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Article

Determinants of the competitiveness of Mexican export tomatoes

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Abstract

Mexico is one of the largest producers and exporters of tomatoes, among other products; the dominant role of this Mexican horticultural product in the international market is due to its competitiveness. The research aimed to analyze the behavior of the competitiveness of the Mexican tomato and identify the main factors that establish the fluctuations in the 1994-2021 period based on a standardized linear regression model. The findings of the research suggest that Mexico has a relative advantage in tomato production and is superior to its closest competitors: Spain and the Netherlands, although with different fluctuations over time. It has presented significant falls in the periods of Mexico's trade liberalization and the 2007-2008 financial crisis; it is from 2016 when a period of ascent begins, with rates of 4.1% per year. Regarding the determinants of competitiveness, the most important are international unit prices and the carry-over effect of its competitors; a change of one standard deviation, *ceteris paribus*, was reflected in changes in its export performance ratio of 0.6846 and 0.821, respectively.

Keywords:

comparative advantage, exports, multiple linear model, time series.

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Introduction

Mexico is one of the largest producers and exporters of tomatoes, is the eighth largest producer worldwide with just over 2% of the total and the main supplier with around 20% (FAOSTAT, 2023). Despite the reduction in the planted area (SAGARPA, 2017), the constant increases in productivity have meant cumulative increases in production of up to 54.25% in the 2003-2016 period.

The 'dominant' role of Mexican tomatoes in world exports is due, among others, to their competitiveness compared to other nations, mainly with regard to the US. market, which is one of the biggest importers and it accounted for 23.56% of the total in 2021 (FAOSTAT, 2023). There are several factors that can explain this advantage, for example, climate, natural resources, availability of labor, geographical proximity to the US. market, technological differences, or differences in demand, etc. (Montaño *et al*., 2021).

As part of the current panorama of the sector, according to figures from FAOSTAT (2023) for 1994 to 2021, the first 10 tomato exporting countries have accounted for 75% of the volume offered to foreign trade and Mexico ranks as the largest exporter with 19.97% of the total.

Since 1994, Mexico's role in the international tomato market has grown. With respect to its traded volume, it went from being the second largest in the 1994-1999 period to ranking as the largest and maintaining its position throughout the twenty-first century. In less than 30 years, it has almost tripled its exports, with average annual growth rates of 5.4%.

This dynamic is only comparable to Turkey, Morocco, and Belgium, with rates of 6.36, 5.43, and 1.3%, but less than three times the volume of the main exporter. In contrast, for its closest competitors, Spain and the Netherlands, a reduction in its growth has been observed, and more recently, the trend has been slightly downward; for the first two years of 2020, there is an average reduction of 21.07 and 3.49%, compared to the 2010-2009 period.

Compared to the volume traded, a contrary trend was observed in unit prices throughout the period. The average annual growth rate has been -0.59% worldwide.

Despite this, the value of Mexican exports has grown significantly, from an average of 1.2 billion dollars in the 2000-2009 period to 2.5 billion in 2020-2021, more than double. This meant that, by 2020, tomato exports will represent 0.52% of the total value of Mexican exports and 29.71% if only horticultural goods are considered (Banco Mundial, 2023).

There can be various explanations behind this growth in the supply of exports despite reductions in unit prices; for example, reductions in production costs or increased productivity, trade agreements or exchange rate issues. In this regard, according to data from Banco Mundial (2023), the real exchange rate of Mexican pesos to US. dollars have grown at an average monthly rate of 0.57% in the 1994-2021 period, that is, approximately 7.08% per year.

Whatever the case, Mexico continues its leading role in the tomato export market. The research analyzes the dynamics and determinants of the competitiveness of Mexican tomatoes in the international arena and identifies the most relevant determinants in its fluctuation over time.

To this end, historical series of international trade and macroeconomic series of Mexico are used, the ratio of export performance is used as a measure of competitiveness, and based on a standardized multiple linear regression, the weight of the determinants and their impacts on competitiveness are analyzed. The processes used are detailed below.

Materials and methods

Measurement of tomato competitiveness

In the empirical literature on competitiveness, it is common to use indices of comparative advantage among nations, in particular the so-called export performance ratio or EPR (Balassa, 1965; Osuntogun *et al*., 1997; Serín and Civan, 2008; Kumar *et al*., 2008; Nwachukwu *et al*., 2010). The index is defined by the following ratio:

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$$EPR=\left(\frac{VX_{ict}}{\sum_{w}VX_{iwt}}\right)\Big/\left(\frac{\sum_{k}VX_{kct}}{\sum_{k}\sum_{w}VX_{kwt}}\right)$$

Where: VX refers to the value of exports, i refers to the exported good (in our case, tomatoes), k is the rest of the goods, t is the time, and c and w represent Mexico and the rest of the world, respectively. If EPR is greater than the unit, the country has a comparative advantage in exporting the product.

As noted by Abdullahi *et al*. (2021), the way in which EPR is traditionally calculated leads us to a double counting problem since the analyzed good is added both in numerator and denominator; to avoid this and to allow direct inferences to be made in the econometric analysis of EPR, the research employes the modified index by Vollrath (1991), which will be called REC:

$$REC=\left(\frac{VX_{ict}}{\sum_{w,w\neq c}VX_{iwt}}\right)\Big/\left(\frac{\sum_{k,k\neq 1}VX_{kct}}{\sum_{k,k\neq i}\sum_{w\neq c}VX_{kwt}}\right)$$

Thus, REC is defined as the ratio between Mexico's tomato exports in the world market and its share with respect to world exports of other commodities. Therefore, any increase in the tomato market has a direct impact on the competitiveness index.

The econometric model

The competitiveness of a country in the production of good; for example, tomatoes, is influenced by factors related to the market and those outside it. The first set is determined, among other things, by the country's domestic supply and demand and its endowment of productive factors (Nazir *et al*., 2021), exchange rates, production costs and internal and external unit prices (Bierut and Kuziemska-Pawlak, 2017).

For its part, the second group of variables that affect competitiveness are related to technological and structural factors for competitiveness, such as institutional strength and the capacity for innovation to reduce production costs (Bierut and Kuziemska-Pawlak, 2017).

In empirical applications, it is common to analyze competitiveness through some comparative advantage index based on geographical factors (Hou *et al*., 2019), the exchange rate and the real interest rate (Pratiwi, 2012; Mwansakilwa *et al*., 2013), changes in domestic policies, GDP, and the availability of productive factors (Nazir *et al*., 2021; Tandra *et al*., 2022), and the degree of specialization of the industry analyzed (Fetscherin *et al*., 2010).

The research proposes to analyze the factors that affect tomato competitiveness according to a multiple linear regression with the following specifications:

$$\ln REC=\propto+\beta\ln GDPP_{t}+\gamma\ln PRICE_{t}+\delta TA_{t}+\theta IP_{t}+\rho\ln E_{t}$$

1). Where: GDPP is GDP per capita, PRICE is the average export price of tomatoes in constant dollars, TA is a dichotomous variable equal to 1 when there are trade agreements, IP is a dichotomous variable that indicates changes in internal policies, and E is the average real exchange rate for each year.

It is expected that β>0: the larger the economy, the greater the production and competitiveness of the sector, γ>0: in the face of higher purchase prices, suppliers have incentives to produce and innovate, δ>0: trade agreements give certainty to suppliers and can increase their competitiveness, θ>0: when the policy encourages trade or subsidizes the countryside, and ρ> 0: the higher the exchange rate, the greater the economic benefit of the suppliers, who can reinvest and improve their technologies and therefore their competitiveness.

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In order to test whether the competitiveness observed in other countries has any carry-over effect on national competitiveness, changes in the observed export ratio (ΔRW_t) for Mexico's main competitors (the Netherlands and Spain) are added to equation (1). It is expected that $\tau > 0$ if there are carry-over effects on competitiveness, that is, as the rest of the countries increase (reduce) their competitiveness, this encourages (slows down) efforts to increase national competitiveness.

$$\ln REC = \propto + \beta \ln GDPP_t + \gamma \ln PRICE_t + \delta TA_t + \theta IP_t + \rho \ln E_t + \tau \Delta RW_t$$

2). Because the estimated parameters of (1) and (2) are in different units of measurement, their direct comparison is not possible. In order to identify the variables with the greatest impact on tomato competitiveness, the standardized version of the model was run (Siegel and Wagner, 2022).

Unlike the classical estimators, the interpretation of the standardized ones is related to the impact on standard deviations of the response variable to a change of one standard deviation of the explanatory variables, so higher coefficients are the most relevant.

Sources of information

The research uses FAOSTAT (2023) time series for tomato exports from each country i, both their volume (Xit) and value (VXit), from 1994 to 2021. From the division of the value of exports by their volume, the unit export prices (PXit) of each country i in year t were obtained.

For Mexico's GDP per capita, the historical series of Banco Mundial (2023) was used. Currency variables were deflated considering the US. price index (US. Bureau of Labor Statistics, 2023) and 2020 was taken as the base year.

For the TA variable (dichotomous, equal to 1 when there are trade agreements), the years considered were those in which the anti-dumping suspension agreement between Mexico and the United States of America has been renewed, which avoids the payment of average tariffs of 17.5% of Mexican tomato exports. Therefore, it takes values equal to 1 in 1996, 2002, 2008, 2013, and 2019 (CABC, 2013; SE, 2019).

For the exchange rate of Mexican pesos to dollars, monthly information from the economic information system (SIE, for its acronym in Spanish) of the Bank of Mexico for the 1994-2021 period was considered (SIE, 2024). For the annual data, the monthly average was considered. The figures were deflated based on the national consumer price index published by the National Institute of Statistics, Geography and Informatics (INEGI, for its acronym in Spanish) with base year 2018= 100.

Results and discussion

Figure 1 shows the modified export ratio index (REC). According to its interpretation, from 1994 to 2021, Mexico and its closest competitors (Spain and the Netherlands) are characterized by having a comparative advantage in tomato production (REC> 1); the fact that Mexico's indicator is higher leads us to infer that its degree of advantage is also higher.

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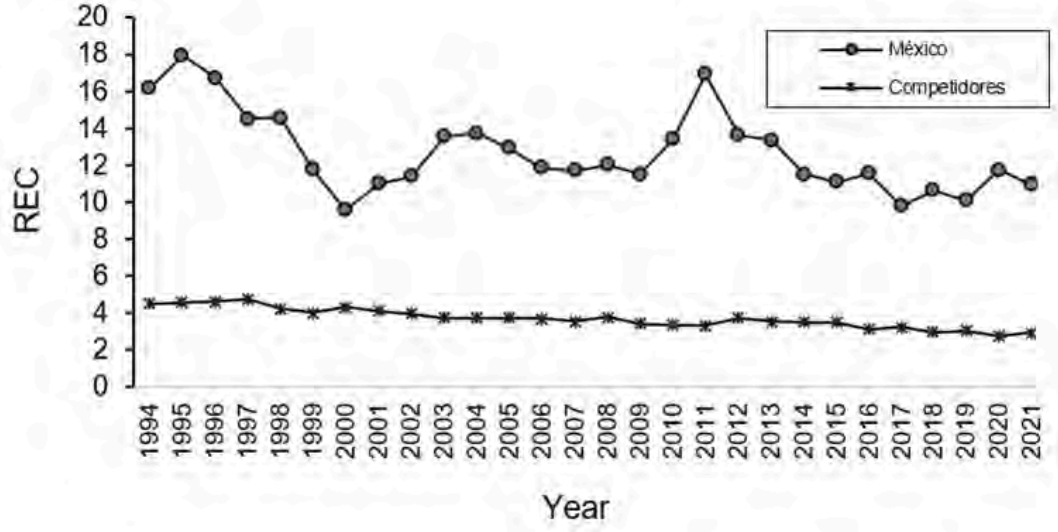
Figure 1. Modified export ratio index (REC) of tomatoes.



Based on the calculation and trend observed in REC, it is inferred that the 'privileged' role of Mexican competitiveness has not been stable; the peak of its indicator and its most pronounced falls can be found from 1994 to 1999; the average growth rate of the period is -6.11% per year.

In contrast, the first decade of the 21st century is characterized by being a stabilizing period; in its first five years, there is a recovery that gradually falls, possibly as a result of the US. economic slowdown (the main destination market) due to the real estate bubble and financial crisis of 2007-2008.

In the second decade of the 21st century, the negative trajectory of competitiveness continued and it is from 2016 that a period of ascent begins; in the first two years of 2020, there is an important recovery, with rates of 4.1% per year. For its closest competitors, there was a persistent downward trend, with a cumulative drop of 54.21% between 1994 and 2021. Table 1 shows the growth rates of the REC for the periods considered.

Table 1. Growth rates of the REC between different periods.

Period	Mexico (%)	Competitors (%)
1994-1999	-6.11	-2.47
2000-2009	-0.22	-1.56
2010-2019	-1.3	-1.18
2020-2021	4.1	-1.6

The periods were defined from the trade liberalization and by decade, which coincide with relevant macroeconomic shocks, which is why there is not the same number of years in each one.

The growth rates calculated are in line with what was found by Soto (2018) and Montaño *et al*. (2021), who, for the 1994-2016 and 2003-2017 periods, respectively and for the US. market, find Mexico to be a competitive country with various ups and downs in its indicators.

The Figure 2 shows: 1) on the main diagonal, the distribution of the quantitative variables used in the multiple regression model; 2) below the diagonal, the association between the variables based on scatter plots and 3) at the top, the coefficient of correlation between the variables; the number of asterisks is associated with the *p*-value of the Pearson correlation test.

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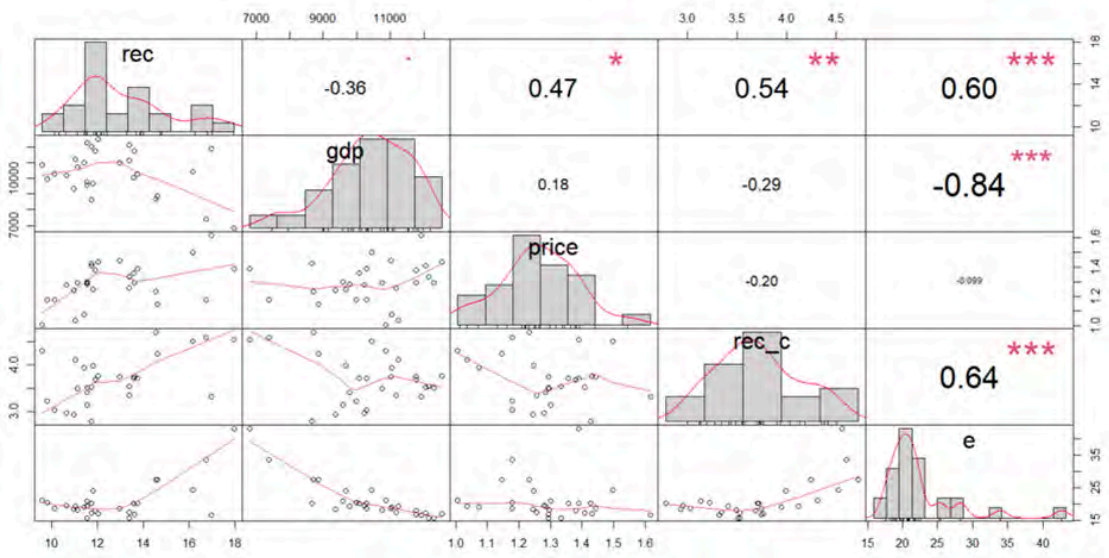
Figure 2. Distribution and correlation of the quantitative variables of the multiple regression model.



Thus, the competitiveness index of Mexican tomatoes is significantly and positively associated with the unit price in the international market, the index of the rest of the competing nations, and the exchange rate, and is negatively associated with Mexico's GDP. In addition, the rest of the covariates have a low correlation, so it is inferred that there is a low multicollinearity effect in the model.

As proposed in equation (1) and in accordance with the literature consulted, it is common to use logarithmic transformation in data modeling. To determine the adequacy of this approach, models with and without logarithms were run, comparing both using the Akaike (AIC) and Bayesian (BIC) criteria (Table 2).

Table 2. Comparison of the logarithmic transformation of model one.

Criterion	No logarithms	With logarithms
AIC	101.87	-37.91
BIC	109.87	-29.91

The results indicate that the model with logarithms has a better fit since it has lower values. Therefore, according to the available information, the logarithmic transformation of the data provides a better fit in the proposed models. Table 3 presents the estimators of the standardized models for equations one and two along with the *p*-values corresponding to the null-hypothesis tests that assume that the estimated parameter is equal to zero.

Table 3. Estimating parameters of the standardized models, response variable logarithm of the export ratio index.

Variable	Equation 1	Equation 2
Intercept	0.0181 (0.8967)	-0.03 (0.802)
GDP	0.458 (0.128)	-0.7051 (0.1268)
PRICE	0.5691 (0.0001)	0.6846 (0)
TA	-0.1015 (0.7637)	0.168 (0.5759)
E	1.0153 (0.002)	-0.5604 (0.327)
RW		0.821 (0.0047)

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Variable	Equation 1	Equation 2
F-statistic	9.8 (0)	12.85 (0)
R-squared	0.6302	0.7449

From equation (1), it can be deduced that both the international unit price and the exchange rate significantly and positively affect the competitiveness of Mexican tomatoes. Among these, the exchange rate has the greatest impact as a change of one standard deviation influences the competitiveness index by 1.0153. In contrast, GDP per capita and the renewal of the anti-dumping suspension agreement between Mexico and the United States of America (variable TA) do not show statistically significant differences from zero at 95% confidence.

Equation two incorporates the possible carry-over effect of competitiveness observed in other countries (RW). When comparing the estimators of both equations, it is observed that this effect is relevant for the analysis of the competitiveness of Mexican tomatoes, increasing the explained variability of the response variable from 63.02% to 74.49%. Compared to the other variables, RW is the most important in explaining competitiveness, since a deviation in the indicator of other countries promotes the national indicator by 0.8210 standard deviations.

Price becomes the second most influential variable, with an impact of 0.6846. The positive relationship between prices and competitiveness is consistent with what Hapsari and Yuniasih (2020) found in a similar study on the comparative advantage of cocoa exports to Germany.

This relationship is explained by the fact that export unit prices or international prices have a positive influence on domestic production and the development of competitiveness, as suppliers seek to take advantage of the surplus profits represented by high prices compared to domestic prices. In the case of tomatoes, Kumar and Rai (2008) found that, in the face of increases in export unit prices, exports increase, positively impacting comparative advantage indicators.

The results of model one show that the positive association of the exchange rate with the comparative advantage of Mexican tomatoes is as expected. An increase in the exchange rate, that is, requiring more Mexican pesos per dollar, makes national exports cheaper and makes products more competitive in price. This incentivizes local suppliers and promotes exports, directly impacting the comparative advantage index used in this research.

Based on the data observed in the first years of 2020, if the positive trend in Mexican tomato export unit prices continues, it is likely that the competitiveness of this horticultural sector will increase and that Mexico will continue its role as a leader in the international market, widening its gap with respect to its closest competitors. However, two risks are identified in the face of increased competitiveness: 1) the downward trend in exchange rates and 2) the inertia of the competitiveness of the rest of the countries.

Conclusions

Since the signing of the North American Free Trade Agreement, Mexico's role in the international tomato market has been outstanding. According to FAO figures, it ranks as the eighth largest producer in the world and the main supplier in the international market, with the United States of America as one of its main destination markets.

According to its REC, the Mexican tomato has a comparative advantage and is superior to closer competitors: Spain and the Netherlands. Despite its ups and downs, it has maintained its role as a leader and unlike the countries mentioned above, it has maintained its advantage and from 2016, a period of growth began, with average rates of 4.1% per year, so it is expected that this role of leader will last during this decade.

The findings of the research suggest that unit prices in the international market and the carry-over effect of competitiveness observed in other countries are the main factors that promote the competitiveness of Mexican tomatoes.

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