both observations show the importance and relevance of the gravity analysis. Therefore, the original model's analogy identifies these two factors: the relative size of countries measured by GDP and their distance.

Along the same line of thinking, the similarity of GDP and language reach close values of 0.23% and 0.51%, respectively. The impact of both explanatory variables is less than proportional. Nevertheless, it is undeniable that they play an essential role in the rapprochement of Mexican foreign trade. Against the expected results, the coefficient obtained for trade agreements is low at 0.1%. These results show that agreements promote trade growth among trading countries. However, the low value of the coefficient suggests that it is the economic and market capacity of the countries that determine the attraction force of Mexican exports by their trading partners.

Discussion and conclusions

The neoclassical approach to international trade has proven insufficient in explaining international trade patterns. The presence of intraindustrial trade in trade is a manifestation of these shortcomings. In this way, the contributions of the New Theory of International Trade seek to complement the theoretical foundations for international trade. Consequently, there is still room to understand these features. The gravity model proposed in this work aims to understand the causes and determinants that lead the countries to sustain commercial activities with Mexico. The model proposed in this paper suggests that the economic conditions, such as GDP and per capita income, contribute to the development of international trade in combination with other factors such as physical and commercial closeness, represented by trade agreements and in some cases other cultural common features as the shared language.

In consequence, the methodology used under Hausman Taylor's technique rescues this approach to distinguishing the influence of variables that are not of strict economic nature but which undoubtedly have a significant relative influence on the settlement of international trade, such as the similarities between countries and above all the use of distance as a variable that is a fundamental feature of gravity analysis.

Results suggest that countries with large GDPs will export more to all destinations since they produce many varieties (Helpman and Krugman, 1985). Moreover, nations with large GDPs must have lower relative prices and, as a result, higher opportunities to sell all their production in market-clearing conditions (Anderson and van Wincoop, 2003). At the same time, import accompanies the industrialization process, driving national GDPs, especially in a group of developing countries (Grossman and Helpman, 1991), and applies to export, accelerating economic growth, which, in turn, leads to higher import (Frankel and Romer, 1999). Thus, there is a direct correlation between GDP and foreign trade with causality, running in both directions (Kadochnikov and Fedyunina, 2013; Nakawiroj, 2016).

Regarding the current context of the world economy since 2020 due to the global coronavirus pandemic, which, in addition to the health consequences, hinders trade due to border closures and has led to a contraction in economic performance among the entire world. In this context, the transportation issue for international trade has increased due to the growth of e-commerce. As a result, it is typically said that distance has been shortened in the globalized world. In this sense, this work can provide an empirical view of the effect of such a relationship between the physical separation of countries and the increase in trade activities, showing that there are still challenges to be overcome to facilitate and promote economic development through international trade.

In addition, this work allows identifying a new research line on whether the modern economy is heading towards a new regionalism, supported by the closure of borders due to the global pandemic and the recent political discourse for protectionism. This phenomenon, in itself, has been mainly shown by the increasingly notorious presence of intra-regional trade in raw materials and the increasing emergence of regional cooperation agreements, which in sum, promote that international trade is based on goods whose production has taken place within the limits of specific regions where countries cooperate in order to create products with greater added value and thus more significant economic spillage in the region. This research line is feasible by analyzing intra-industrial trade flows within specific regions and inter-industrial trade flows of final consumer goods.

Future research can be directed to investigate if these results could be replicated at the level of industrial sectors and firms. However, at this time, it is not possible to hold a significant impact in determining international business. Instead, the consensus is that the bulk of trading costs are due to trade-reducing factors such as differences in legal systems, administrative practices, market structures, networks, languages, and monetary regimes (Fratiani, 2009).

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