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Comparison of the Export Competitiveness of Limes from Mexico, Colombia, Argentina, and Brazil to the European Union

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ABSTRACT

Objective: To determine the competitiveness in the world and in the European Union of the main Latin lime-producing countries through the calculation of the normalized revealed comparative advantage to generate a discussion around the use of the free trade agreement that the countries have with the European Union.

Design/Methodology/Approach: Official sources were used to obtain the information in the period from 2001 to 2021, the normalized revealed comparative advantage was calculated and the behavior in the global market and in the European Union was forecasted. The Prais-Wisten method was used for the correction of autocorrelation.

Results: Competitiveness was estimated through the Normalized Revealed Comparative Advantage Index, both globally and in the European Union, for the main Latin American limes producers.

Study limitations/Implications: The limitation of the study was that it was only compared with Latin American countries, the study could expand its comparison with other regions of the world.

Findings/Conclusions: The main Latin American lime producers were compared using the NRCA. Mexico has maintained a competitive advantage since 2003, while Argentina lost it in 2004. Brazil became competitive in 2021, while Colombia is not. Argentina has the biggest advantage, although declining, and Brazil has surpassed Mexico since 2019. Projections show that Mexico and Brazil will continue to improve their competitiveness, while Argentina will reduce it. The concentration of production in Mexico is an opportunity for other regions with similar conditions to increase production and export to the European market. The proposed hypothesis is accepted.

Keywords: market precariousness, commercial diversification, commercial concentration

INTRODUCTION

The export of citrus fruits is one of the most important economic activities for the agricultural sector in Mexico. The country is a leader in both production and export, with the U.S. being the main destination (Ruiz *et al.*, 2016). According to Nicolás and Favila (2019), limes are one of the products with significant commercial potential because the production system is one of the most competitive in Latin America. In Mexico, limes represent one of the perennial crops with the highest production value (SIAP, 2023).

According to Trademap data (2023), Mexico ranks second worldwide in lime exports (705,596 t), after Spain (634,771 t), Turkey (594,140 t), South Africa (557,482 t), and the Netherlands (201,770 t). In terms of production, according to FAOSTAT (2023), India ranks first (3,548,000 t), followed by Mexico in second place (2,983,802 t), China (2,623,202 t), Argentina (1,826,355 t), Brazil (1,632,109 t), Turkey (1,323,000 t), and the U.S. (938,030 t).

Nationally, the types of lime produced are sour or Mexican lime (*Citrus aurantiifolia*) (43.13%), Persian lime (*Citrus latifolia*) (51.31%), and Italian lime (*Citrus limon*) (5.48%). Veracruz and Michoacán are the states with the highest production, accounting for 23.23% and 27.08%, respectively, followed by Oaxaca and Colima with 10% each (SIAP, 2023). According to SIAP data (2023), in 2022, there was a 4% increase in Persian lime production compared to 2021, while Mexican lime production increased by 3%. The cultivated area for limes overall saw a 2% increase. The highest production of limes occurs between July and December, which influences prices.

Zea *et al.* (2016) conclude that Mexican lime is the preferred variety nationally, although its export volume is limited due to its heterogeneous quality and shorter shelf life compared to other varieties, such as Persian lime. Caamal *et al.* (2017) mention that the Persian variety is easier to manage because the crop has fewer thorns compared to the Mexican lime variety. It is noted that Mexican Persian lime cultivation saw a commercial boom in the 1980s due to a phytosanitary issue with Mexican lime exports. Valencia *et al.* (2016) point out that while Persian and Mexican limes differ in crop management, greater integration of the lime sector is necessary in marketing to find new potential markets. According to Trademap data (2023), in 2022, Mexico exported 689,517 tons to the U.S., meaning that 97.7% of total exports are concentrated in a single destination. According to basic indicators of trade position, the concentration of both destination and origin countries for exports and imports depends on the number of destinations or origins; the more destination countries, the greater the trade diversification (Durán, 2008). The second most important trade agreement after the USMCA is the free trade agreement with the European Union. The modernization of the Global Agreement, which took place in 2020, established the elimination of tariffs on the remaining agricultural products that were not liberalized in the current Agreement (Delegation of the EU in Mexico, 2021).

The European Union is one of the most important markets in the world due to its purchasing power and the size of its population. Known since 1993 as the European Common Market, it had a GDP of 14,522,000 million euros in 2021 and comprised 23 million companies (European Council, 2023). Given the characteristics, the European Common Market is attractive from a commercial perspective, and access to it is of great importance for the diversification of international markets.

A comparison is proposed among Mexico, Colombia, Argentina, and Brazil. The justification for this approach is that they share similar conditions with Mexico in terms of trade balance and relations with the European Union. According to SICE (2023), all the Latin American countries in the study have trade agreements with the European Union. Mexico has an agreement through the Free Trade Agreement between Mexico and the European Union (TLCUEM) since 2001, while Argentina and Brazil are covered by the Free Trade Agreement between Mercosur and the European Union, which has been in

effect since 2019. Colombia formalized its relations with the European Union through the Trade Agreement between Colombia, Peru, Ecuador, and the European Union, which has been in effect for Colombia since 2013. Competitiveness is related to the natural conditions of producing regions, market demand, and technological change, which can lead to a geospatial concentration of production (Vargas *et al.*, 2020). This is an undesirable quality; in this case, lime production is highly concentrated in a few countries in the region, and therefore, competitiveness must be promoted.

Contreras and Leos (2021) state that in the agri-food sector, competitive products must meet consumer demand in terms of price, quality, and quantity while also being sustainable for producers. The objective of this study is to determine the competitiveness of the main Latin American lime-producing countries in the world and in the European Union through the calculation of the normalized revealed comparative advantage, to generate a discussion around leveraging the free trade agreement these countries have with the European Union. The hypothesis is that Mexico has competitiveness and that if it continues with the current pace of exports, it will position itself as a significant supplier and competitor in the European market compared to the main Latin American lime exporters.

MATERIALS AND METHODS

Official sources were used to obtain the information: two for international trade and one for the characterization of Mexico. The variables considered for all countries were exports, imports, and production from 2001 to 2021. Global trade data were obtained from the FAO database (2023) (Faostat) and Trademap (2023). For the collection of bilateral trade data, the databases provide homogenized information on the countries, which is pertinent for generating consistent statistical comparisons. The characterization of Mexican production was expanded; for this purpose, the information bank of SIAP (2023) was used.

Data Collection

Lime is a product with various exportable varieties both within and outside of Mexico. For this reason, the tariff classification number 080550 was considered for the documentation of the data, which, according to CAAAREM (2023), refers to lemon (*Citrus limon*, *Citrus limonum*) and limes (*Citrus aurantifolia*, *Citrus latifolia*). The variables used to calculate the global competitiveness of each exporter included the trade flows of each country with the world. The data were obtained through Faostat (2023); this database is pertinent for considering trade without a specific destination market.

Regarding the calculation of the NRCA for Mexico, Colombia, Argentina, and Brazil, exports and imports between each Latin American exporter and the European Union were analyzed, resulting in the competitiveness of each exporter in this specific market. Documentation was done through Trademap (2023), as it allows for the collection of bilateral trade information. The econometric estimates were conducted using STATA software version 17.

Normalized Revealed Comparative Advantage Index

The NRCA is an important tool in formulating trade policies and economic development strategies, as it allows countries to determine areas of specialization and make informed decisions about how to allocate resources and compete in international markets. To estimate competitiveness and identify the best exporter in the European market and globally, the NRCA index created by Yu *et al.* (2008) was used, adapted for a specific market by Contreras and Leos (2021). Furthermore, the index is more precise and consistent than other measures used due to the theoretical properties of normalization.

The calculation was performed over the period from 2001 to 2021; the start is marked by the entry into force of the TLCUEM, and 2021 is the last available year, representing 21 observations, a consistent time series for econometric forecasting (Harrell, 2015). The NRCA was calculated for each of the four countries, both in the European market and globally, and its mathematical formula was as follows:

$$NRCA = \frac{\Delta E_{jm}}{E} - \left[\frac{E_m}{E} \right] \left[\frac{E_j}{E} \right] \qquad [1]$$

Where: E_{jm} represents the lime exports of each country in the world and the European Union; E_j is the total supply of lime including exports from the countries plus the internal supply of the destination and imports to the region from the rest of the world. For the global market, global production and exports were used; E_m refers to the exports of the group of fruit from FAOSTAT of the exporters, in both the global and European markets; and E is the total supply of all fruits in the global and specific market.

Trend of the Normalized Revealed Comparative Advantage Over Time

The calculation of the trend through regressions is a statistical technique used to analyze data and predict future values in time series (Moreno, 2008). To calculate the trend of the normalized revealed comparative advantage (NRCA), the following simple regression model was initially used through Ordinary Least Squares (OLS):

$$NRCA_t = \alpha_t + \beta_t + \varepsilon_t$$

Where: $NRCA_t$ is the NRCA index of lime; α_t is the intercept coefficient; β_t is the trend coefficient over time of the lime NRCA; and ε_t is the random error of the regression. The regressions were estimated using OLS, and inconsistencies were found in the t-student test, which demonstrates independence, normal distribution, and homogeneity of variances among the variables (Lugo and Pino, 2022). Therefore, the OLS estimation was not optimal. The Durbin-Watson test was calculated, and it was found that the cause of non-optimality in the regression was autocorrelation, which is a very common problem in regressions with time series data (Luquez *et al.*, 2022). Consequently, an econometric method using first differences was proposed.

Prais-Winsten Correction

Time series regressions are used to predict their behavior. Based on the calculated NRCA, regressions were performed, which had the issue of serial autocorrelation. Due to this, the Prais-Winsten method was employed to correct for autocorrelation.

First-difference methods offer many benefits; among the notable ones for this analysis is that the interpretation of the regressors is made as growth rates and also corrects the regression residuals, transforming them into white noise (Gujarati, 2010). The Prais-Winsten method is an econometric technique used to address autocorrelation in time series by transforming data and estimating adjusted regression models (Vougas, 2021). This method performs a first-difference transformation and generates optimal results. To ensure the correction of the problem, the Durbin-Watson test was applied again.

RESULTS AND DISCUSSION

A positive result indicates that a country has a comparative advantage, while negative results indicate a comparative disadvantage in the production and export of a particular good relative to the world or a specific market. Figure 1 illustrates the results of the calculation of the normalized revealed comparative advantage (NRCA) for Mexico, Colombia, Argentina, and Brazil in relation to global trade, and it also presents a linear projection for the period of 2022-2026.

Mexico has the highest normalized revealed comparative advantage (NRCA) among the countries considered in the study since 2003, and the trend is positive, showing the highest growth rate as well. This can be explained by the specialization in nine states of the republic (Vargas-Canales, 2020). Furthermore, Mexico's position in global exports is consistent with the findings of Canales *et al.* (2019), who state that Mexico accounts for 31% of citrus exports. Argentina was the country with the highest competitiveness from 2001 to 2003; however, starting in 2004, it has lost its competitive edge. From 2004 onward, the trend has generally been negative, which is also reflected in the projected years. Nonetheless, it is still considered competitive due to the positive index. Regarding
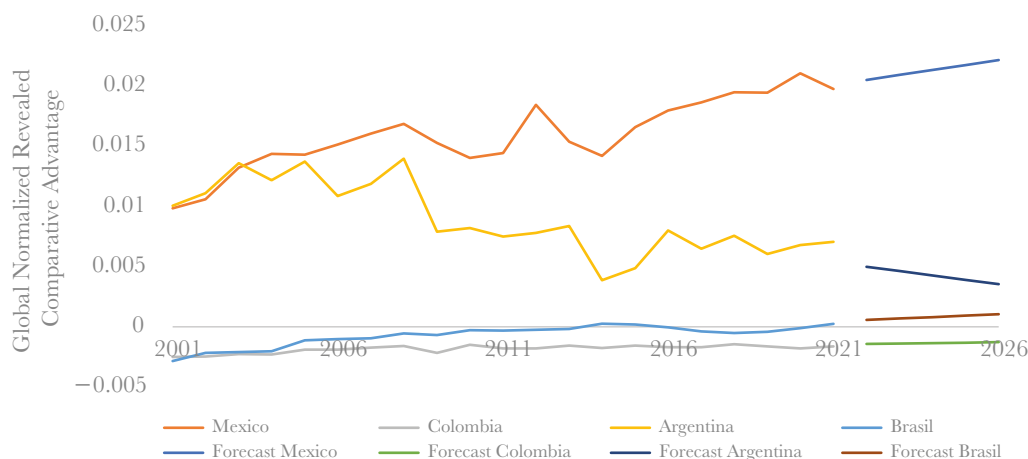
Figure 1. Global VCRN index for Mexico, Colombia, Argentina and Brazil from 2001 to 2021, and its extrapolation from 2022 to 2026.

Table 1. IVCRN in the global market, results of the regressions to first differences.

Independent variable=Time	NRCA Mexico	NRCA Colombia	NRCA Argentina	NRCA Brasil
Coefficient	0.000424	0.000038	−0.000340	0.000141
Constant	−0.838368	−0.078709	0.692626	−0.284378
T-student, time	5.90	4.24	−3.92	4.01
Prob > F	0.0005	0.0000	0.0005	0.0001
R-square	0.47	0.60	0.48	0.55
DW original	1.20	1.51	1.40	0.40
DW converted	1.70	1.98	1.90	1.87

Brazil, it has transitioned from being a non-competitive and therefore deficit country to a competitive one in 2021. In the years 2014 and 2015, it also recorded values indicating competitiveness. The trend is upward, and in the future, it could become a competitor to Mexico. Colombia, on the other hand, does not show a clear trend, but it can be seen from the previous figure that it does not possess a comparative advantage and does not demonstrate the potential to achieve one in the future.

The previous table summarized the regressions. All the t-student values are accepted, and the F probability is lower than the critical value, therefore they are valid, and the Durbin-Watson test values approach their optimal value. The coefficient values found allow us to conclude that Mexico is the country with the highest expected growth in the future, followed by Colombia and Brazil. For Argentina, however, a loss of competitiveness in the global market is expected.

European Market

Figure 2 represents the NRCA of Mexico, Colombia, Argentina, and Brazil in the European Union, which could demonstrate the utilization of the various trade agreements with Europe.

In the previous graph, the results of the NRCA in the European market were presented. Argentina has the greatest advantage, although with a clearly decreasing trend, indicating a loss of competitiveness. Throughout almost the entire time series, Mexico held the second position, but starting in 2019, it was surpassed by Brazil, which experienced accelerated growth. Colombia, on the other hand, does not possess an advantage in this market, despite the fact that the Colombian agricultural sector has been one of the most benefited by the signing of the Free Trade Agreement with the European Union (Tamayo *et al.*, 2017).

Although in the last observed year, Argentina and Brazil were the countries with the highest competitiveness, the trend in the extrapolation of the NRCA can be seen. Extrapolations imply a certain trend; in the estimates, it is evident that the slope of the NRCA is greater for Brazil, followed by Mexico, while Argentina shows a tendency to become less competitive in the near future. Colombia, for its part, does not exhibit a clear trend and therefore is not considered likely to be competitive in the future. In Table 2, the results of the autoregressive regressions of the NRCA are presented.
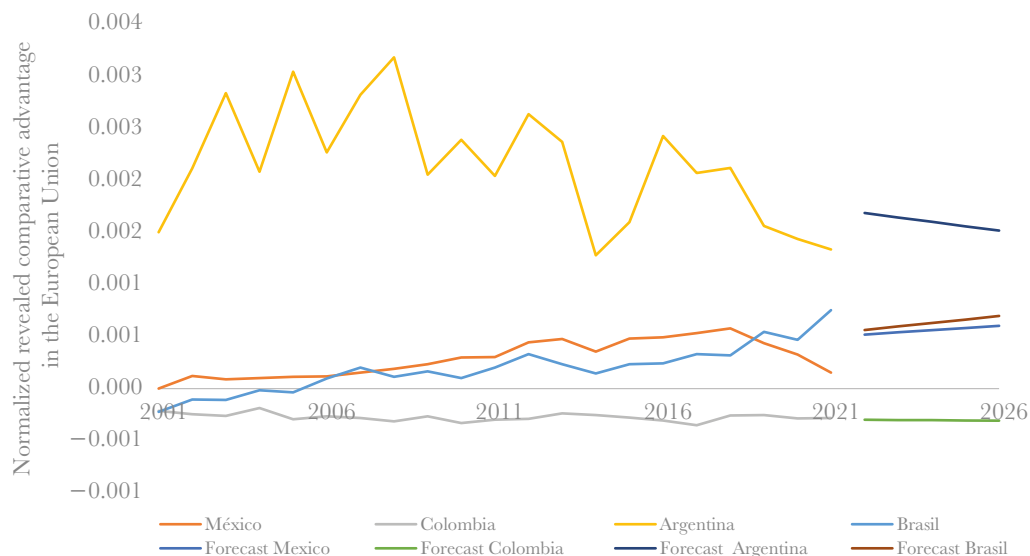
Figure 2. VCRN index for Mexico, Colombia, Argentina and Brazil from 2001 to 2021 in the European market, and its extrapolation from 2022 to 2026.

Table 2. IVCRN in the global market, results of the first difference regressions.

Independent Variable=Time	NRCA Mexico	NRCA Colombia	NRCA Argentina	NRCA Brasil
Coefficient	0.00001150	−0.00000226	−0.00004150	0.00003550
Constant	−0.022864	0.000427	0.085541	−0.071189
T-student, time	1.04	−1.68	−2.14	7.98
Prob > F	1.0000	0.2000	0.0625	0.0000
R-square	-	0.08	0.17	0.75
DW original	0.56	1.83	1.60	1.30
DW converted	1.48	1.93	1.73	1.80

The previous table summarizes the results of four regressions, where each dependent variable is the NRCA in the European Union for each of the American countries considered in this analysis. The independent variable is time, aimed at determining the future evolution of competitiveness. The value of the t-student test indicated that the significant regressions were only for Brazil and Argentina. The regressions for Mexico and Colombia were inconclusive, but the coefficients show that the future trend of competitiveness for Mexico and Brazil is expected to increase, while for Colombia and Argentina, the trend indicates a decline.

CONCLUSIONS

The main Latin American lime producers were compared using the NRCA. Mexico has maintained a sustained competitive advantage since 2003, while Argentina has lost competitiveness since 2004, Brazil became competitive in 2021, and Colombia is not competitive. Argentina maintains the highest advantage, albeit declining, and Brazil

surpassed Mexico starting in 2019. Projections indicate that Mexico and Brazil will increase their competitiveness, while Argentina will decrease it. The spatial concentration of lime production in Mexico presents an opportunity for other regions with similar conditions to increase production and, at the same time, enhance exports to the European market. The proposed objective was achieved, and the research hypothesis is accepted.

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