





Analysis of Mexican Cocoa (*Theobroma cacao*) Competitiveness

Análisis de la competitividad del cacao (*Theobroma cacao*) mexicano

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Received: June 13, 2023
Approved: July 23, 2024
Published: August 14, 2024

Subject Editor: Ingrid Fromm, Bern University of Applied Sciences, Bern, Switzerland.

To cite this article: Rivera-López, S., Nuñez-Betacourt, E. Y., Revilla-Chaviano, A., & Luquez-Gaitan, C. E. (2024). Analysis of Mexican Cocoa (*Theobroma cacao*) Competitiveness. *Ciencia y Tecnología Agropecuaria*, 25(2), e3427. https://doi.org/10.21930/rcta.vol25_num2_art:3427

Abstract: Cocoa has been present in Mexico since pre-Hispanic times. It was used in rituals, drinks, and even for trade. However, Mexico's share in the world cocoa market is currently meager. This research aims to establish the current climate of Mexican cocoa production and marketing. The dependency ratio and the revealed comparative advantage index were calculated to determine whether the Mexican market has taken advantage of its climatological and geographical characteristics. The results show that the country is not competitive in the international cocoa market; its share in both harvested area and production volume is zero, and the Mexican market's commercial demand for cocoa imports to satisfy domestic needs is high. The country's consumption of this crop depends mainly on imports from Ecuador, which is a risk because any issue in the cocoa production system would directly affect the Mexican market. In conclusion, Mexico is not competitive in the international cocoa market. The country's strategy should be to increase the harvested area and thus reduce its dependence on cocoa imports.

Keywords: Apparent consumption, trade balance, dependency ratio, revealed comparative advantage index, cocoa.

Resumen: El cacao ha estado presente en México desde la época prehispánica; se utilizaba en rituales, bebidas e incluso para el comercio. Sin embargo, en la actualidad, la contribución de México al mercado mundial del cacao es muy baja. Esta investigación tuvo como objetivo establecer el panorama actual de la producción y comercialización del cacao mexicano. Específicamente, se calculó el índice de dependencia y el índice de ventaja comparativa revelada para mostrar si el mercado mexicano ha aprovechado las ventajas comparativas de sus características climatológicas y geográficas. Los resultados muestran que el país no es competitivo en el mercado internacional del cacao; su participación tanto en área cosechada como en volumen de producción es nula. Además, la demanda comercial del mercado mexicano de importaciones de cacao para satisfacer sus necesidades internas es alta. El consumo de este cultivo en el país depende principalmente de las importaciones desde Ecuador, lo cual es un riesgo porque cualquier impacto en el sistema de producción de cacao en ese país repercutiría directamente en el mercado mexicano. En conclusión, México no es competitivo en el mercado internacional del cacao a pesar de ser el origen del cultivo. La estrategia del país debería ser aumentar la superficie cosechada y así reducir su dependencia de las importaciones de cacao.

Palabras clave: consumo aparente, balanza comercial, índice de dependencia, índice de ventajas comparativas reveladas, cacao.



Introduction

Cocoa (*Theobroma cacao*) is a tropical plant that brings profit and environmental benefits in a sustainable environment, so it is grown by more than 6 million farmers worldwide (Ricaño-Rodríguez et al., 2019). Besides, many nations plant and harvest cocoa for its nutritional value and medicinal properties (Suárez et al., 2021).

Referring to Mexican agricultural production is mandatory when writing about cocoa. Historically, the added value given to this product and its agroindustrialization began in the 16th century, when the Spanish conquest led to its introduction in Europe and its taste spreading throughout the country (Rovirosa Pérez & Pérez Akaki, 2020). *Theobroma cacao* originated in the Neotropics from South America (Lanaud et al., 2024), in Mesoamerica it was used as a bargaining chip. With the Spaniards' conquest of Mexico, cocoa was the first product that linked Mexico with Spain. The first evidence of cocoa in Mexico dates to 1900 and 1800 BC in Chiapas and Veracruz, respectively. Since cocoa is usually grown in the shade, and its fruit is heart-shaped, natives associated it with darkness, the underworld, and blood; thus, its use became important in rituals. Likewise, its consumption became exclusive to the upper classes, merchants, and warriors (Secretaría de Agricultura y Desarrollo Rural [SADER], 2019).

The world's most widely grown cocoa variety is Forastero because of its high disease resistance during cultivation, growth, and harvest (Tadeo-Sánchez & Tolentino-Martínez, 2020). According to genetic studies, there are three varietal types of cocoa in Mexico: Criollo (with its Criollo Antiguo and Criollo Moderno sub-varieties), Forastero, and Trinitario. The Criollo Antiguo variety is found in La Lacandona, Yucatan, and Michoacan, while the Criollo Moderno and Trinitario varieties are found in Tabasco (Tadeo-Sánchez & Tolentino-Martínez, 2020). At present, the denomination of origin, "Cacao Grijalva," protects the green or roasted cocoa produced in the Grijalva region in Tabasco State (México, 2006). This state has the largest production of this bean in the country.

In 2021, the cocoa harvested area in Mexico was 51.9 thousand hectares, a figure that evidenced significant productivity and low yield problems in many plantations, especially for small producers, due to genetic and management reasons, as well as socioeconomic problems caused by several severe diseases that affected the planted areas (González Rosado et al., 2022).

World cocoa production exceeds 4 million tons of beans. Côte d'Ivoire, Ghana, Indonesia, Nigeria, and Cameroon account for 84 % of world production; Africa as a continent contributes 73 % of production and 64 % of the area planted (Molina Martínez & Ramos Martínez, 2020). In 2021, the national cocoa production was 28.1 thousand tons, amounting to 1.17 billion pesos. The only states producing the grain that year were Tabasco with 17.4 thousand tons, Chiapas with 10.4 thousand tons, and Guerrero with 250 tons (Servicio de Información Agroalimentaria y Pesquera [SIAP], 2023).

Internationally, the country has been facing trade deficits regarding this crop. In 2020, 37.29 thousand tons were imported, and only 254.17 tons were exported. In the same year, the apparent national consumption of cocoa in Mexico was 66.46 thousand tons, with an apparent national *per capita* consumption of 530 grams, contrasting with the 700 grams per year consumed

in developing countries (Bermúdez et al., 2015). Cocoa imports accounted for about 58 % of the national apparent consumption. The main countries from which Mexico imports cocoa are Ecuador, Côte d'Ivoire, and the Dominican Republic, while the leading destinations for Mexican cocoa beans have been Switzerland, France, and Japan (SIAVI, 2023).

According to data from the SIAP for 2023, Mexico is fourth among cocoa producers worldwide, producing 170 thousand tons in 2023. However, Mexican cocoa marketing faces several challenges. These problems include the lack of infrastructure, competition from other producing countries, and a lack of added value; i.e., despite Mexican cacao's outstanding quality and flavor characteristics, its added value is limited. This lack of added value can be seen in how cocoa is exported. The marketing of Mexican cocoa can be improved through investment in infrastructure, promotion of products derived from Mexican cocoa, and collaboration between producers, governments, and companies (National Research Institute Forestry, Agricultural and Livestock [INIFAP], 2022).

At present, competitiveness, together with foreign investment and globalization, directly affect the economies of developing countries, mainly when referring to the commercial and agricultural sectors that support investment, credit creation, and capital circulation, among others, thus allowing greater opportunities for national development and growth (Rodríguez et al., 2020). This research aims to establish the current climate of Mexican cocoa production and marketing. Specifically, the dependency ratio and the revealed comparative advantage index (RCAI), were calculated to determine if the Mexican market has a comparative advantage.

The dependency ratio, or commercial dependency coefficient (Zavala Martínez et al., 2023), quantifies whether the foreign market satisfies the national consumption. If the estimator is close to one, it is concluded that production in the national market cannot supply domestic demand (Velín & Medina, 2011). On the other hand, the RCAI allows for analyzing the commercial exchange of exportable products between two or more countries (Goya, 2020).

Materials and Methods

Production and marketing variables were analyzed from 2004 to 2021; the period analyzed was determined by the availability of data in the Tariff Information System Via Internet (SIAVI) of the Government of Mexico. The tools allow measuring the capacity of a company, a sector, or an economy to compete in the global market, considering the technological, economic, and social transformations that occur globally today concerning Mexican cocoa (World Bank, 2023). Powerful longitudinal and evolutionary data analysis tools, used to study a variety of phenomena, including development, social change, and the effects of interventions (Preacher & Hayes, 2022), were employed to generate the historical outlook of the national and international Mexican cocoa market, as well as to analyze the trend of competitiveness indicators in the period, including the adaptation of Mexican cocoa to different environmental conditions (Duana-Ávila et al., 2023).

The variables analyzed included cocoa production since it determines the amount of cocoa available for sale (International Cocoa Organization [ICCO], 2022); performance, because it

determines the capacity of the Mexican producers to compete with producers from other countries; average country price to know the capacity of cocoa producers to maintain their operations and their livelihoods (Food and Agriculture Organization [FAO], 2022); volume, being an important factor for the sustainability of cocoa production, as it determines the ability to satisfy the demand for cocoa (Suh & Molua, 2022); and the production value to analyze the evolution of cocoa production in Mexico (Espinosa-García et al., 2015). The information was taken from the Agricultural Consultation Information System (SIACON, 2023). The rate of change of each production variable from 2004 to 2021 was calculated using the formula proposed by Pérez et al. (2010); Equation 1.

$$r_{t,0} = \left(\frac{x_t - x_0}{x_0} \right) \times 100 \quad (1)$$

Where r is the rate of change in percentage; x_t is the value of the variable in 2021; x_0 is the value of the variable in 2004.

The percentage of Mexican cocoa share in the world market was calculated. For this purpose, the harvested area, yield, and production volume of this crop were consulted in the Food and Agriculture Organization of the United Nations (FAO) database. The analysis period was from 2004 to 2021.

In terms of international trade, the Mexican cocoa trade balance was calculated, for which it was necessary to consult the export and import variables, both in value and volume. For this purpose, tariff item 18010001, "Cocoa beans, whole or broken, raw or roasted," was used. Data were taken from the Tariff Information System Via Internet (SIAVI, 2023). The main origins and destinations of the bean in question were also taken from this database.

To analyze the evolution of cocoa demand in Mexico, apparent consumption and apparent *per capita* consumption were calculated. Apparent consumption was calculated with the formula used by Miranda Miranda (2005); Equation 2:

$$NAC = P + M - X \quad (2)$$

Where NAC is the national apparent consumption of cocoa in tons; P is the volume of cocoa produced in Mexico; M is the imports of this grain by the Mexican market; X is the crop exported from Mexico.

The apparent *per capita* cocoa consumption in Mexico was calculated using Rivera and Gutierrez's (2019) formula (Equation 3).

$$PCC = (NAC/Pop) \times 1,000 \quad (3)$$

Where CPC is the *per capita* cocoa consumption in Mexico (in kilograms per person); NAC is the national apparent consumption of cocoa in tons; Pop refers to the Mexican population, taken from the World Bank (2023) database.

The two competitiveness indicators calculated were the dependency ratio and the RCAI. The dependency ratio was calculated with Equation 4, as stated by Moreno et al. (2016).

$$DR = \frac{M}{NAC} \quad (4)$$

Where DR is the dependency ratio of the Mexican market for cocoa imports; M means total cocoa imports; NAC is the national apparent consumption of cocoa in tons.

The RCAI of Mexican cocoa was calculated for the country's leading trading partner, Ecuador, using Equation 5 (Durán Lima & Álvarez, 2008).

$$RCAI = \frac{X_{ij} - M_{ij}}{|X_{iw} + M_{iw}|} \quad (5)$$

Where IVCR is the RCAI; X_{ij} is the value of cocoa exports from Mexico to the Ecuadorian market; M_{ij} is the value of cocoa imports by the Mexican market from Ecuador; X_{iw} is the value of cocoa exports from Mexico to the world market; M_{iw} is the value of cocoa imports into the Mexican market from the rest of the world.

Lastly, the Mexican cocoa market's dependency ratio on its leading trading partner, Ecuador, was estimated by calculating the percentage represented by the total value of cocoa imports from the Ecuadorian market.

RCAI Projection Using a Hodrick-Prescott Filter

The trend allowing an accurate prediction of the competitiveness behavior was calculated using the Hodrick-Prescott (1980) filter. This filter separates the filtered series into trends and deviations with respect to the original series. Therefore, it is a valuable tool for trend extraction. The mathematical formula is shown in Equation 6:

$$\frac{\text{Min}}{\{gt\}_{t=-1}^T} \{ \sum_{t=1}^T c_t^2 + \lambda \sum_{t=1}^T [(g_t - g_{t-1}) - (g_{t-1} - g_{t-2})]^2 \} \quad (6)$$

Where smoothness measure $\{gt\}$ is the sum of the squares of their second difference; c_t are deviations from g_t and average close to zero over long periods; the λ factor is the so-called smoothing median and has been the object of analysis in many studies. $\Lambda = 1,600$ is the one proposed initially since the series studied was quarterly. In the case of the annual series, the factor $\lambda = 6.25$ is used (French, 2001; Rabanal, 2022; Sakarya & De Jong, 2020). The previous considerations reach a more precise estimate since they are based on the original RCAI series.

Results and Discussion

The data showed that the historical share of the Mexican market in global cocoa production in the period analyzed was small. In 2004, it was 0.95 % harvested area and 1.08 % production

volume of said grain. In 2021, this share was reduced to 0.45 % and 0.50 %, respectively. However, the average yield per hectare on Mexican soil is slightly higher than the average yield worldwide, which implies that the low contribution of Mexican cacao is due to the harvested area of the country (Table 1).

These results can be interpreted in various ways. One possibility is that cocoa production in Mexico is inefficient. This would mean that Mexican producers are not using their resources effectively due to a lack of training, failure to access inputs and services, or the presence of pests and diseases. Another possibility is that cocoa production in Mexico is small compared to other countries' production. This could be due to factors like climatic conditions, the availability of arable land, or Mexican consumers' preference for other agricultural products.

The fact that the average performance by hectare on Mexican soil is slightly higher than the average performance worldwide suggests that inefficiency is not the only explanation for Mexican cocoa's low contribution. However, Mexico's potential for cocoa production in Mexico is greater than what has been achieved.

To increase Mexico's share in the world cocoa market, it is necessary to tackle the factors contributing to its small share. This could imply measures to improve production efficiency, increase the harvested area, or improve the quality of Mexican cocoa.

The cocoa-harvested areas in Mexico show a negative trend. From 2004 to 2005, this variable was reduced by approximately 20 thousand hectares, and the variation rate of the harvested area of this crop was -35.76 %. The yield of this grain has remained relatively stable from 2007 to 2021, except for the highest yields in 2005 and 2006. The years with the lowest yield in the period analyzed were 2009 and 2011, with productions below 0.44 tons per hectare.

The reduction of the harvested area decreased cocoa production in the country by 36.09 % between 2004 and 2021. However, because the average country price of cocoa increased by 132.97 %, the production value increased by 48.9 % in the period analyzed (Table 2). This decrease can be attributed to climate change, pests and diseases, and the lack of incentives for producers.

Cocoa yield in Mexico has remained relatively stable in recent years, with some exceptions. The best performance years were 2005 and 2006, while the worst occurred in 2009 and 2011. The decline in cocoa production has been partially offset by a price increase.

The results in table 2 show that cocoa production in Mexico faces major challenges. To increase it, the factors contributing to the decrease in harvested areas must be addressed. This could imply measures to mitigate the effects of climate change, control pests and diseases, and provide incentives to producers. Some specific recommendations to increase cocoa production in Mexico include:

- developing varieties of cocoa that are resistant to climate change, pests, and diseases;
- encouraging the adoption of agricultural practices that help conserve natural resources;

- improving the producers' access to supplies and services necessary to produce efficient cocoa; and
- creating markets for high-quality Mexican cocoa.

Table 1. Historical share of the Mexican market in global cocoa production

Year	Mexico			Worldwide			HA (%)	P (%)
	HA (ha)	Y (t/ha)	P (t)	HA (ha)	Y (t/ha)	P (t)		
2004	80,878.96	0.54	43,974.52	8,514,468	0.48	4,069,807	0.95	1.08
2005	61,476.51	0.59	36,366.16	8,708,509	0.46	4,044,041	0.71	0.90
2006	60,866.27	0.63	38,150.87	8,515,376	0.51	4,299,997	0.71	0.89
2007	60,933.77	0.49	29,909.74	8,645,453	0.45	3,899,063	0.70	0.77
2008	61,035.85	0.45	27,548.93	9,561,425	0.45	4,266,012	0.64	0.65
2009	61,317.35	0.37	22,660.79	9,437,317	0.45	4,211,423	0.65	0.54
2010	61,187.25	0.44	27,173.61	9,599,074	0.45	4,329,483	0.64	0.63
2011	60,708.25	0.35	21,387.52	10,253,973	0.45	4,614,810	0.59	0.46
2012	61,385.98	0.45	27,619.11	10,313,954	0.45	4,613,817	0.60	0.60
2013	61,168.10	0.46	27,844.12	10,177,654	0.44	4,486,252	0.60	0.62
2014	59,623.60	0.45	26,969.36	10,577,963	0.45	4,741,947	0.56	0.57
2015	59,118.06	0.47	28,006.59	10,959,573	0.44	4,817,460	0.54	0.58
2016	58,733.55	0.46	26,863.09	10,700,382	0.43	4,643,998	0.55	0.58
2017	58,690.30	0.46	27,287.25	11,336,072	0.46	5,159,325	0.52	0.53
2018	58,360.96	0.49	28,398.86	11,557,479	0.47	5,438,354	0.50	0.52
2019	58,527.06	0.49	28,452.01	11,751,239	0.47	5,492,530	0.50	0.52
2020	58,598.16	0.50	29,428.77	12,617,835	0.46	5,780,850	0.46	0.51
2021	51,952.83	0.54	28,105.84	11,535,884	0.48	5,580,432	0.45	0.50

Note. HA: harvested area; Y: yield; P: production volume.

Source: Based on SIACON (2023) and FAO (2019) data.

The trade balance of Mexican cocoa has historically been negative; that is, imports of this grain have exceeded exports during most of the years analyzed. Regarding the period studied, 2007 was the only year this grain exports exceeded imports; the trade balance was 1,916.87 tons, amounting to 3.24 million dollars (Table 3). The trade balance value was positive in 2006, but the volume was negative. In recent years, the trade balance deficit of this crop has exceeded 35 thousand tons.

The deficit on the scale of cocoa trade has increased in the last few years. In 2021, the deficit exceeded 35 thousand tons. This means that Mexico imported more than 35 thousand tons of cocoa from other countries while it only exported about 5 thousand tons. This deficit on the commercial scale has a series of negative implications for Mexico. First, Mexico is losing opportunities to generate income through exports. Second, Mexico depends on other countries

to satisfy its demand for cocoa, which may be a vulnerability in case of contingencies in international cocoa markets. To reverse this situation, Mexico must increase its cocoa exports through a series of measures, such as:

- improving the quality of Mexican cocoa so that it is further competitive in international markets.
- promoting Mexican cocoa consumption in the domestic market; and
- Making Mexican producers' access to international markets easy.

Table 2. Mexican cocoa production variables

Year	ACP (\$)	PV (thousands of \$)
2004	17,972.24	790,320.76
2005	17,871.26	649,909.18
2006	15,406.36	587,766.02
2007	16,992.77	508,249.25
2008	25,700.69	708,026.43
2009	31,689.04	718,098.73
2010	37,473.85	1,018,299.71
2011	40,268.58	861,245.16
2012	38,268.74	1,056,948.67
2013	36,503.24	1,016,400.51
2014	35,525.69	958,105.03
2015	36,948.19	1,034,792.76
2016	39,110.61	1,050,631.84
2017	39,370.16	1,074,303.38
2018	37,899.54	1,076,303.75
2019	38,464.74	1,094,399.26
2020	40,503.12	1,191,956.93
2021	41,870.70	1,176,811.11
$r_{t,0}$ (%)	132.97	48.90

Note. ACP: average country price; PV: production value.

Source: Based on data from Sistema de Información Agroalimentaria de Consulta (SIACON, 2023).

In recent years, the local consumption of cocoa has exceeded 60 thousand tons. This implies that the local market production does not meet the demand for this bean. Thus, imports are of great importance to avoid an increase in the price of this crop (Table 4). The apparent *per capita* cocoa consumption in recent years was approximately half a kilogram. It is worth noting the recovery of this variable after 2009, when it was at its lowest level, 0.24 kg per person. This amount is relatively low in comparison with other countries' cocoa consumers. For example, the apparent *per capita* consumption of cocoa in Europe is approximately 2 kilograms. In the United States, it is approximately 1.5 kilograms.

Table 3. Trade balance of Mexican cocoa

Year	Exports		Imports		Trade balance	
	Volume (t)	Value (dls)	Volume (t)	Value (dls)	Volume (t)	Value (dls)
2004	3.37	8,728	4,655.64	7,291,246	-4,652.27	-7,282,518
2005	634.45	1,026,968	7,703.89	12,285,114	-7,069.44	-11,258,146
2006	1,234.84	2,408,279	1,325.97	2,117,265	-91.13	291,014
2007	2,976.74	5,874,861	1,059.87	2,626,410	1,916.87	3,248,451
2008	176.83	591,467	6,187.79	16,200,171	-6,010.96	-15,608,704
2009	41.86	206,633	4,058.48	11,701,950	-4,016.63	-11,495,317
2010	324.49	1,514,469	15,660.71	51,190,071	-15,336.22	-49,675,602
2011	237.59	1,057,610	18,922.07	61,799,260	-18,684.48	-60,741,650
2012	277.01	986,560	13,589.86	34,098,906	-13,312.85	-33,112,346
2013	2,246.41	3,935,260	22,952.92	57,832,799	-20,706.52	-53,897,539
2014	210.34	872,603	28,659.41	90,111,491	-28,449.07	-89,238,888
2015	133.83	459,632	23,521.37	73,630,545	-23,387.54	-73,170,913
2016	169.09	866,451	38,293.03	116,328,140	-38,123.93	-115,461,689
2017	1,032.19	2,811,297	41,321.97	89,975,751	-40,289.78	-87,164,454
2018	476.30	2,050,979	38,546.47	93,786,458	-38,070.18	-91,735,479
2019	137.62	741,634	48,112.58	117,679,725	-47,974.96	-116,938,091
2020	254.17	1,201,771	37,291.56	96,635,762	-37,037.39	-95,433,991
2021*	138.40	644,919	35,561.71	90,915,614	-35,423.31	-90,270,695

Note. *Jan-Nov

Source: Based on data from SIAVI (2023).

Mexico's apparent per capita cocoa consumption recovered in 2009 following a positive trend. This suggests that cocoa consumption is increasing in Mexico, which could trigger opportunities for the production and export of Mexican cocoa. To increase cocoa consumption in Mexico, cocoa cultivation among consumers must be promoted through marketing and education campaigns about cocoa's benefits. Improving Mexican cocoa's quality is vital to becoming more competitive in international markets. This could be done through research and development of new varieties of cocoa that are more resistant to pests and diseases and have a more pleasant flavor and aroma.

Implementing these measures could help Mexico increase its production and consumption of cocoa and improve its position in the world market for this crop. Some specific recommendations to increase cocoa consumption in Mexico are as follows:

- Promoting Mexican cocoa as a food that is healthy and nutritious;
- Developing innovative and attractive cocoa products for Mexican consumers and
- Easing access to high-quality cocoa products at competitive prices.

Table 4. Apparent local consumption and apparent *per capita* consumption of cocoa in Mexico

Year	Apparent consumption (t)	Population	Apparent <i>per capita</i> consumption (kg)
2004	48,626.79	103,945,813	0.47
2005	43,435.60	105,442,402	0.41
2006	38,242.00	106,886,790	0.36
2007	27,992.87	108,302,973	0.26
2008	33,559.89	109,684,489	0.31
2009	26,677.42	111,049,428	0.24
2010	42,509.83	112,532,401	0.38
2011	40,072.00	114,150,481	0.35
2012	40,931.96	115,755,909	0.35
2013	48,550.64	117,290,686	0.41
2014	55,418.43	118,755,887	0.47
2015	51,394.13	120,149,897	0.43
2016	64,987.02	121,519,221	0.53
2017	67,577.03	122,839,258	0.55
2018	66,469.04	124,013,861	0.54
2019	76,426.97	125,085,311	0.61
2020	66,466.16	125,998,302	0.53

Source: Based on data from SIACON (2023), SIAVI (2023), and the World Bank (2023).

The trend of the dependency ratio of the Mexican cocoa market on imports has been positive (Figure 1). The highest dependency ratio was in 2019; 63 % of the apparent consumption of this bean corresponded to imports (i.e., for every ton of cocoa consumed in Mexico, 0.63 tons came from the foreign market).

This positive trend has a series of implications for Mexico. Firstly, it means that Mexico is increasingly dependent on cocoa imports to satisfy its domestic demand, which may be a vulnerability in case of issues in international cocoa markets. Secondly, Mexico is losing opportunities to generate income through cocoa exports. To reverse this trend, Mexico must increase its cocoa production through a series of measures, such as:

- improving the efficiency of cocoa production;
- increasing the cocoa harvested area; and
- improving the quality of Mexican cocoa to become more competitive in international markets.
- Implementing these measures could help Mexico reduce its dependence on cocoa imports and improve its position in the world market for this crop.

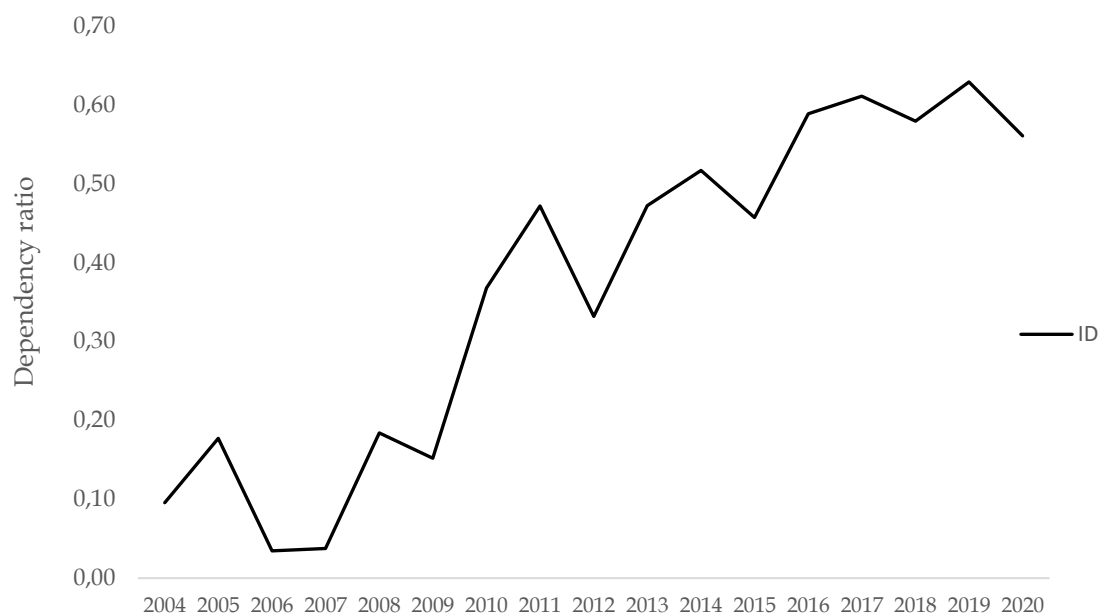


Figure 1. Evolution of the dependency ratio.

Source: Based on data from SIACON (2023), SIAVI (2023), and the World Bank (2023).

During all the years under study, Mexican cocoa's RCAI was negative, around -0.50 (i.e., the country is not competitive compared to the Ecuadorian market; Table 5). It should be pointed out that Mexico does not export cocoa to Ecuador.

The Mexican market's trade dependence on Ecuadorian cocoa shows that close to 60 % of Mexican imports of this crop come from Ecuador (Figure 2). A negative RCAI suggests the country is not competitive in the foreign market. In the case of Mexican cocoa, this means that Mexico cannot produce cocoa at a cost lower than Ecuador's. The fact that Mexico does not export cocoa to Ecuador indicates that the negative RCAI of Mexican cocoa is a real problem. Mexico could export cocoa to Ecuador if it were competitive in cocoa production. To improve the competitiveness of Mexican cocoa, it is necessary to tackle the factors contributing to negative RCAI. These factors could include:

- Inefficiencies in cocoa production.
- Adverse climatic conditions for cocoa production.



Figure 2. Ecuadorian market contribution to cocoa imports from Mexico.
 Source: Based on data from SIACON (2023), SIAVI (2023), and the World Bank (2023).

Table 5. Estimate of the revealed comparative advantage index for Mexican cocoa

Year	Imports from the world market (dls)	Exports to the world market (dls)	Imports from Ecuador (dls)	RCAI
2004	7,291,246	8,728	3,621,747	-0.50
2005	12,285,114	1,026,968	5,991,769	-0.45
2006	2,117,265	2,408,279	2,117,265	-0.47
2007	2,626,410	5,874,861	2,032,407	-0.24
2008	16,200,171	591,467	13,653,712	-0.81
2009	11,701,950	206,633	6,042,204	-0.51
2010	51,190,071	1,514,469	23,892,080	-0.45
2011	61,799,260	1,057,610	34,802,794	-0.55
2012	34,098,906	986,560	17,892,693	-0.51
2013	57,832,799	3,935,260	33,347,933	-0.54
2014	90,111,491	872,603	48,078,082	-0.53
2015	73,630,545	459,632	37,671,663	-0.51
2016	116,328,140	866,451	68,287,009	-0.58
2017	89,975,751	2,811,297	57,664,753	-0.62
2018	93,786,458	2,050,979	53,131,187	-0.55
2019	117,679,725	741,634	63,270,780	-0.53
2020	96,635,762	1,201,771	41,837,731	-0.43
2021*	90,915,614	644,919	52,747,145	-0.58

Note. RCAI: revealed comparative advantage index; *Jan-Nov.
 Source: Based on data from SIAVI (2023).

Figure 3 shows the RCAI trend, the R2 was 92.95%, resulting in the goodness of fit of the regression model (Gujarati, 2010; Wooldridge, 2009). R2 indicates the accuracy of the model. The R2 in the regression model allowed an accurate prediction that can be extrapolated for 2024-2026. The trend, in general, was decreasing, implying a loss of future competitiveness. The R2 of the regression model indicates that the regression equation is a good predictor of the RCAI trend. This means you can extrapolate the RCAI trend for 2024-2026. If the trend is extrapolated, Mexico's RCAI is expected to continue decreasing in the following years. In other words, Mexico will continue losing competitiveness in cocoa production.

This loss of competitiveness can have negative implications for Mexico. The country will be less capable of exporting cocoa to other countries and further dependent on cocoa imports. Thus, Mexico must improve its competitiveness in cocoa production to avoid negative implications.

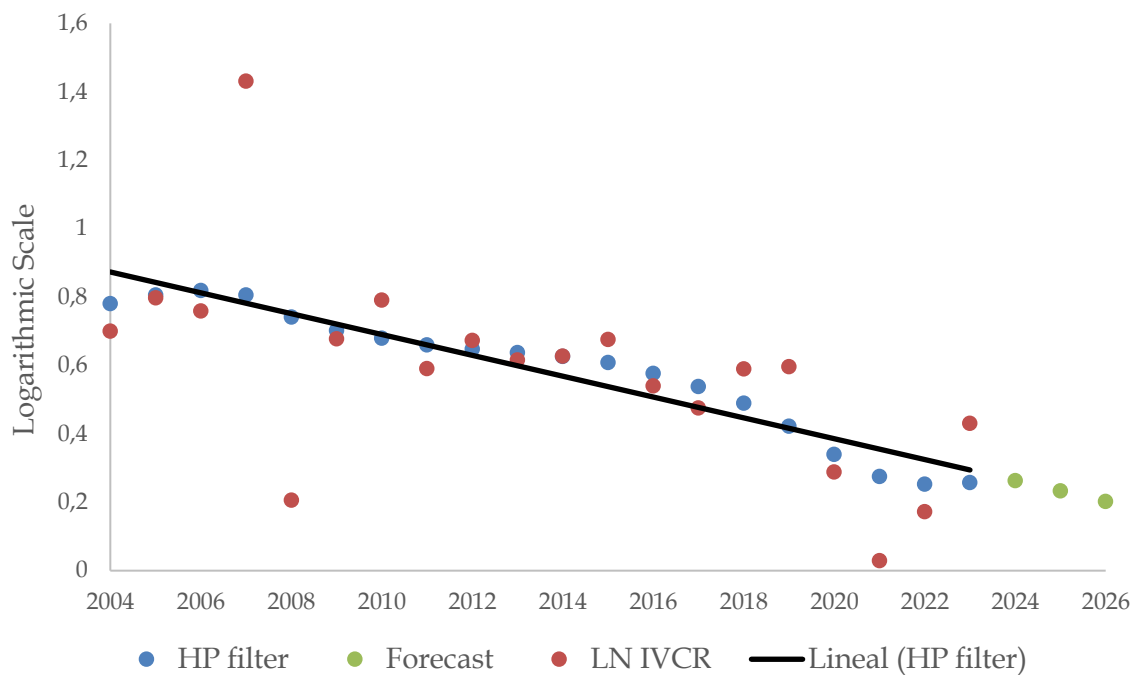


Figure 3. Revealed Comparative Advantage Index trend.

Source: Based on data from SIACON (2023), SIAVI (2023), and the World Bank (2023).

The article's results are consistent with those of other recent research on the production and marketing of cocoa in Mexico. For example, a study by the Inter-American Institute for Cooperation on Agriculture (IICA) published in 2022 found that cocoa production in Mexico has decreased by 20 % in the last ten years. The study also found that the Mexican cocoa trade balance has been historically negative and that cocoa imports have exceeded exports by an average of 10,000 tons yearly.

A 2023 study from the University of Guadalajara found that Mexican cocoa has great growth potential. It also revealed that Mexican cocoa is superior in quality to cocoa produced in other countries and that there is a growing demand for cocoa quality in the international market.

The data analysis revealed that Mexico's historical share in world cocoa production is minimal. Although the average yield per hectare in Mexico is slightly higher than the world average, the harvested area in Mexico has decreased significantly since 2004 (Table 1). This decrease is the main reason for Mexico's low contribution to global cocoa production.

Several factors could be responsible for the decrease in harvested area:

- **Climate change:** Changes in climate patterns may be affecting the suitability of land for growing cocoa in Mexico.
- **Pests and diseases:** The spread of cocoa diseases and pests could discourage farmers from growing it.
- **Lack of incentives:** Insufficient financial support or infrastructure for cocoa production could make farmers switch to other crops.

Challenges and Opportunities in Mexican Cocoa Production

Mexico can potentially increase its cocoa production and compete more effectively in the global market. However, several challenges need to be addressed:

- **Limited harvested area:** It is necessary to reverse the decrease in the harvested area. This could involve strategies to mitigate the effects of climate change, control pests and diseases, and incentivize farmers to grow cocoa.
- **Negative trade balance:** Mexico imports a significantly larger volume of cocoa than it exports. To improve the trade balance, Mexico needs to increase cocoa exports. This could be achieved by:
 - **Improving cocoa quality:** Improving the quality and reputation of Mexican cocoa would make it more competitive in the international market.
 - **Promoting domestic consumption:** Encouraging domestic consumption of Mexican chocolate products could reduce dependence on imports.
 - **Facilitating market access:** Supporting Mexican cocoa producers in connecting with international buyers would increase export opportunities.

Outlook / Recommendations

This study provides a basic understanding of the current state of cocoa production and marketing in Mexico. Additional research is needed to explore specific solutions to the identified challenges; thus, researchers may:

- Conduct in-depth studies to identify the most important factors that deter farmers from growing cocoa in Mexico.
- Analyze the effectiveness of existing government programs or initiatives to support cocoa production in Mexico.
- Investigate successful strategies other cocoa-producing countries use to increase production and improve competitiveness.

By implementing effective solutions and conducting more research, Mexico has the potential to become a major player in the global cocoa market.

Conclusions

The results of this research suggest that Mexico has the potential to become a major producer and exporter of cocoa. However, it is necessary to tackle the challenges facing the production and marketing of Mexican cocoa so that it can fully take advantage of its potential. Cocoa production has decreased in the last few years due to reduced surface harvested. This can be attributed to climate change, pests and diseases, and the lack of incentives for producers.

The Mexican cocoa trade balance has been historically negative, meaning that imports of this grain have exceeded exports. Mexico is losing opportunities to generate income through exports and depends on other countries to satisfy its demand for cocoa. To reverse this situation, Mexico must increase its cocoa exports. This could be achieved through a series of measures, such as improving the quality of Mexican cocoa, promoting Mexican cocoa consumption in the internal market, and facilitating access of Mexican producers to international markets. In conclusion, Mexican cocoa has excellent potential, but it is necessary to tackle several challenges first.

The national production lacks comparative advantages concerning Ecuador, its leading cocoa trading partner. It is known that Mexico has other variables, such as climate, soil, and experience, among others, that can help recover the relevance of this crop at the national level. On the other hand, Mexico exports cocoa to high-value markets, such as Switzerland, France, and Japan, but the trade balance for this crop is in deficit. The increase in the national average price of cocoa should encourage its production; however, the crop's phytosanitary problems have slowed expansion to other regions with productive potential. In this sense, technical assistance and training are recommended for producers in cocoa-producing areas.

Acknowledgments

To Claudia Villa editor for her attention and follow-up during the publication process.

Authors' Contributions

Carlos Ernesto Luquez Gaitan: determination of competitiveness and econometrics; Ernest Yasser Núñez Betancourt: compilation of information and preparation of part of the manuscript; Alejandro Revilla Chaviano: supervision of activities, bibliographic review and information analysis; Samuel Rivera López: preparation of the manuscript, review of writing and style and analysis of alternative methodologies.

Ethical implications

This study has no ethical implications.

Conflict of interest

The authors declare no conflicts of interest in this study.

Funding

This research did not have external funding

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