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Commercial dynamics of mexican tomato in the framework of the USMCA: an analysis of trade with the united states using the gravity model

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ABSTRACT

Objective: Within the framework of the treaty between Mexico, the United States and Canada (USMCA), the objective of this study is to provide a description through econometric methods of the variables that influence tomato trade, in addition to describing the commercial dynamics of the sector in both Mexico and the United States.

Design/Methodology/Approach: A gravity model was applied to investigate and evaluate the role of some of the main economic and geographic variables as determinants of Mexican trade flows.

Results: The results show that the most important variables are the US gross national income *per capita* (GNI_{PC}), as well as the US *per capita* production and consumption volumes calculated from apparent national consumption (ANC). It was also found that the variable GNI_{PC} is better to determine the model than the gross domestic product *per capita* (GDP_{PC}), due to the qualities of the variables.

Limitations/Implications: Statistical records for the period 1994 to 2020 were taken into account, considering all varieties of tomato produced and exported.

Findings/Conclusions: Regarding income, the variable with the best fit in the model was in GNI_{PC}, which was adopted in the World Bank's current way of classifying countries by income, variables such as consumption and production behaved in a typical way increasing and decreasing the volume traded. Tomato (*Lycopersicon esculentum* Mill.) is one of the most competitive and profitable agricultural products in Mexico.

Keywords: Agricultural Econometrics, International Agricultural Trade, Agricultural Competitiveness.

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INTRODUCTION

Mexico is the main supplier of tomato worldwide, with an international market share of 25.11% of the value of world exports (SAGARPA, 2017). Tomato (*Lycopersicon esculentum* Mill.) is one of the most consumed vegetables in the world (Castillo, Moreno-Pérez, & Cruz-Arellanes, 2009). It is one of the most important horticultural species produced in Mexico, due to its importance not only as a generator of foreign currency, but also because of the high economic spillover it generates (Reyes, 2014).

Image by Alexa at Pixabay

According to SIAP (2017), production was 3.35 billion tons. Since 1994, Mexico has a free trade agreement with the United States and Canada that allows it to have preferential treatment in terms of international trade with both nations; the agreement has had several modernization processes and in its latest version was given the name United States-Mexico-Canada Agreement or USMCA.

The USMCA is the new trade agreement between Mexico, the United States and Canada that replaces the North American Free Trade Agreement (NAFTA). On November 30, 2018, the three nations signed a new agreement to begin the process of updating the Treaty within the framework of the G-20, held in Buenos Aires (FORBES, 2020); this update did not modify what was previously established for tomato trade in NAFTA.

The red tomato or tomato taken into account for analysis in this study, according to the Committee for Tariff Classification (CCA-CAAAREM) (2021), is represented by tariff fraction 070200 and refers to fresh or refrigerated tomatoes; it is not subject to tariffs for exports or imports, and its import is not subject to payment of the value-added tax (VAT). The SIAVI (2021) specifies that there is no applicable tariff for imports from the United States and Canada.

NAFTA established a trade liberalization regime of up to 5 and 10 years for some horticultural products, which included the establishment of tariffs and safeguard fees during the period of total trade openness. In the case of tomato, several periods were established to consider seasonal factors. From November 15 to February 28 (Period 1), the tax relief period was established for 10 years with a tariff of 3.3 US dollar cents per kilogram and a safeguard fee of 172.3 thousand tons, which would grow at a compound annual rate of 3%. From March 1 to July 14 (Period 2) the tariff has been zero since the beginning of 2004, with a rate of 4.6 US dollar cents per kilogram and a safeguard fee of 165.5 thousand tons, which will also increase 3% each year. A 5-year tax relief period was established for the periods from July 15 to August 31 (Period 3) and from September 1 to November 14 (Period 4), with tariffs of 3.3 and 4.6 US dollar cents per kilogram, respectively; in this case, no safeguard fee was established (Bay, DeFrehn & Fox, 1994). According to Garcia, Williams and Malaga (2005), such tariffs and safeguards were a consequence of the protection granted to Florida producers by the U.S. Government.

During the 1999-2001 period in the North American market had a consumption and production of 4.37 and 4.31 million tons, respectively. The region was almost self-sufficient, since 98.3% of the demand was supplied by NAFTA countries, and only 1.7% came from the rest of the world. Of North America's tomato production, 99.7% was consumed in the same region. In the same period, consumption was 2.48, 1.64 and 0.255 million tons for the US, Mexico and Canada, respectively, while production was 1.89, 2.24 and 0.18 million tons (Garcia *et al.*, 2005). According to SAGARPA (2017), during 2016 Mexican tomato covered 90.67% of imports in the United States and 65.31% in Canada.

Currently, 100% of national requirements are met with domestic production, and world imports have increased 34.41% in the last decade, which has generated an increase in Mexican exports mainly destined to the United States (SAGARPA, 2017). Since there is self-sufficiency in the region, a considerable difference between Mexican production and consumption, it is logical to assume that the unsatisfied demand in the United States is supplied mainly by Mexican exports; the geographic position could be the most important factor to explain the success of exports, and Mexico's favorable climatic factors should also be taken into account, the seasonality of exports shows that between January and April are the months of greatest commercial flow abroad as shown in Figure 1. Consequently, from the above, an analysis is suggested through the gravity model.

As stated by CEPAL (2017): "The gravity model has been used to analyze the determinants of bilateral trade relations since its introduction by Tinbergen (1962). The basic idea is to approximate trade between two countries according to a Newtonian gravity rule, where the degree of trade is directly related to the size of the trading economies and inversely related to the distance that separates them. In the 1960s and 1970s it received much criticism regarding its foundation, since the models that explained trade patterns (Ricardo and H-O) were not able to explain the relationship. However, from the empirical point of view, the explanatory power and its robustness were unquestionable. Krugman (1997) referred to the gravity equations as examples of 'social physics', the relatively few empirical regularities that characterize social interactions". Because of this and Mexico's trade in the USMCA, it is appropriate to develop an analysis through the gravity model.

Due to the importance of tomato farming in Mexico's primary sector and in the global market, the objective of this study is to measure the effects of the USMCA on the growth experienced by fresh tomato exports from Mexico to the United States, which is the main importer worldwide, during the period 1994-2020, as well as to determine the effects of the total elimination of tariffs under NAFTA on Mexico's trade dynamics.

Due to the low level of tariffs agreed to in NAFTA and their subsequent elimination, the hypothesis put forward is that the effects of tariff relief have been moderate on the growth of Mexico-US trade. That is, it supports the claim that the absolute growth experienced by Mexico's exports to the United States during the period from 1994 to 2020 is due to non-NAFTA factors, as proposed by García *et al.* (2005).

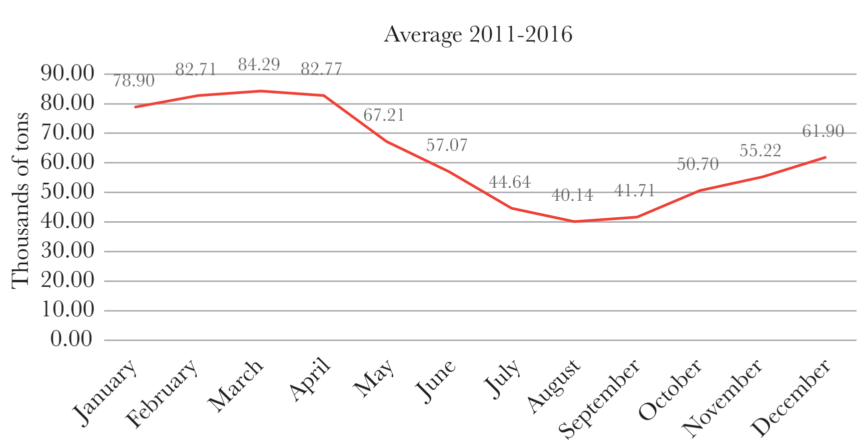

Figure 1. Seasonality of tomato exports.
Source: SAGARPA, 2017.

MATERIALS AND METHODS

The empirical evidence for the gravity equation in international trade is strong. The contribution made by Krugman (1980) was motivated in part by the empirical regularity of the gravity equation. His model explains how, in the aggregate, trade flows are proportional to country size and inversely related to trade barriers.

Distance and economic size have been remarkably stable variables over time, in different countries, and using several econometric methods. Existing theoretical models can easily explain the role of economic size in trade flow participation, but none explain the role of distance. To the extent that distance represents trade barriers, their model can also explain why distance has a negative impact on trade flows in general, but has nothing more to say about the specific role of distance (Chaney, 2011).

The gravity equation is very successful in explaining international trade empirically (Sá Porto, 2000). The gravity model represents a kind of spatial interaction model and can be used to calculate the number of interactions between two countries. The fundamental idea behind spatial interaction models is that the degree of interaction between two countries is a function of the degrees of concentration of people or things in the two countries, and a measure of the distance separating these countries (Cardoso, Rasetti, Giampietri, Finco & Shikida, 2017).

A time series gravity model was used to analyze the dynamics of trade between Mexico and the United States, member countries of the USMCA during the period from 1994 to 2020, considering data related to the trade of fresh tomato with tariff fraction 0702000.

Data documentation was carried out mainly through 5 sources: the Agrifood and Fishing Information Service (*Servicio de Información Agroalimentaria y Pesquera*, SIAP, 2021) with its Agrifood Information Consultation System (*Sistema de Información Agroalimentaria de Consulta*, SIACON NG, 2021) tool; the TRADEMAP tool that was developed by the International Trade Center of UNCTAD/WTO (INTRACEN, 2006); the FAOSTAT databank from Food and Agriculture Organization of the United Nations (FAO) which provides free access to food and agriculture data for more than 245 countries and 35 regions, from 1961 to the most recent year available (FAO, 2021); the United States Foreign Agricultural Service (USDA, 2021); and the World Bank's Open Access Data (World Bank, 2021).

The gravity model estimated to analyze trade dynamics has the following form:

$$Vcommercial_{Mx-USA}=\alpha_0+\alpha_1 GNIpc_{USA}+\alpha_2 GNIpc_{MX}+\alpha_3 PRODpc_{USA}+\alpha_4 CONSpc_{USA}+v_{ij}$$

Where: $Vcommercial_{Mx-USA}$=Is the commercial volume of US plus Mexican tomato expressed in tons. $GNIpc_{USA}$=Gross national income at real *per capita* prices for the United States. $GNIpc_{MX}$=Gross national income at real *per capita* prices for Mexico. $PRODpc_{USA}$=United States *per capita* tomato production. $CONSpc_{USA}$=Apparent national *per capita* consumption of US tomato. v_{ij}=Estimation error.

An ordinary least squares (OLS) regression was estimated to make an initial approximation of the results that were intended to be found through the proposed model. Signs of inconsistency were found, denoted by the values that were estimated for the t-Student test, which was designed to examine the differences between two independent and small samples that have normal distribution and homogeneity in their variances (Sánchez, 2015), which translates into the loss of the optimality of the OLS.

In this first estimation it was found that one of the main problems with the model was the serial autocorrelation and multicollinearity of the independent variables. This implies that the variances and covariances matrix of the disturbances present non-zero values in the elements outside the main diagonal (Gujarati, 2004; Griffiths & Judge, 1993), and not due to the estimated values of the t-test, but rather because it is an annual time series with 27 observations.

When the Durbin-Watson test was calculated and serial correlation was evidenced in an OLS regression, the Durbin-Watson test contrasts the first-order autocorrelation under the linear regression model with autocorrelation and tests whether the differences between consecutively observed residuals are very large or small (Universidade de Vigo, 2019), which implies that, according to Roldán Rosales (2021):

- The OLS estimator is still linear and unbiased, but it is not of minimum variance and there is another more efficient linear estimator.
- The variances and covariances of the OLS estimators are biased.
- The confidence intervals and the usual statistics for hypothesis testing are not adequate.
- The R^2 statistic is biased.

Therefore, the use of OLS to estimate the effects of the trade dynamics was initially ruled out. In this case, to correct the autocorrelation problem in the linear regression model it is necessary to perform a transformation of the model leading to the use of the generalized least squares (GLS) technique in the Cochrane-Orcutt or Prais-Winsten procedures (De Lira Arenas, 2011).

In addition, the use of robust estimators was applied in the definitive estimation, because it eliminates the loss of optimality of the OLS in face of two possible disturbances that normally occur in economic series in some abnormal periods, when the errors are not normal and the model may fail to be fulfilled (Yohai, 1984). The application of these two methods together could be expressed as a robust estimation in autoregressive processes, and showed improvement in the results of the hypothesis tests. All estimations were performed using STATA version 12 econometric software.

RESULTS

To decide which model was the most appropriate for analyzing Mexican tomato trade under the USMCA, this study applied the Durbin-Watson test to an ordinary least squares regression and resulted in a value of 0.93. The test showed the presence of first-order autocorrelation. This problem was solved by considering the minimization of standard errors through robust estimators in conjunction with the application of the Prais-Winsten methodology, and it was the best solution to estimate this gravity model which transformed the Durbin Watson test from 0.93 to 1.77; the results can be seen in Table 1.

Table 1. Results of the Gravity Model.

Dependent variable=Trade MEX-USA	Coefficient	Standard error	T-student	P-value
EE. UU. GNI *per capita*	4.95	2.71	1.82	0.082
Mexico GNI *per capita*	9.48	12.3	0.77	0.449
Production *per capita* EE. UU.	−261681.5	20375.97	−12.82	0
ANC *per capita* EE. UU.	264138.2	20560.25	12.85	0
Constant	−187697.8	101372.6	−1.85	0.078
R^2 0.94		Durbin-Watson	F(4, 22)=151.53	
		1.77	Prob>F=0.000	

Source: Prepared by the authors with data from World Bank, Trade Map, SIACON, INTRACEN, FAOSTAT and USDA.

The F statistic defines the hypothesis test that all coefficients are simultaneously zero; that is, all explanatory values together have no impact on the regression. Given that the calculated F value of approximately 151.53 is highly significant and the (Prob>F=0.000), it means that the variation in the dependent variable can be explained by the explanatory variables, with the coefficients in the model being different from zero.

The high R^2 value of 0.94 can be explained by the fact that the Mexican trade under analysis contemplates a long time series of 27 periods; variables such as a country's total production are variables that move very little during a short period of time, and the behavior of one period is highly influenced by the behavior exhibited in the previous period.

The use of Gross National Income (GNI) *per capita* instead of Gross Domestic Product (GDP) *per capita* is due to the methodology by Serajuddin & Hamadeh (2020) of the World Bank, where they use GNI to measure the income levels of countries and is part of the contribution to the gravity model methodology of this study.

Among the explanatory variables considered by the time series gravity model, the Mexican GNI *per capita*, which represents the purchasing power of the population, is not significant for tomato trade. One possible reason could be the existence of a relatively large domestic market; accordingly, Cardoso *et al.* (2017) argue that a home bias effect, such as local distribution networks, may play a more important role in trade compared to the GDP.

In contrast, the US GNI *per capita*, being a proxy for the magnitude of wealth, was a significant variable at 93% confidence. In particular, if "US GNI increased by 1%, US trade increased by 4.95 tons. According to this, it is expected that the higher the GDP of exporting countries, the greater their capacity to supply the consumption needs of importing countries (Cardoso *et al.*, 2017).

Regarding the consumption variable, representing the potential US tomato market, it showed a direct relationship with trade. The results indicate that increases in US consumption make US-Mexico trade increase. A possible reason is that tomato varieties produced in Mexico are highly demanded by US consumers, and because of this, trade in tomato produced in Mexico increases when US consumption increases, probably because it satisfies specific consumer interests and needs absolutely.

In relation to the production variable, it showed an inverse relationship with trade. Results indicate that increases in US production decrease trade between the US and Mexico. A possible reason is that tomato varieties produced in Mexico are less desirable than those produced in the US, so trade of tomato produced in Mexico decreases when US production increases. Finally, the distance and proximity variables are fixed effects, which is to say that they do not vary over time and would only generate collinearity; therefore, these variables were omitted from the model.

CONCLUSIONS

In order to determine the trade dynamics of the USMCA member countries on an annual basis, it is pertinent to take into account the entire series of data available since 1994, which generates sufficient data to perform procedures that correct problems generated by time series analysis. The OLS estimation was biased and lacked optimality due to the presence of first-order serial autocorrelation. This difficulty was solved through the application of the Prais-Winsten methodology in combination with robust estimators to ensure model optimality.

The ANOVA uses the F-test to determine if the variability between means of the groups is greater than the variability of the observations, due to the high calculated value; it can be concluded that not all means are equal, and the model is globally accepted to explain the phenomenon. The model in general presents a high goodness of fit due to its high R^2 statistic, a typical characteristic in time series models. The relationship of the F test and R^2 is fulfilled.

The way in which the economic level of countries can be determined has changed over time, and currently the World Bank is the international organization responsible for providing guidelines on how to classify the income of a nation and uses GNI *per capita*; this indicator gave much better results through the calculated t statistic than the classic GDP *per capita* used in gravity models consulted in the literature.

The GNI *per capita* for the US is accepted at 93% and shows a positive sign, which is in accordance with expectations, while for Mexico the statistic lacks significance and does not show the expected sign; this can be explained by the fact that tomato is a normal basic consumption good in Mexico.

The consumption variable was constructed through US apparent domestic consumption and has a positive influence on trade, which is to say US consumption fosters an increase in Mexican exports. Production showed the expected relationship because if US production increases, it is logical that it discourages imports from Mexico. The model assumes geographic proximity variables, because not changing the data generates collinearity in the regression, reason why the software omits them.

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