978-607-96203-0-12

RED INTERNACIONAL DE INVESTIGADORES EN COMPETITIVIDAD

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Effects of an increase in Mexican strawberry exports to Canada on the profitability of producers in Mexico

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Abstract

The objective of this research work was to determine the viability of increasing the exported quantity of Mexican strawberries to the Canadian market. To perform this analysis, the international market was represented in a partial equi-librium model. According to the calculated price flexibility, an increase in the exported quantity of Mexican strawberries to Canada of 50% in one year would cause a positive final effect. With this estimate, it can be established that an increase in the exported quantity of Mexican strawberries to Canada of 50% in one year would be viable in the economic sense. The results showed that an increase in strawberry production to export to Canada in Michoacan and Baja California would be profitable for the producer, while an increase in strawberry production for export to the Canadian market in Guanajuato would further decrease profitability.

***Keywords**:* agricultural production; econometric analysis

Introduction

In 2020, 8,861,381 t of strawberries were produced in the world; from these, 48.94% was harvested in Asia (4,336,603 t), 22.72% in America (2,012,879 t), 18.78% in Europe (1,664,506 t), 8.86% in Africa (785,227 t), while 0.70 % was produced in Ocean-ia (62,166 t) [1].

Regarding the producing countries, China was the first place with 3,326,816 t (37.54%); USA, second with 1,055,963 t (11.92%); Egypt, third with 597,029 t (6.74%); Mexico, fourth with 557,514 t (6.29%); Turkey, fifth with 546,525 t (6.17%); Spain, sixth with 272,550 t (3.08%); Brazil, seventh with 218,881 t (2.47%); Russia, eighth with 218,400 t (2.46%); Poland, ninth with 167,300 (1.89%); and Morocco, tenth with 166,955 (1.88%) [1].

In the same sense, from the total strawberry production in the world, producing countries allocated 89.48% (7,929,285 t) to the local market, while 10.52% (932,096 t) went to the export market. In the same way, Spain ranked first in strawberry exports with 290,826 t, which represented 31.20% of the world total; Mexico was the second exporter with 149,461 t (16.03%), USA was third with 132,333 t (14.20%), Netherlands was ranked fourth with 59,770 t (6.41%), Greece was fifth with 55,305 t (5.93%) and Belgium was sixth with 42,949 t (4.61%) [1].

Likewise, USA was the main importer with 197,475 t that represented 20.50% of total strawberry imports in the world; Germany, second with 130,778 t (13.58%); Can-ada, third with 100,906 t (10.48%); United Kingdom, fourth with 58,608 t (6.08%); France, fifth with

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54,621 t (5.67%); Russia, sixth with 43,366 t (4.50%); Italy, seventh with 36,661 t (3.81%); Netherlands, eighth with 33,876 t (3.52%); Mexico, thirteenth with 15,497 t (1.61%); and, Portugal was the fourteenth importer of strawberries in the world with 15,110 t (1.57%) [1]. In 2020, Canada imported 100,906 t of strawberries. From this total, 82.30% were imported from USA (83,049 t); 17.46%, from Mexico (17,618 t); 0.19%, from South Ko-rea (191.84 t); 0.03%, from Turkey (29.64 t); while 0.02% from other countries (16.70 t) [2].

In the same sense, the annual growth rate of Mexican strawberry imports in Can-ada averaged 3.27% between 2003 and 2021. It is worth mentioning that the annual growth rate between 2003 and 2019 averaged 12.11%, while between 2019 and 2021 the annual average of this same rate was equal to –46.50% [3]. It is important to say that, in 2020 and 2021, imports of Mexican strawberries in Canada decreased –34.61% and –56.23% respectively compared to previous years. It is necessary to mention that this decrease in imports of Mexican strawberries in Canada is contrary to the intentions of the Trade Agreement between Mexico, United States of America and Canada (T-MEC), as well as the North America Free Trade Agreement (NAFTA 1994-2020).

In this context it would be expected to improve competitiveness in the three na-tions, taking advantage of preferential import and export rates, thus encouraging the increase in the exportable supply. Thus, between 2003 and 2021 the growth rate of strawberry production in Mexico averaged 7.57% per year, while the National Con-sumption (NC) of strawberries in Mexico grew at an average annual rate of 6.28% in the same period, maintaining a growing trend of exports (with an average annual rate of 9.40% [3,4]).

However, it is necessary to mention that between 2003 and 2019, the annual growth rate of strawberry production in Mexico averaged 11.73%, while in 2020 and 2021, this same rate averaged –20.61%. This drop in production affected the National Consumption of strawberries in Mexico in the period 20032021, the annual growth rate averaged 11.71%, while in the years 2020 and 2021 this same rate averaged –28.66%. This drop in the exports reduces the competitiveness of Mexican strawberry in the Canadian market and is contrary to expectations into the T-MEC agreement be-tween Mexico and Canada. Likewise, the natural efforts of the producers in Mexico to increase the exportable supply to Canada are not enough; therefore, it is necessary that the government implements actions to encourage it [5].

On the other hand, when a nation has a growing demand (importer country) and is not capable of producing the necessary quantity of a good to satisfy its domestic consumption, it must import and ensure these imports at a price that is convenient for consumers. That is, it is not too expensive for the country to pay for these purchases in the international market [6]. Globalization influences several economic processes, in-cluding the exchange of goods in the international market. So, an importer country has the opportunityto find the foreign providers which can sell the goods in which it is mutually beneficial for both countries to trade [7].

Both exporters and importers benefit from the international market; the decrease in tariffs, the reduction in logistics costs, as well as the reduction in barriers to interna-tional trade, offer an opportunity for producers who have a technical efficiency at such a level that allows them to export, obtaining important benefits to recover the invest-ment [7].

A partial equilibrium analysis of the Mexican mango exports to USA was carried out by the main author of this paper in 2009. In that research the authors considered that an increase in the mango exports caused two simultaneous effects on the value of the traded quantity: an increase in value due to the increase in quantity, and a de-crease in the value due to the decrease in price. Likewise, it was necessary to determine whether the final value of these two effects is positive, i.e., whether the increase in the quantity traded caused an increase in value (despite the decrease in price) [8]. If it oc-curred, then the growth of the international trade between the two countries would cause that the benefits for producers in the exporting country and the benefits for consumers in the importing country grew when the quantity traded increased.

On the other hand, the increase in the quantity traded could cause the combined final value of both effects to decrease, that would cause the benefits for producers in the exporting country and the benefits for consumers in the importing country to de-crease. In this case, the quantity traded should not grow, i.e., the increase in quantity would not be viable. That is why the partial equilibrium analysis of a good between both countries must be carried out, since decision-making in agricultural policy to en-courage exports requires determining its viability in the international market [8].

This analysis can also be interpreted as a forecast of the quantities and prices in the international market to get an understanding of its operation. From this perspec-tive, it is possible to simulate a scenario under certain conditions to identify the reper-cussions, opportunities, as well as the consequences of applying an agricultural policy to increase the quantity exported of a good to a specific market [9]. Thus, Zhang, Onel and Seale Jr. simulated a 25% increase in tariff rates for French and Spanish wines des-tined for the US market. They identified the negative effects on the quantity demand-ed. However, there were positive effects on German wines due to an inelastic demand for imports of these ones. It is important to mention that the simulated increase in tar-iff rates would cause a decrease in welfare for US consumers. A simulated scenario showed the repercussions on the international trade of a good between two economies, and allowed to determine if it would be viable to increase the quantity traded [10].

In 2022, a partial equilibrium analysis of the Mexican avocado exports destined to USA was carried out for the main author of this paper. A hypothetical scenario with an increase in the quantity export that represented an annual growth rate of 30% was developed. In that research, the viability of encouraging an increase in the avocado exports to US market was determined. Additionally, within the simulated scenario, the effects on the profitability of the main producer areas were shown [11]. Likewise, a partial equilibrium analysis was carried out to determine whether an increase of the Mexican strawberry exports to US market was viable. For this analysis, the main au-thor of this paper simulated an increase in an annual rate of 18% in the quantity ex-ported. In that work, the viability of the increase was determined. The simulated sce-nario allowed to determine the profitability for producers in the three main producer areas: Michoacan, Baja California and Guanajuato [12].

At this point it, is necessary to express that the present work allowed a partial equilibrium analysis to be carried out simulating a 50% increase in the quantity ex-ported of Mexican strawberries to the Canadian market, and to transfer the effects of the simulated

scenario to the context of the producer in three different strawberry production areas for export in Mexico: Michoacan, Baja California and Guanajuato. Once the profitability analysis had been carried out, elements can be identified to im-prove the exportable offer. In this context, the research question was whether it would be feasible for the producer in Mexico to increase strawberry exports to the Canadian market in a magnitude that represents a 50% annual. In other words, whether it would be viable to increase the export of strawberries to Canada and, in this way, to take ad-vantage of the opportunities that the market offers.

To carry out this research work, the first hypothesis was that it would be via-ble—from an economic perspective—to increase exports of Mexican strawberries to Canada, even when this caused a decrease in the price of exports. Likewise, the second hypothesis states that an increase in the production of strawberries in Mexico for ex-porting to the Canadian market would be profitable for producers in the sense of in-come, at a growth rate that represented an annual increase of 50% in the quantity ex-ported.

Thus, considering the negative growth rate of Mexican strawberry exports to the Canadian market in the last two years, the objective of this research work is to deter-mine the economic feasibility of increasing the quantity of Mexican strawberry ex-ported to Canada. To achieve this, it was proposed to represent the Mexican strawber-ry market for export to the Canadian market in an econometric model that made it possible to calculate the price flexibility of demand and, with this, the establishment of a scenario in which an increase of 50% in the quantity exported was simulated with the purpose of determining the feasibility for Mexican producers to encourage this in-crease.

Theoretical Analysis

Nations trade goods basically due to a fundamental principle: nations, like re-gions, have differences in terms of their physical and climatic characteristics, as well as the soil and biological properties of their territories. That is to say, that each nation, as well as each region, has its own conditions, and these are different from those that exist in other nations. Likewise, there is an endowment of its own resources, with its own development processes that depend on the productive propensity of the factors of production (land, work, capital, technology, innovation, and business skills) that are carried out in relation to the conditions previously mentioned. In this sense, the physi-cal characteristics of each nation and each region—as well as the endowment of re-sources they have—play a fundamental role in determining the goods that each nation can produce efficiently and, in this way, generating a competitive advantage in rela-tion to other ones [13].

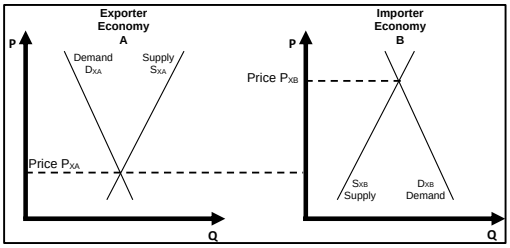
On this basis, when a country A can produce the good X at a lower cost than country B, and country B is capable of producing good Y at a lower cost than country A, for both countries it is more convenient to orient the factors of production that each one possesses to produce the good that they are capable of producing efficiently than the other country [14]. This specialization in production means that the quantities of each good produced in each country are greater than those necessary to cover domes-tic consumption. Once the internal demand is satisfied, this excess production of each good in each country can be used for export to the other country. In this way, the trade of surpluses between both countries

promotes efficiency in the production of goods in which they have a comparative advantage, and then international trade is mutually beneficial.

Now, a country A that has a comparative disadvantage in the production of good X compared to another country B, can buy it in country B at a cost less than the cost of producing it domestically. In this sense, each country specializes in the goods in which it has a higher productivity compared to other countries. Thus, it is possible to under-stand why international trade allows obtaining general benefits for the participating countries; even if a country has a comparative advantage in the production of all goods, it is more beneficial for it to specialize in the production of those in which its comparative advantage is greater compared to other countries, and then buy in the in-ternational market those in which their comparative advantage is lower; since it would not be efficient to produce and consume all. A country should specialize in producing and exporting goods that need a greater quantity of factors of production that are cheaper internally than in another country, and importing those goods that it can produce with a greater quantity of factors of production that are more expensive than in another country. In this way, the foreign market allows a country to increase its productivity by ceasing to produce all goods, and it is possible for it to specialize in those sectors in which its companies are more productive, and to import those goods in which its companies are less productive than their competitors in the other country. In this sense, the international trade of goods between countries is a factor of productivity growth, and therefore, of the better standard of living of its citizens [15].

Figure 1

Price of good X in exporting nation A and in importing nation B.



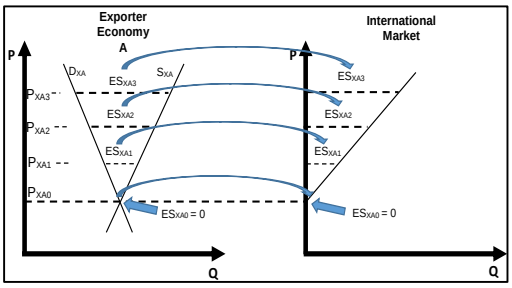
The trade of a good X between two economies takes place when it is possible for nation A to produce good X with a greater efficiency than nation B and, therefore, at a lower cost. In this way, for nation B it is more convenient to import it than to produce it in the interior. In the other sense, the price at which nation A can offer good X is lower in the market than the price at which nation B can offer it, as can be seen in Fig-ure 1 [6].

The international trade of a good X between a nation A and a nation B can be ex-plained by means of a partial equilibrium model, in which, in the first instance, it can be understood with the graph of nation A (exporting country) that has a competitive advantage in the production of good X [16]. Based on the equilibrium price PXA0 in na-tion A, for price values above this, the difference between the demand for good X: DXA and the supply of good X: SXA, has an increasing trend. This excess supply ESXA that is generated for each price above PXA can be trans-ferred to a second scenario that constitutes the international market, and by drawing a straight line, the quantities supplied of good X that exceed the

domestic demand in the nation A can be noted, and that it is possible to allocate to the international market, as can be seen in Figure 2.

Figure 2

Excess supply of good X in nation A allocated to the international market



In this sense, at the equilibrium point, the Demand and the Supply of good X are equivalent in nation A, so the excess supply ESXA0 is equal to 0, so no quantity can be allocated to the international market. In this sense, at the price PXA0 the excess supply ESXA0 is equal to 0; if the price were PXA1 there would be an excess supply of ESXA1 that can be destined for the international market; if the price were PXA2 there would be an excess supply of ESXA2 that can be destined for the international market; if the price were PXA3 there would be an excess supply of ESXA3 that can be destined for the interna-tional market.

On the other hand, based on the equilibrium price PXB0 in nation B, for price values below this, the difference between the supply of good X: DXB and the demand for good X: SXB, has an increasing trend.

This excess demand EDXB that is generated for each price below PXB0 can be transferred to a second scenario that represents the international market, and by drawing a straight line the demanded quantities of good X that exceed the domestic supply in na-tion B can be noted, and that it is possible to buy in the international market. In the same way, at the equilibrium price, the supply and demand of good X are equivalent in nation B, and the excess demand EDXB0 is equal to 0, so it is not necessary to buy any quantity on the international market, since the supply perfectly covers the demand for good X.

In this sense, at the price PXB0 the excess demand EDXB0 is equal to 0; if the price were PXB1 there would be an excess demand for EDXB1 that can be purchased on the international market; if the price were PXB2 there would be an excess demand for EDXB2 that can be purchased on the international market; if the price were PXB3 there would be an excess demand for EDXB3 that can be purchased on the international market.

Then, in the international market, it is possible to concentrate the different quan-tities of excess supply ESXA that are generated for each price level PXA in nation A and the different quantities of excess demand EDXB that are generated for each price level PXB in nation B. In this scenario there is a price level in which both straight lines are equivalent, and equilibrium conditions are met, now in the international market, since ESXA and EDXB intersect at that point. Now, focusing on the equilibrium price level in the international market, this is where the international price IPX is generated, causing an excess supply ESXA that can be seen in the graph of nation A (exporting country), and an excess demand EDXB that can be seen in the graph of nation B (importing country). In this way, at the interna-tional

price IPX, the excess supply of SXA-DXA (ESXA) in nation A is equal to the excess demand of DXB-SXB (EDXB) in nation B.

Now, focusing on the equilibrium price level in the international market, this is where the international price IPX is generated, causing an excess supply ESXA that can be seen in the graph of nation A (exporting country), and an excess demand EDXB that can be seen in the graph of nation B (importing country). In this way, at the interna-tional price IPX, the excess supply of SXA-DXA (ESXA) in nation A is equal to the excess demand of DXB-SXB (EDXB) in nation B.

In this context, the price flexibility of demand for a commodity in the market can be described in two dimensions: first, as the increase in price (measured as a percent-age), when the quantity demanded decreases by 1%; and second, as the decrease in price (measured as a percentage), when the quantity demanded increases 1%. In this way, it is possible to conceive of the price flexibility of demand as the sensitivity of the price of a good to changes in the quantity of that good in the market. It is worth men-tioning that the relationship between price and quantity, in this sense, is inverse, and according to the final impact, three possible results can be identified [17]:

1. When the quantity increases 1%, and this causes a decrease of less than 1% in the price, or, if the quantity decreases 1%, and this causes an increase of less than 1%, it can be established that the demand is inflexible.

2. When the quantity increases 1%, and this causes a decrease of 1% in the price, or, if the quantity decreases 1%, and this causes an increase of 1%, it can be affirmed that the price flexibility of demand is unitary.

3. When the quantity increases 1%, and this causes a decrease of more than 1% in the price, or, if the quantity decreases 1%, and this causes a greater than 1% increase in the price, it can be established that the demand is flexible.

Now, it is important to say that the partial equilibrium model is an analysis of in-ternational trade that allows to identify the impact of a change in quantity or price in the market of a good between two nations. The simulated quantities and prices allow the establishment of hypothetical scenarios for the characterization of the repercus-sions in certain production areas, as well as the profitability in the face of said changes.

Capps, Williams, and Dang carried out a partial equilibrium analysis in the US lamb market; to develop it, they represented the lamb market in an econometric model, and with the results they estimated the advertising elasticity of demand. With this base, they determined the impacts on the quantity and on the total value and, through a simulation, they established that the costs made in promotion were less than the in-come generated by this market strategy [18]. Likewise, they determined that the re-sources invested in advertising caused an increase in demand, i.e., a displacement of excess demand in the international market in the positive sense. This effect in turn caused an increase in the price of lamb purchases abroad in USA. It is worth mention-ing that Hernandez, Cornejo, and Galvan carried out a partial equilibrium analysis of Mexican avocado exports destined for the Canadian market [19]. In their research they represented the international avocado market in an econometric model and, based on the results, they calculated the price flexibility of the demand for Mexican avocados in Canada.

With these results, they estimated that an increase in the quantity exported in a magnitude that represents 50% in one year causes a decrease in the price of 4.7339%. In this way, they developed a hypothetical scenario to simulate the impacts in quantity and price, in order to calculate the combined final effect of both impacts. On this basis, they affirmed that encouraging Mexican avocado exports to the Canadian market is viable from an economic perspective. Additionally, they moved these simulated im-pacts to the producer level in the most important avocado producing areas for export in Mexico: Michoacan, Jalisco and the State of Mexico, with the purpose of estimating the B/C R to determine profitability. In this analysis, they determined that producing avocados to export to Canada in Michoacan, Jalisco and the State of Mexico continued to be profitable given a 50% increase in the quantity exported in one year.

Based on these results, they recommended encouraging the production of Mexican avocado in these producing areas to export to Canada, implementing agricultural pol-icy mechanisms that allow increasing the exportable supply and, in this way, taking advantage of their infrastructure and knowledge to trade avocado in the foreign mar-ket, as well as the opportunities offered by the international market based on the pref-erential export rates of the Free Trade Agreement between Mexico, USA and Canada (T-MEC).

Williams, Capps, and Bessler carried out a partial equilibrium analysis in the or-ange juice market for export in USA, and they affirmed that the large investments made in advertising were the cause of a large part of the income the producers receive [20]. They also found that the resources invested in advertising in the orange juice market produce two main effects: one effect is produced when advertising directly causes increases in the demand for orange juice, thus the industry increases its con-sumption of fresh oranges, causing increases in price, resulting in increases in income for producers of orange juice and for producers of fresh orange.

Another effect occurs when the industrial consumption of oranges increases, ab-sorbing large quantities of product, and causing the supply to the fresh orange market to decrease, causing price increases that in turn improve the income of producers. It is worth mentioning that advertising expenses in the orange juice market yield signifi-cant increases in the income of producers, so the return of benefits is significant.

It is important to mention the work of Hernández and Gonzalez, who carried out a partial equilibrium analysis in the Mexican avocado market for export to USA [11]. In their research, they built an econometric model to represent the Mexican avocado market for export to USA and, with the results, they calculated the price flexibility of demand. In their analysis, they developed a simulation scenario, and determined that an increase in the quantity exported in a magnitude that represents an annual increase of 30% causes a decrease of 4.4032% in the price. With these two impacts in quantity and price, they calculated a positive final effect of US$ 595,556,756.00, which repre-sented the increase in total income in the market.

The result showed that encouraging a 30% increase in one year in the quantity of Mexican avocado exported to USA would be viable from an economic perspective in terms of income. The effects of the simulation scenario were transferred to the scope of the producer in Mexico; in this context, they calculated the B/C R for avocado produc-ers in Michoacan,

Jalisco and the State of Mexico, finding the following results: 1.6890, 1.8514 and 1.8124, respectively. With these results, they established that encouraging avocado production to export to USA in Michoacan, Jalisco, and the State of Mexico at an annual rate of 30% would be profitable for the producers of this states. Additional-ly, they recommended increasing the exportable supply, i.e., increasing the production with the organoleptic characteristics that the export market demands, i.e., a first qual-ity product with the purpose of taking advantage of the export infrastructure in the three states.

On the other hand, Hernandez, Lopez, and Casique applied a partial equilibrium model to Mexican mango exports destined for the US market [17]. They identified a downward trend in the competitiveness of the Mexican mango, since in 1992 the mar-ket share in the US market was 82.94%, while in 2016 it fell to 65.92%. To determine the economic viability of encouraging exports, they developed an econometric model to represent the international mango market with the purpose of estimating the price flexibility of demand. The results showed that an increase in the exported quantity at an annual rate of 20% causes a price decrease of a magnitude that represents 10.1237%. With these impacts in quantity and price, they developed a simulated sce-nario in which they calculated a combined positive final effect of US$ 20,955,114.70 in the total value of the quantity traded. With these results, they affirmed that an in-crease in Mexican mango exports to the US market would be economically viable.

The results were transferred to the context of production in Mexico. By extending the simulated impacts in quantity and price to the producer environment in Micho-acan, Sinaloa, and Nayarit. By applying the estimate of the B/C R, the results would be 1.1806, 1.1543 and 0.9171 for each state, respectively, and they interpret that for the producers of Michoacan and Sinaloa it would continue to be profitable to increase mango production to export to USA at an annual rate of 20%; while for the producers of Nayarit it would stop being profitable. With these results, they recommend increas-ing the exportable supply in Michoacan and Sinaloa that meets the quality and price characteristics to take advantage of the opportunities that US market offers as a result of the preferential export rates resulting from the NAFTA, the geographic proximity to USA, as well as Mexico competitive advantage in mango production based on physical and edapho-climatic conditions.

On the other hand, they recommended to apply mechanisms to improve the tech-nological conditions in mango production in Nayarit that must be considered: im-proved seed, fertilizers, as well as the application of pesticides, and efficient irrigation systems; all this with the purpose of improving the quality of the product, meeting the characteristics that the consumer in US market demands, and increasing the yield that allows reducing the unit cost, in order to improve the income for the producer and compensating the investments made. In other words, to increase the supply that meets the organoleptic characteristics for export in Mexico, it is necessary to improve the technology transfer mechanisms that allow increasing the quality of the final product, so that the price in the US market covers the investment costs and, in this way, the in-come for producers would increase.

It is important to mention that the partial equilibrium analysis allows modeling the reality in the international market of a good between two national economies, in which it is possible to calculate the income derived from the commercial exchange and, through price

elasticity or flexibility of demand, the impact on said income of a change in the fundamental variables of the market model: quantity and price. These changes can have a diverse origin, however, if the analysis is fed with true data from the market in question and attached to the reality analyzed, it is possible that the re-sults derive in valid conclusions and recommendations to improve production and trade conditions of the good between both nations.

Materials and Methods

To carry out this research work, a descriptive study was developed to show the effects of an increase in Mexican strawberry exports to the Canadian market. In order to do it, the Mexican strawberry market between Mexico and Canada was represented in an econometric model to calculate the price flexibility of demand and to carry out a partial equilibrium analysis of the international market for a good between two economies. This calculation allows the simulation of an increase in the quantity traded. Thus, it is possible to affirm that the study is explanatory, since to carry it out it is nec-essary to establish the effect that an increase in the quantity exported of Mexican strawberries to Canada causes on the price. Then, the increase in the quantity exported imply two effects, and it is necessary to determine the final effect. The work is quanti-tative since the market is represented through an econometric model, considering the relationship between the variables that exist for the international trade of strawberries between Mexico and Canada to take place.

The Econometric Model of Simultaneous Equations

The econometric model that represents the strawberry market between two economies was made up of two main equations:

The first one was a demand function for Mexican strawberry imports, in which PIFMCant is the CIF real unit price, and operates as the dependent variable, and was influenced by:

$$PIFMCant = \beta 10 + \beta 11 QIFMCant + \beta 12 PPFMRt + \varepsilon 1 \quad (1)$$

The second one was a supply function for strawberry exports in Mexico, in which the real unit price of PEFMt was the price of strawberry exports in Mexico, and oper-ates as the dependent variable, and was influenced by:

QEFMt, which was the quantity exported of strawberries in Mexico, and by PPFMRt, which was the real unit price of the strawberry to the producer in Mexico:

$$PEFMt = \beta 20 + \beta 21 QEFMt + \beta 22 PPFMRt + \varepsilon 2 \quad (2)$$

At this point, it is necessary to say that the method of 3-Stage Least Squares (3SLS) was applied to the simultaneous equations model (supply and demand in the interna-tional market) with the purpose of calculating the coefficients β10-β22. In this regard, the β coefficients were calculated simultaneously based on the relationship of the var-iables in the market, and they were represented inside the model [21].

Likewise, it is important to mention that the PIFMCant, QIFMCant, PEFMt and QEFMt variables were built with data from the Internet Tariff Information System Via Internet (SIAVI, by its Spanish acronym) of the Mexican Ministry of Economy [3], while the variable PPFMRt was built with information from the Food and Fisheries In-formation Service (SIAP) of the Mexican Ministry of Agriculture [4].

The Partial Equilibrium Analysis

In order to apply the partial equilibrium model, the following assumptions were established:

1. The international market for a good: Mexican strawberries for export to Cana-da.
2. An international market between two nations: Mexico as the country that ex-ports strawberries to Canada; and Canada as the importing country of Mexican strawberries.
3. For this analysis, strawberry exports in Mexico were equal to the excess supply in the international market.
4. For this analysis, Mexican strawberries imports in Canada were equal to the excess demand in the international market.
5. Monetary values in Canadian dollars Can$.
6. Values and prices in real terms.
7. A 50% increase in the quantity of Mexican strawberries imported in Canada in 2022 compared to the quantities imported in 2021.

Likewise, an increase in the quantity imported of strawberries in Canada was expressed in the international market as a displacement of the excess supply curve from its starting position ES0 to position ES1. This change causes a decrease in the international price from the starting position IP0 towards position IP1, and this, in turn, causes an increase in the quantity traded from IQ0 towards position IQ1. This decrease in the price from IP0 to IP1 also causes an increase in the excess de-mand ED for strawberries in the international market. Now, the response of a change in price to a change in the quantity traded is given by the price flexibility of demand, which can be calculated as follows:

$$FPIFMCan = (dPIFMCan / dQIFMCan) * (QIFMCan / PIFMCan) \quad (3)$$

Thus, through the price flexibility of demand, the percentage by which the international price decreases when the quantity traded (between both countries) increases by 1% can be calculated. The analysis begins (in the first moment) in the real interna-tional market for imported Mexican strawberries in Canada in 2021; in this scenario, the international price of imports is IP0 while the quantity imported is given by IQ0. Now, in a second moment, the simulated 2022 scenario considers a 50% increase in the quantity imported of Mexican strawberries in Canada, denoted by IQ1 in the interna-tional market, while the IP1 price is less than IP0 (in 2021), in a magnitude determined by the price flexibility of demand.

Likewise, it can be established that an increase in the amount imported causes an increase in the value of imports, while, on the other hand, a decrease in the price caus-es a decrease in the mentioned value. The com-bined effects of both impacts on the value of Mexican strawberry imports destined for Canada in the international market cause a final impact. The calculation of these ef-fects can be determined as follows:

The increase in value (due to the increase in the quantity imported):

$$Increase\ in\ Value\ =\ (Q1 - Q0)\ *\ P1 \quad (4)$$

The decrease in value (due to the decrease in the quantity imported):

$$Decrease\ in\ Value\ =\ (P0 - P1)\ *\ Q0 \quad (5)$$

The final effect is the result of both impacts combined, i.e., the difference between the increase in value (of total imports of Mexican strawberries in Canada) due to the increase in quantity minus the consequent decrease in value due to the decrease in price; i.e., this final effect can be calculated as follows:

$$Increase\ in\ Value - Decrease\ in\ Value\ =\ Final\ Effect \quad (6)$$

The calculation of this final effect is the result of the simulated 50% increase in the quantity imported. So, to determine the viability of this increase in the quantity of strawberries traded between Mexico and Canada in the international market, the cri-teria are:

1. If the Increase in Value is greater than the Decrease in Value, the difference will have a result with a positive sign, which means that the total value of the quantity traded will increase. This result allows us to establish that a 50% increase in the quan-tity imported of Mexican strawberries in Canada is viable from an economic perspec-tive.

2. If the Increase in Value is less than the Decrease in Value, the difference will have a result with a negative sign, which means that the total value of the quantity traded will decrease. This result allows us to establish that a 50% increase in the quan-tity imported of Mexican strawberries in Canada is not viable from an economic per-spective.

The Profitability in the Producing Areas

Both impacts (50% increase in quantity and the consequent 9.16% decrease in price) can be transferred to the context of strawberry producers in Michoacan, Baja California and, Guanajuato to determine the final effect that a 50% increase in the quantity exported of Mexican strawberries to Canada over the profitability of produc-tion. That profitability in production can be expressed through the Benefit/Cost Ratio [22] and calculated as follows:

$$B/C\ R\ =\ Benefits\ /\ Costs \quad (7)$$

In order to determine the profitability for the producer, the first criterion can be expressed as follows:

$$B/C\ R\ >\ 1 It\ is\ profitable \quad (8)$$

In this sense, equation 8 shows that: to determine the profitability of carrying out a productive activity, the B/C R is greater than 1, this result means that the income is greater

than the expenses, so that the performance of the determined activity is prof-itable. When applied to the case of the 2022 simulated scenario, this result would mean that under the specified conditions, an increase in production with the purpose of in-creasing the quantity exported of Mexican strawberries to Canada by a magnitude that represents an annual increase of 50% in 2022 compared to 2021, it would be profitable for the producer in Mexico:

$$B/C\ R\ =\ 1 There\ are\ no\ profits\ no\ losses \quad (9)$$

Now, equation 9 shows that: to determine the profitability of carrying out a productive activity the B/C R is equal to 1, this result means that the income is equal to the expenses, so that the performance of the determined activity does not represent no profit or loss. When applied to the case of the 2022 simulated scenario, this result would mean that under the specified conditions, an increase in production with the purpose of increasing the quantity exported of Mexican strawberries to Canada by a magnitude that represents an annual increase of 50% in 2022 compared to 2021, for the producer in Mexico there would be no profit or loss:

$$B/C\ R\ <\ 1 It\ is\ not\ profitable \quad (10)$$

Now, equation 10 shows that to determine the profitability of carrying out a productive activity, the B/C R is less than 1; this result means that the income is less than the expenses, so that the performance of the determined activity is not profitable. When applied to the case of the 2022 simulated scenario, this result would mean that under the specified conditions, an increase in production with the purpose of increas-ing the quantity exported of Mexican strawberries to Canada by a magnitude that represents an annual increase of 50% in 2022 compared to 2021, it would not be prof-itable for the producer in Mexico.

Results

Based on the results of the application of 3-Stage Least Squares to the econometric model, the β coefficients were calculated, as can be seen in Table 1.

Table 1

Coefficients β of the function of demand

Variable	Coefficient	Value[8]	Standard Error[8]	t-Student value[8]	Pr > | t |
Intercept	β_{10}	2490.00200	509.844100	4.88	0.0005 [10]
$QIFMCan_t$	β_{11}	–4.33127	1.880600	–2.30	0.0418 [9]
$PPFMR_t$	β_{12}	0.0000000054	0.000000001174	4.60	0.0008 [10]

8 Note: Adapted from the results of the Econometric Model.

9 Note: It is significant at the level of 0.05.

10 Note: It is significant at the level of 0.01.

Based on the results, t-Student tests were accomplished. To carry them out, it is necessary to mention that the critical value of t-Student for a significance level of 0.05 (5%)

is equal to 1.7613, while the critical value of t-Student for a significance level of 0.01 (1%) is equal to at 2.6245. In this way, in the hypothesis test, the value of t-Student for the coefficient β10 was equal to 4.88, therefore, it was greater than 2.6245, so the probability of the respective t-Student test is (0.0005) is less than 0.01**. In the same sense, the t-Student value for the coefficient β11 was equal to -2.30, that is, it was less than –1.7613, so the probability of the respective t-Student test (0.0418) was less than 0.05*. Likewise, the value of t-Student for the coefficient β12 was equal to 4.60, that is, it was greater than 2.6245, so it was possible to interpret that the probability of the cor-responding t-student test (0.0001) was less than 0.01**. Then, with these results, it can be established that the estimated values of β10, β11 and β12 were statistically significant. With the estimation of the values of the coeffi-cients β's, it was possible to build the demand equation:

$$PIFMCant = 2490.002 - 4.33127QIFMCant + 0.0000000054PPFMRt + \varepsilon t \quad (11)$$

In order to calculate the price flexibility of demand, the partial derivative of the demand function (12) was developed with respect to the quantity QIFMCant:

$$PIFMCant = 2490.002 - 4.33127QIFMCant + 0.0000000054PPFMRt + \varepsilon t \quad (12)$$

With this estimation, price flexibility of demand was calculated:

$$(dPIFMCan/dQIFMCan) = -4.33127 \quad (13)$$

Thus, it was possible to establish that if the quantity demanded increases 1%, the price decreases 0.18%. So, based on this flexibility, it is possible to affirm that if the quantity demanded increased by 50% for the simulated scenario of 2022 (compared to 2021), this situation would cause a decrease of –9.16% in the price of Mexican straw-berries in Canada, compared to the price in 2021, as can be seen in Table 2.

Table 2

Estimates of price flexibility of Mexican strawberry demand in Canada

Increase in the quantity imported of Mexican strawberry in Canada	Decrease in the price of the Mexican strawberry imports in Canada[11]
1%	–0.183288751%
50%	–9.164437532%

11 Note: Adapted from the results of the Econometric Model.

Now, an increase in the quantity imported of Mexican strawberries in the Cana-dian market from IQ0 to IQ1 causes the value of the quantity traded to increase. How-ever, there is also a second effect, a decrease in price from IP0 to IP1. The result of both effects is an increase in the total value of the quantity traded in Can$403,542.07 (see in Table 3).

Table 3

Total value of the Mexican strawberry imports in Canada if the quantity increases 50%

Qt[12]	Pt[13]	Total Value Qt*Pt
Q_{2021} = 192.81	P_{2021} = 5,772.98	$Q_{2021}*P_{2021}$ = Can$1,113,116.84
Q_{2022} = 289.22	P_{2022} = 5,243.92	$Q_{2022}*P_{2022}$ = Can$1,516,658.91
	Increase	Can$403,542.07

12 *Note:* Adapted from Sistema de Informacion Arancelaria Via Internet. Ministry of Economy, 2022.

13 *Note:* Adapted from Sistema de Informacion Agropecuaria y Pesquera. Ministry of Agriculture, 2022.

Now, the value of the areas, resulting in an in-crease of Can$403,542.07 in the total value of the quantity imported of Mexican strawberries in Canada (as can be seen in Table 4).

Table 4

Increase in the total value of the Mexican strawberry imports in Canada

Increase in the value due to the increase in the quantity[14]	$(Q_{2022}-Q_{2021})*P_{2022}$	Can$505,552.97
Decrease in the value due to the decrease in the in the price[14]	$(P_{2021}-P_{2022})*Q_{2021}$	Can$102,010.90
Final increase		Can$403,542.07

14 *Note:* Adapted from Sistema de Informacion Arancelaria Via Internet. Ministry of Economy, 2022.

Then, with these results, the B/C R was estimated to determine the profitability of producing strawberries in Michoacan to export to the Canadian market for the year 2021. It is important to say that, in 2021, 90% of strawberry production in Baja Califor-nia it was destined for the US market, while 10% was destined for the national market. Likewise, in 2021, the state of Guanajuato allocated 30% of its production to the US market approximately. That is to say, Baja California and Guanajuato did not export strawberries to Canada.

Table 5

Determination of the B/C R of producing strawberries in Mexico to export to Canada

State	Quantity[15] t	Unit price[16]	Unit cost[17]	Income	Expenses	B/C R
Michoacán	192.81	MXN19,616.72	MXN16,401.00	MXN 3,782,397.87	MXN 3,162,358.81	1.1961
Baja California	0	MXN31,029.61	MXN16,391.00	0	0	0
Guanajuato	0	MXN12,057.64	MXN15,976.00	0	0	0

15 *Note:* Adapted from Sistema de Informacion Arancelaria Via Internet. Ministry of Economy, 2022.

16 *Note:* Adapted from Sistema de Informacion Agropecuaria y Pesquera. Ministry of Agriculture, 2022.

7 *Note:* Adapted from Agrocostos. 22. Fideicomisos Instituidos en Relacion con la Agricultura, 2022.

The Table 5 shows that, in 2021, the B/C R of strawberry production in Micho-acan was 1.1961, so it was possible to affirm that producing strawberries to export to Canada in Michoacan was profitable. Now, with the purpose of establishing the hypo-thetical 2022 scenario with a 50% increase in the quantity exported of Mexican straw-berries to the Canadian market, exports equal to 289.22 t were simulated. In this sense, of the total simulated exports, 260.30 t (90%) were assigned to Michoacan; while to in-clude Baja California and Guanajuato in the analysis, which already export strawber-ries to the US market, 14.46 t (5%) and 14.46 t (5%) were assigned to each state respec-tively. It is worth mentioning that in order to carry out this scenario, the assumption is a linear function of costs, in this way the cost per t is constant.

Table 6

Determination of the B/C R of producing strawberries in Mexico to export to Canada in the simulated scenario

State	Quantity[18] t	Unit price[19]	Unit cost[20]	Income	Expenses	B/C R
Michoacán	260.30	MXN17,818.96	MXN16,401.00	MXN4,638,279.21	MXN4,269,184.40	1.0865
Baja California	14.46	MXN28,185.92	MXN16,391.00	MXN407,600.12	MXN237,032.30	1.7196
Guanajuato	14.46	MXN10,952.63	MXN15,976.00	MXN158,387.28	MXN231,030.93	0.6856

18 *Note*: Adapted from Sistema de Informacion Arancelaria Via Internet. Ministry of Economy, 2022.

19 *Note*: Adapted from Sistema de Informacion Agropecuaria y Pesquera. Ministry of Agriculture, 2022.

20 Note: Adapted from Agrocostos. Fideicomisos Instituidos en Relacion con la Agricultura, 2022.

Thus, in the simulated 2022 scenario, Table 6 shows that the B/C R for the pro-ducers of Michoacan, Baja California and Guanajuato are 1.0865, 1.7196 and 0.6856 respectively. With these results, it was possible to establish that, for producers in Mi-choacan and Baja California, it would be profitable to produce strawberries to export to Canada in the face of an annual increase in quantity. On the other hand, producing strawberries to export to Canada in Guanajuato would not be profitable, since in the simulated 2022 scenario, given an annual increase of 50% in the quantity exported, the B/C R gets even worse.

Discussion

In this context, a simulation scenario provides the chance to observe the conse-quences of a significant change in the fundamental variables on the reality represented in the analysis. In this regard, the partial equilibrium model of a good between two countries allows visualizing the effects of specific changes in the economy in which international trade takes place. In this sense, it is necessary to say that, in the market for a specific good, the relationship between quantity and price was determined by the price flexibility of demand; and then, knowing this magnitude, impacts on quantity and price could be simulated, and transferred to the international market. In the par-tial equilibrium model, these impacts have direct effects on the total value of the quantity of the good traded between both nations. In the event

that this effect on the value of imports is positive, the proposed change is viable, since it increases the total value, and then it is pertinent to carry it out; however, in the event that this effect on the total value of imports is negative, the proposed change is not viable from an eco-nomic perspective, since the total value decreases, so it is not pertinent to carry it out.

Now, it is necessary to say that the strawberry is one of the most important export markets in Mexico, so in 2021, it represented approximately US$ 890,544,745.00. In that year, Mexico exported 214,443.34 t of strawberries, that is, 39.50% of the total produced (542,890.63 t). In that same year, of the total exported (214,443.34 t), Mexico destined approximately 99.38% to the US market (213,115.44 t). Canada is the second destination of Mexican strawberry exports and represented 0.09% (192.82 t) of the market [3].

In this regard, Hernandez, Alejos, and Casique developed a partial equilibrium analysis in the international market for Mexican strawberries for export to the USA [12]. Calculating the price flexibility of demand, they estimated that an 18% increase in the quantity exported causes a 6.6% decrease in the price. With these results, they es-tablished that the combined effect between both impacts was a positive increase in the total value of the quantity traded of US$ 59,703,057.26. With this increase, they said, it can be established that a policy that allows increasing the exportable supply of straw-berries destined for the US market in a magnitude that represents an annual increase of 18% would be viable from an economic perspective, since it would increase the val-ue of the quantity traded.

Additionally, they transferred these changes in quantity and price in the interna-tional market to the context of the strawberry producer in Mexico and determined that, in the simulated scenario, the B/C R in the producing areas of Baja California, Michoacan and Guanajuato would be 1.9813, 1.9020 and 0.9234. With these results, they affirmed that in the case of increasing strawberry exports to Mexico in a magni-tude of 18% in one year, it would be profitable for producers in Baja California and Michoacan; however, for producers in Guanajuato it would not be.

With these results, they established that Guanajuato does not have the production technology conditions that allow it to contribute to the increase in the exportable sup-ply of strawberries to export to the USA. In order to develop strawberry production with the organoleptic and quality characteristics demanded by the US market, it is necessary to improve production technology, through the introduction of improved seed, safety systems, as well as controlled environments for production. In this way, it is possible to develop in the producing area of Guanajuato the exportable supply of strawberries that improves the financial and economic conditions for production, im-proving the price in the international market that compensates for the investment in technology.

Then, it is possible to observe that the partial equilibrium analysis allows identi-fying the feasibility of producing a good to export to a given market. Once the viability, in the economic sense, has been established, it is possible to visualize the conditions of financial profitability in which it occurs, since in addition to the comparison of the different producing areas, this relative analysis allows visualizing the B/C R with the purpose of identifying the areas with low productivity of the specific good, as well as associating it with an inadequate technological level in relation to the needs and op-portunities that international trade offers in certain circumstances.

Thus, Ahmad, Khalid, Karim, and Zainuddin affirmed that the technical efficien-cy in the production of a good determines the export potential. In this regard, they say that the potential export is the maximum amount that can be exported in the absence of commercial resistance [24]. This calculation makes it possible to determine the gap between the amounts exported and the potential export. These estimations in the lon-gitudinal sense, allow to visualize the performance of a country in the international market. In the sense of technical efficiency, this analysis makes it possible to determine the use of their productive capacities to export a good.

The partial equilibrium analysis allows the identification of the economic condi-tions in which the production takes place, as well as the repercussions that the increase in productive capacity entails for the production areas. In addition, the economic via-bility analysis is essential, because it is not only focused on the foreign market, since the domestic market must first be covered and determine the commercial bases on which a policy of increase in exports can be promoted, as well as the development of local production in the different producing regions. It is worth mentioning that, in the examples mentioned above, the results show that an increase in the quantity exported in the international market is viable from an economic perspective for both countries, since the final effect would be an increase in the total value of the quantity traded.

However, an alternate result in the simulated scenario could show that: given an increase in the quantity traded, the decrease in price would occur in such a magnitude that the final effect would be a decrease in the total value of the quantity traded. In such a scenario, a policy that encourages production with the purpose of generating an increase in the quantity exported would not be viable, since the import market would not support larger quantities from the international market; in such a case, the value of the quantity traded would tend to decrease, decreasing the benefits for the consumer in the importing country, and decreasing the benefits for the producer in the exporting country. In such a case, the international trade of the good between both nations is not viable, which would lead to alternative mechanisms, such as the need to invest re-sources in advertising in the export destination with the purpose of increasing de-mand, or the search for other markets. to export. In this sense, the quantities that the market of the importing nation supports are determined by the magnitude of the price flexibility of demand.

In this regard, Hernandez, Casique, and Gonzalez applied a partial equilibrium analysis of Mexican mango exports to the Canadian market and determined that the annual increases in the quantity traded should not be greater than 1.30% [25]. With this result, they recommended that the quantities exported to the Canadian market remain stable in the coming years, and that other markets such as Japan or Europe be explored, considering that if Canada were avoided being saturated, the price in the market would tend to a gradual recovery in the medium term. This analysis showed that it was possible for the market to have a level of con-sumption capacity in which the saturation level was very close to the level of exports made. In this case, it is necessary to keep the quantity exported at a stable level (no annual increases) for several years to maintain economic viability, as well as the prof-itability of the producing areas that export to that destination.

Finally, it is necessary to indicate that the results of this research are congruent with the previous cited works, since the procedure of analysis allows to determine whether the simulated increase in the exports of the good causes an increase in the benefits for the producers in the exporter country and the benefits for the consumers in the importer country.

Conclusions

Canada is the third strawberry importer in the world, mainly from the USA. Mex-ico is the fourth producer, the second exporter in the world, and the second exporter of strawberries to the Canadian market. The results showed that the price flexibility of the demand for Mexican strawber-ries in Canada was equal to –0.1833%. With this estimate, the simulated scenario showed that an increase of 96.41 t in the quantity exported of strawberries to Canada in 2022 (compared to 2021) would cause a decrease of Can$529.06 per t in the price and causing an effect on income of the producer. The results showed that the final im-pact on total income would be an increase of Can$403,542.07, therefore, it is possible to establish that the application of mechanisms that increase the quantity exported of Mexican strawberries in Canada in a magnitude that represents annual increases of 50%, would be viable from an economic perspective. Then, transferring the effects calculated in the simulated scenario 2022 to the producer context in Mexico, the results showed that the B/C R for producers in Michoacan, Baja California and Guanajuato would be equal to 1.0865, 1.7196 and 0.6856, respectively. Based on these results, it is possible to affirm that an increase in strawberry production to export to Canada that represents a growth rate of 50% in one year would be profitable for producers in Mi-choacan and Baja California.

Thus, in Michoacán, strawberry exports to the Canadian market were already carried out, while Baja California exports more than 90% of its production to the US market, since it has the characteristics and quality in the product to obtain Animal and Plant Health Inspection Service (APHIS) certification, an essential requirement to ex-port strawberries to this market. Both states have the technological capabilities to in-crease the quantity exported; while, regarding Guanajuato, the results show that, for the producer, exporting strawberries to the Canadian market is not profitable, and an increase in the quantity exported in a magnitude that represents 50% in one year would cause that the B/C R got even worse.

Likewise, it is necessary to improve the technological conditions for production of strawberries with the organoleptic and quality characteristics that allow the produc-tion developed in Guanajuato to be suitable for entering the Canadian market. In this sense, the technological resources that must be implemented to improve production conditions must include improved seed, fertilizer, adequate mechanisms to combat pests, a controlled environment, as well as the necessary infrastructure for the correct post-harvest handling (food safety, packing and packaging) with the purpose of guar-anteeing that the product reaches its destination in optimal conditions, and complying with the demands of the consumer in the international market.

Finally, through a partial equilibrium analysis a scenario was built to simulate specific conditions in the market with the purpose of determining effects on the inter-national market, on the economy of the countries, as well as on the technical efficiency for the production and its profitability in the different productive areas. In this way, it is possible to make a forecast

of the repercussions of encouraging exports to a specific market and, in this way, determine the feasibility of making the decision to encourage that increase.

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