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Determination of the Economic Viability of Increasing Exports of Mexican Mango to the Canadian Market

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Abstract: Mexico is the main mango exporter in the world, while Canada is the eleventh importer and to cover its domestic demand, it imports mango mainly from Mexico. It is important to mention that, between 2003 and 2021, the annual growth rate of Mexican mango imports in Canada averaged 4.19%. On this basis, the purpose of this research is to determine the economic viability of increasing Mexican mango imports in Canada at an average annual growth rate of 10%. In order to carry out the work, the international mango market between Mexico and Canada was represented in an econometric model, through a partial equilibrium analysis, to simulate a rate of 10%. The results show that an increase in the exported quantity of Mexican mango to the Canadian market at an annual growth rate of 10% is not viable from an economic perspective. Likewise, the results of the simulated scenario show that the Benefit/Cost Ratio (B/C R) in mango production for Michoacán, Sinaloa, Nayarit and Oaxaca would be 1.1264, 1.2475, 0.8543 and 1.1053, respectively. On the other hand, the simulation scenario shows that the annual growth rate of Mexican mango exports to the Canadian market should not be greater than 1.2966%, since increases in magnitudes less than this rate causes the total value of the traded quantity to increase. In the same way, increases greater than a rate of 1.2966% causes that the total value of the traded quantity to decrease.

Keywords: Mango, International Trade, Viability

1. Introduction

Information of the Food and Agriculture Organization (FAO) shows that, in 2020 were produced 54,831,104 t of mango in the world, 72.48% was harvested in Asia (39,742,461 t), 15.72% in Africa (8,621,035 t), 11.67% in America (6,398,975 t) and 0.13% in Oceania (68,633 t). India was the main producer with 24,748,000 t, which represented 45.13%; Indonesia was ranked second with 3,617,271 t (6.60%), China was third with 2,539,717 t (4.63%), Mexico was fourth with 2,373,111 t (4.33%), Pakistan was fifth with 2,344,647 t (4.28%), Brazil was sixth with 2,135,304 t (3.89%), Malawi was seventh with 1,938,066 t (3.53%), Thailand was eighth with 1,657,589 t (3.02%), Bangladesh was ninth with 1,448,396 t (2.64%) and Egypt was tenth with 1,395,244 t (2.54%) [1], as can be seen in Table 1.

Table 1. *Main mango producing countries in 2020.*

Country	Production	%
India	24,748,000	45.13
Indonesia	3,617,271	6.60
China	2,539,717	4.63
Mexico	2,373,111	4.33
Pakistan	2,344,647	4.28
Brazil	2,135,304	3.89
Malawi	1,938,066	3.53
Thailand	1,657,589	3.02
Bangladesh	1,448,396	2.64
Egypt	1,395,244	2.54
Others	10,633,759	19.39
Total	54,831,104	100.00

According to information from FAO, between 1990 and 2020, the world production of mango grew at an average annual rate of 3.95% [1], as shown in Table 2.

Table 2. *Annual rate of the world mango production between 1990 and 2020.*

Year	t	%	Year	t	%
1990	17,166,061	4.51	2006	34,135,094	6.99
1991	17,932,600	4.47	2007	35,307,498	3.43
1992	18,506,240	3.20	2008	36,739,665	4.06
1993	19,960,551	7.86	2009	35,639,746	-2.99
1994	21,870,513	9.57	2010	37,578,530	5.44
1995	23,019,098	5.25	2011	39,901,960	6.18
1996	22,805,466	-0.93	2012	42,186,958	5.73
1997	23,929,366	4.93	2013	44,797,125	6.19
1998	22,893,746	-4.33	2014	46,480,248	3.76
1999	23,758,188	3.78	2015	46,786,660	0.66
2000	24,927,037	4.92	2016	47,074,851	0.62
2001	25,101,577	0.70	2017	52,000,350	10.46
2002	26,407,652	5.20	2018	53,510,801	2.90
2003	29,956,738	13.44	2019	55,026,131	2.83
2004	29,853,673	-0.34	2020	54,831,104	-0.35
2005	31,903,956	6.87	Average annual rate		3.95

FAO data show that, in 2020, of the total mango produced (54,831,104 t), 4.23% was destined for foreign trade, that is, 2,319,009 t. Mexico was the main mango exporter in the world with 421,636 t, which represented 18.18% of the total, Thailand was second with 391,280 t (16.87%), Brazil was third with 243,466 t (10.50%) and Peru was fourth with 239,391 t (10.32%).

It is important to say that Netherlands was fifth with 239,007 t (10.31%) and it is the main non-producing exporter country, India was sixth with 128,018 t (5.52%), Pakistan was seventh with 107,195 t (4.62%), Vietnam was eighth with 61,403 t (2.65%), Spain was ninth with 60,159 t (2.59%) and Ecuador was tenth with 60,102 t (2.59%) [1], as can be seen in Table 3.

Table 3. *Main mango exporting countries in 2020.*

Country	t	%
Mexico	421,636	18.18
Thailand	391,280	16.87
Brazil	243,466	10.50
Peru	239,391	10.32
Netherlands	239,007	10.31
India	128,018	5.52
Pakistan	107,195	4.62
Vietnam	61,403	2.65
Spain	60,159	2.59
Ecuador	60,102	2.59
Others	367,352	15.84
Total	2,319,009	100.00

According to information from FAO, in 2020, of the total mango imports in the world (1,913,853 t), the United States of America (USA) was the main mango importer with 549,210 t, Netherlands was ranked second with 277,727 t, Germany was third with 97,713 t, United Arab Emirates (UAE) was fourth with 91,466 t and Saudi Arabia was fifth with 79,584 t.

Likewise, United Kingdom (UK) was sixth with 73,227 t, Spain was seventh with 70,290 t, Malaysia was eighth with 63,054 t, France was ninth with 60,520 t, Belgium was tenth with 44,758 t, and Canada was eleventh with 41,302 t [1], as shown in Table 4.

Table 4. *Main mango importing countries in 2020.*

Country	t	%
United States of America	549,210	28.70
Netherlands	277,727	14.51
Germany	97,713	5.11
United Arab Emirates	91,466	4.78
Saudi Arabia	79,584	4.16
United Kingdom	73,227	3.83
Spain	70,290	3.67
Malaysia	63,054	3.29
France	60,520	3.16
Belgium	44,758	2.34
Canada	41,302	2.16
Russia	38,695	2.02
Portugal	38,301	2.00
Thailand	37,410	1.95
Others	364,534	19.05
Total	1,913,853	100.00

Information of the Trade Data Online show that, in 2021 Canada imported 76,212.84 t of mango, of which 44,677.99 t came from Mexico, which represented 58.62% of the total. 7,687.25 t was originated in Peru (10.09%), 5,176.70 t were imported from Brazil (6.79%), 3,397.71 t from Colombia (4.46%), 2,942.04 t from Thailand (3.86%), 2,623.53 t from Taiwan (3.44%), 1,566.40 t from the Philippines (2.06%), 1,321.05 from India (1.73%), 1,253.03 from Ecuador (1.64%), 919.63 t from USA (1.21%) and 875.46 t from Dominican Republic (1.5%) [2], as can be seen in Table 5.

Table 5. *Main mango exporting countries to the Canadian market 2021.*

Country	t	%
Mexico	44,677.99	58.62
Peru	7,687.25	10.09
Brazil	5,176.70	6.79
Colombia	3,397.71	4.46
Thailand	2,942.04	3.86
Taiwan	2,623.53	3.44
Philippines	1,566.40	2.06
India	1,321.05	1.73
Ecuador	1,253.03	1.64
United States of America	919.63	1.21
Dominican Republic	875.46	1.15
Others	3,772.05	4.95
Total	76,212.84	100.00

According to information of the Mexican Ministry of Economy, in 2021, Mexico exported 373,610.42 t of mango to the US market, which represented 87.07% of the Mexican mango exports [3].

Likewise, Canada was the second destination for Mexican mango and, in 2021, imported 44,677.99 t, which represented 10.41% of the Mexican mango exports, Japan was third with 4,261.87 (0.99%), France was fifth with 3,076.46 t (0.72%) and Spain was sixth with 811.74 t (0.19%) [3], as can be seen in Table 6.

Table 6. *Main importing countries of mango originating in Mexico 2021.*

Country	t	%
United States of America	373,610.42	87.07
Canada	44,677.99	10.41
Japan	4,261.87	0.99
France	3,076.46	0.72
Spain	811.74	0.19
United Kingdom	669.03	0.16
Netherlands	582.39	0.14
Germany	458.12	0.11
Others	941.01	0.22
Total	429,089.03	100.00

SIAVI data show that, in 2003 Canada imported 21, 355.89 t of mango originating in Mexico; while, in 2021 these imports amounted to 44,677.99 t. In other words, between 2003 and 2021, Mexican mango imports into Canada grew at approximately an average annual rate of 4.19% [3], as shown in Table 7.

Table 7. *Mexican mango imports in Canada 2003-2021.*

Year	t	%	Year	t	%
2003	21,355.89		2013	36,256.18	17.82
2004	22,530.99	5.50	2014	32,858.17	-9.37
2005	21,112.60	-6.30	2015	33,511.67	1.99
2006	24,817.13	17.55	2016	32,961.72	-1.64
2007	25,487.66	2.70	2017	38,732.31	17.51
2008	24,051.32	-5.64	2018	37,958.91	-2.00
2009	26,798.05	11.42	2019	36,826.85	-2.98
2010	27,906.76	4.14	2020	41,302.72	12.15
2011	33,165.92	18.85	2021	44,677.99	8.17
2012	30,771.23	-7.22	Average annual rate		4.19

In this context, the research question is whether it is economically viable to increase Mexican mango exports to the Canadian market, so that the average annual growth rate is 10% per year. It is worth mentioning that derived from the first one, the second question is whether in the face of increases in which the rate of the exports to the Canadian market were 10% annual, to produce mango in Mexico would continue to be profitable.

2. Literature Review

Torres affirms that the quantity and the price at which a good X is traded in an economy are determined by the quantities that its citizens demand, and by the efficiency which it is produced internally. And since the physical conditions, the endowment of resources, the technological development and the specialization in the production of certain goods are specific to each region, then each country will be able to produce the good X in a quantity and at a price different from all the others nations.

In these particular conditions, the industry will satisfy the need for this good for citizens within each economy, with different efficiency [4]. Williams states that in autarky, there will be a country that is capable of producing the good X with greater efficiency and offering it to the market at a lower price than all other countries [5].

In these conditions, country A will naturally specialize in the production of good X, country B will specialize in the production of good Y, and country C in the production of good Z, and so on, since each one produces different goods with the greater efficiency than any other nation. This international division of labor is based on the differences in the physical conditions that each nation has, so it has direct repercussions on the economy, since it causes differences in the production costs of the same goods in different countries.

In this regard, this cost depends on the availability and cost of the factors necessary for its production. So a nation that is abundant in capital (for example), will specialize in industrial goods as advanced in the technological sense as the availability of that capital allows. If a country is scarce in capital, it will tend to specialize in light industries such as textiles or in the production of agricultural goods, if it is abundant in natural resources available to do so [4].

Krugman & Wells say that the economic objectives of a nation should focus on providing the best standard of living for its citizens with the endowment of resources it possesses. This will depend on the productivity of the resources used (labor and capital) [6]. The productivity of the human resource determines their salary, while the productivity of capital determines the return for the capitalist [7].

The standard of living of citizens then, is a function of the productivity of resources, since per capita income depends on them. In this understanding, international trade offers the opportunity to increase productivity, since it is not necessary for all goods to be produced internally.

A country can specialize in those sectors in which its companies are more productive in relative terms, and buy abroad the goods in which its companies are less productive than their foreign rivals, instead of producing them inefficiently and with resources that it can use in the production of other goods optimally [4].

Thinking idealistically, these resources are used in the most productive way possible. The specific sectors on which the nations base their development depend largely on the country natural resource endowment. Resource rich countries begin the upgrading process from positions of international success in resource based sectors. Resource poor countries have started from positions of success in labor intensive consumer goods sectors [8].

The economic success of nations will tend to increase to the extent that the country leads to increased productivity in those goods in which it is efficient in production. A country with a vast endowment of natural resources, however, can realize high national gains despite being in the factor driven stage, even though it is unlikely to be able to sustain them indefinitely [7].

Over time, the fact that the country is dependent on natural resources will make the country vulnerable to depletion from new foreign sources or technological changes that reduce or eliminate the need for this resource. This in turn causes a major problem, it provides high levels of profit that avoids the need for productive development towards subsequent stages based on technology and later on investment [8].

International trade theory says that, in the absence of

specific government intervention in foreign trade, the flows of goods and services between countries are determined by market prices. And then the theory of international trade refers to the study of the specific circumstance in which goods are exchanged between at least two countries with independent economic and monetary systems [4].

The explanation of why goods and services are exchanged between countries has traditionally been the center of international trade theory. Trade flows are determined by the price differences of each good. International goods are basic goods of a homogeneous nature, traded internationally, mainly raw materials and food in which their price tends to equalize.

Potential price and cost differences give rise to the international division of labor or specialization; and then the production of some goods increases in one country, so they are exported, and that of others is reduced, so they are imported.

For David Ricardo, even if one nation has an absolute disadvantage in the production of both goods with respect to the other, an exchange favorable to both can still take place. The most efficient nation must specialize in the production and export of the good in which its absolute advantage is greatest. This is the good in which the country has a comparative advantage [7].

On the other hand, a nation must import the good in which its absolute disadvantage is greatest. Each country specializes in the export of those goods in which it achieves greater relative productivity and it is possible to obtain generalized benefits from the commercial exchange, even if one of the participants managed to produce all the goods at a lower cost than the others.

On this basis, the Hecksher-Ohlin model is developed. It establishes that each nation must specialize in the export of goods that require a large quantity of relatively cheaper factors of production [8].

Specifically, when country A can produce a commodity cheaper than country B, and country B in turn can produce another commodity cheaper than country A, it is beneficial for both countries to specialize in the commodity that they could produce cheaper, since each one could produce its good more efficiently than the other. This would cause the produced quantities of each good to exceed the internal consumption needs of each country where it is produced.

The surplus of the production of each good in each country can be destined to another since they are not able to consume everything in the internal market [7].

Trading surpluses of each good in each country with the other benefits the economy and production efficiency of both nations. Then both countries, by using the division of labor and producing the merchandise in which each one has an absolute advantage, can carry out an exchange at the international level [8].

In the same way that the division of labor improves productivity in a country, the international division of labor favors efficiency at the international level; if one country can produce one good with less labor than another, and if the latter can produce some other good with less labor, both would lose if they continued to produce both goods. Each one must concentrate on the production of the good that can be produced with lower labor cost, or on the production of which it has an advantage, in order to later exchange its surplus production.

For Ricardo, the trade of a good X between two countries is generated when a country A (comparative advantage) produces it at a lower price than country B; and then country B is better off importing it than producing it domestically, as can be seen in Figure 1 [7].

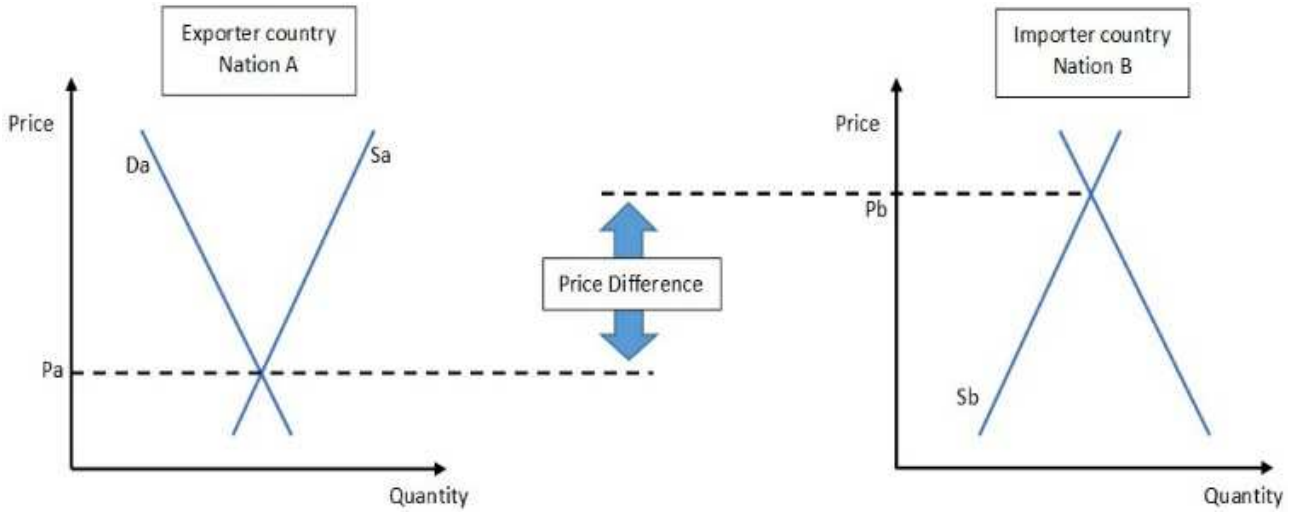

Figure 1. *Domestic price differences between the exporter country and the importer country.*

The exchange of a commodity between two nations is explained through a partial equilibrium model, in which two economies and one good are assumed. This model can be exposed, first, through the graph of Nation A (exporting country) that has a competitive advantage in the production of good X [5].

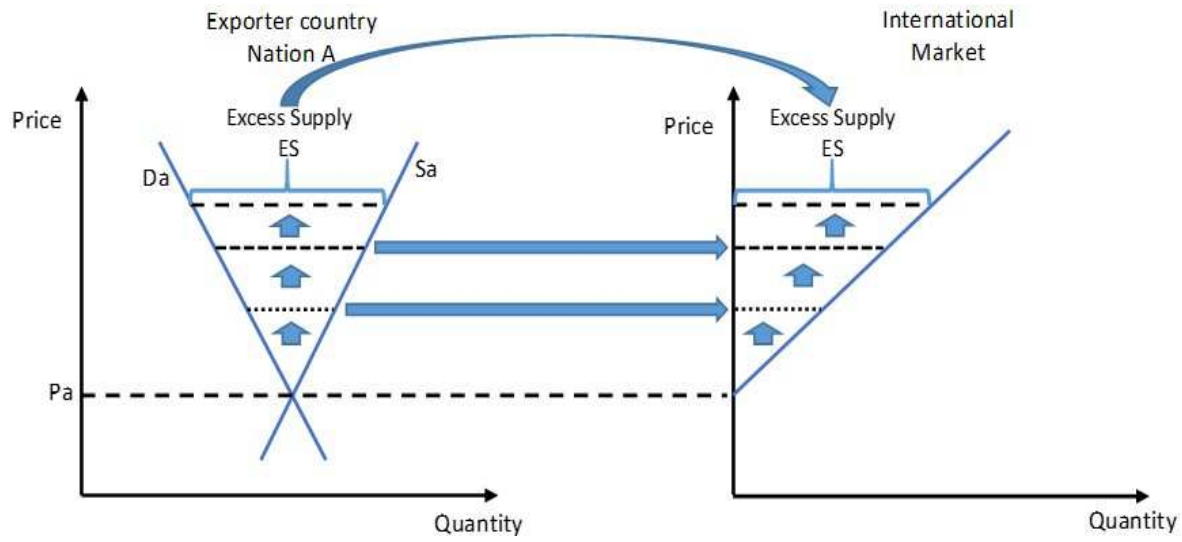

Figure 2. *Excess supply of a good in the international market.*

Based on the equilibrium price Pa in the Nation A, it can be conceived that, if this price were to rise, the difference between supply Sa and demand Da for good X would tend to increase.

These excess supply ES generated at different prices can be transferred to a second scenario that represents the international market and a line can be drawn that represents the quantities of good X available in the foreign market, as can be seen in Figure 2.

The model also shows the graph of the importing country B, which is at a competitive disadvantage in the production of good X against the exporting country A.

In this respect, the price Pb at which this good is produced in the national economy B is higher than the international price IP (and higher than the equilibrium price Pa of good X in Nation A).

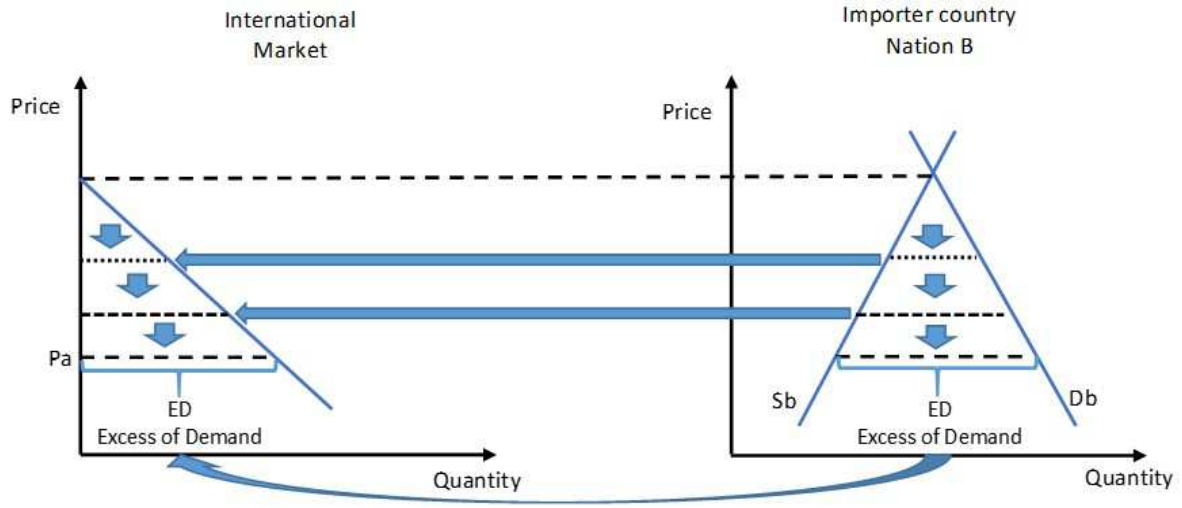

Figure 3. *Excess supply of a good in the international market.*

At this point, it should be noted that at the equilibrium price Pb, the quantity demanded Db and the supplied quantity Sb of good X in Nation B are equal (as can be seen in Figure 3).

Now, based on the equilibrium price Pb, it can be conceived that, if this price were to fall, the difference between the demand Db and the supply Sb of good X would tend to fall.

This falling difference can be considered as an excess of demand ED; that is to say, that at a Price P below the equilibrium price Pb, greater quantities of demand are generated that exceed the national supply of good X in the importing country B.

The aforementioned excess of demand ED generated at different prices, within the international trade model of two economies, can be transferred to the scenario that represents the international market (mentioned above) in such a way that if a line is drawn that represents the quantities of the good X demanded and missing in the international market (as shown in Figure 3).

Now, focusing on the international market scenario, it can be seen in Figure 4, that there is an intersection point between the excess supply ES and the excess of demand ED in which the equilibrium conditions of the market are met, since ES and ED are equivalent.

Figure 4. *Exporter country A, importer country B and international market of a good X.*

At this point, then, the international price IP causes an excess supply ES observable in the graph of exporter country A (Figure 2) and an excess demand ED also observable in the graph of importer country B (Figure 3). Then, at the international price IP, the excess supply Sa-Da in the Nation A is equal to the excess demand Db-Sb in the Nation B, as can be seen in Figure 4.

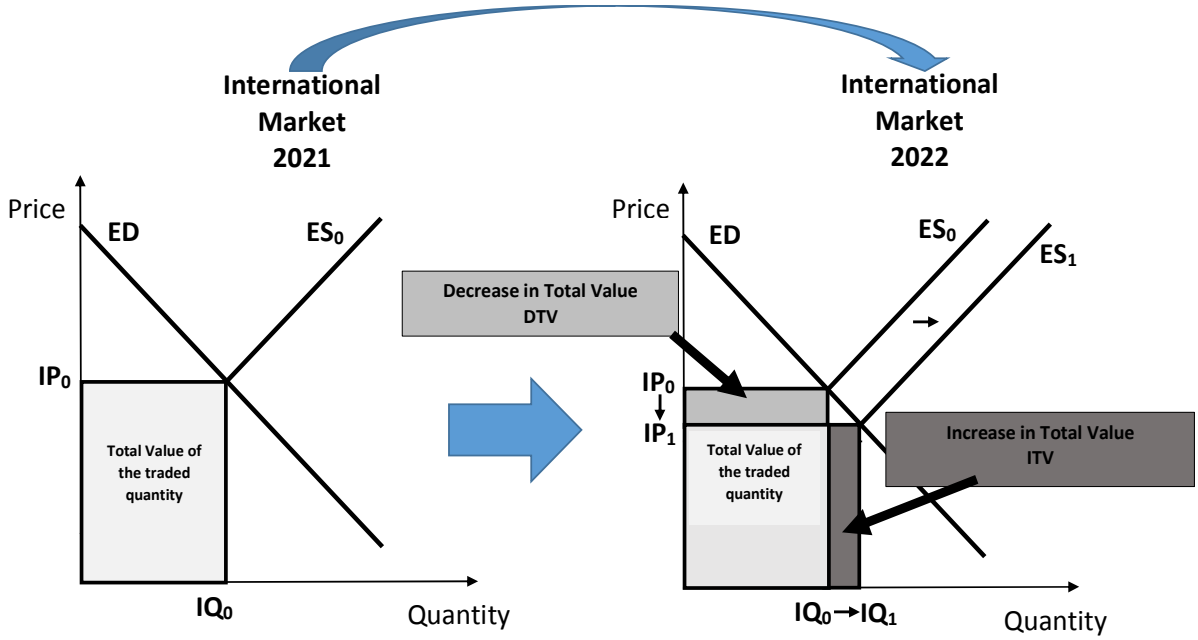

Figure 5. *Changes in the total value of Mexican mango exports to Canada.*

It is important to mention that a displacement of the supply curve in excess ES to the right, that is, a positive change (as can be seen in Figure 5) causes a decrease in the international price IP, in which the magnitude of said decrease it is given by price flexibility [9].

The price flexibility of demand is defined as the percentage change in the price of a good in the face of a 1% change in the quantity demanded [10], that is, the price is sensitive to a change in the demanded quantity. It is worth mentioning that there is an inverse relationship between quantity and price, and each case of analysis can fall into three possible scenarios:

1. Demand is inflexible when the inverse percentage change in price is less than 1% for a 1% change in quantity,
2. The price flexibility of demand is unitary when the inverse percentage change in price is equal to 1% for a 1% change in quantity,
3. Demand is flexible when the inverse percentage change in price is greater than 1% for a 1% change in quantity.

Through the partial equilibrium analysis, Hernandez, Alejos & Casique estimated that the price flexibility of Mexican strawberry imports in the US market is equal to -0.3669. They calculated that a simulated annual increase of 18% in the year 2019 in relation to the year 2018 results in an increase in the total value of the traded quantity of strawberry in the international market between Mexico and USA. So they conclude that increasing the Mexican strawberry exports to the US market in a magnitude that represents an annual growth

rate of 18% is viable in the economic sense [11].

The partial equilibrium analysis for the orange juice market in USA allows Williams state that most of the profits that orange producers obtain come from investments made in advertising. This investment influences the market in two ways: first, advertising affects the market by increasing the demand for orange juice (as well as fresh orange) to the consumer, causing an increase in price, improving the income of producers of orange juice (and fresh orange). Second, advertising causes an increase in the industrial consumption of oranges, which reduces the quantity available in the market, causing an increase in price, improving income for orange (and orange juice producers) in USA [12].

Hernandez & Gonzalez carried out a partial equilibrium analysis for the international avocado market between Mexico and USA. In this research, they calculate that the price flexibility of the demand for Mexican avocado imports in USA is equal to -0.1468%. In the simulated scenario, they estimate that a 30% increase in the quantity in 2020 compared to 2019, the price would decrease US$ 110.61 per t. The final balance of both impacts on the total value of the traded quantity would result in an increase of US$ 595,556,756.00. With these results, they conclude that a 30% increase in the exported quantity of avocado to the US market is economically viable [13].

Using the partial equilibrium analysis, Capps, Williams & Dang state that advertising expenses on lamb imports in the US market cause an increase in the demanded quantity, and this in turn increases the price; this impact causes the profits for the producers to increase in the international market. They also conclude that the benefits derived from the investment in advertising are greater than the amount of the expenses incurred in it [14].

Through the partial equilibrium analysis in the international trade of Mexican avocado for export to the Canadian market, Hernandez, Cornejo and Galvan estimate that the price flexibility of the demand for avocado imports in Canada is equal to -0.0946%. With this calculation they simulate an increase of 50% in the quantity (in 2021 respect a 2020), with the consequent decrease in the price of 4.7339%, resulting in a final impact of C$117,618,792.39. With this result, they conclude that an annual increase of 50% in Mexican avocado exports to the Canadian market is viable in the economic sense [15]. It is necessary to say that the partial equilibrium analysis of two economies in the international trade of a good allows calculating the price flexibility of demand, as well as the price elasticity of demand, and with them, observing the effects on the variables considered in the econometric model.

3. Methods

With the purpose of carrying out the research, a descriptive study was developed, since a report is made in which the impacts of an increase in Mexican mango imports in the Canadian market are exposed. The study is quantitative since to carry it out an econometric model of simultaneous equations was developed whose foundation is the relationship that exists in the market for imported Mexican mangoes in Canada. The study is causal, since, with the results of the econometric model, the impact of the exported quantity of Mexican mango on its price in Canada was determined.

Now, to represent the international market, two simultaneous equations were built:

$$PIMMCANR_t = \beta_{10} + \beta_{11}QIMMCAN_t + \beta_{12}PEMMRt + \varepsilon_{1t} \quad (1)$$

$$PEMMR_t = \beta_{20} + \beta_{21}QEMM_t + \beta_{22}PPMR_t + \varepsilon_{2t} \quad (2)$$

This econometric model represents the international mango trade between two countries in which the first equation is a demand function for mango imports in Canada, while the second is a supply function for mango exports in Mexico. In this sense, through the price flexibility of the demand, the simultaneous equations are raised in an inverse way in such a way that the price is the dependent variable and is influenced by the quantity in each equation. In the same sense, it should be mentioned that the demanded quantity affects the price, according to economic theory [6], as can be seen in Figure 5. Now, in the supply equation, the dependent variable is the price of mango exports in Mexico, which is influenced by two independent variables: quantity exported and the producer price of mango.

Considering the relationship between the variables in the international mango trade between Mexico and Canada, the econometric model was built with two main equations:

The first equation is a demand function for Mexican mango imports in Canada where the dependent variable is the real import unit price $PIMMCANR_t$ which is determined by:

$QIMMCAN_t$ which is the quantity of imported Mexican mangoes in Canada as an independent variable. Corresponding to economic theory, it is necessary to say that there is an inverse relationship with $PIMMCANR_t$ characterized by a negative sign. $PEMMR_t$ is the unit export price of mango in Mexico, and is another independent variable. It is worth mentioning that $PEMMR_t$ acts as a dependent variable in the supply function.

The second equation is a supply function for mango exports in Mexico where the dependent variable is the real export unit price in Mexico $PEMMR_t$, which is determined by:

$QEMM_t$ which is the exported quantity of mango in Mexico as an independent variable; while the price $PPMM_t$ is the average real producer price of mango in Mexico, it is another independent variable within the function.

The three-stage least squares method was applied to the simultaneous equations econometric model to estimate the β_{10}-β_{22} coefficients. The variables are determined simultaneously (Gujarati and Porter, 2010), so the β_t coefficients are estimated based on the relationship of the variables within the model.

The variables $PIMMCANR_t$, $QIMMCAN_t$, $PEMMR_t$ and $QEMM_t$ were constructed with information from the Internet Tariff Information System (SIAVI) of the Ministry of Economy [3]. While the $PPMR_t$ variable was constructed with information from the Agrifood and Fisheries Information Service (SIAP) of the Ministry of Agriculture [17].

To carry out the partial equilibrium analysis, the following assumptions were established:

1. A good, the mango.
2. An international market of two nations: Mexico and Canada.
3. The excess of demand for mango in Canada is equal to the imports of Mexican mango.
4. The excess supply of mango in Mexico is equal to the mango exports to Canada.
5. Prices and values in real terms.
6. Monetary values in Canadian dollars C$.
7. A simulated increase of 10% in Mexican mango exports to Canada in 2022 compared to those made in 2021.

It is necessary to consider that an increase in the supplied quantity of Mexican mango in Canada is expressed graphically as a shift in the supply curve from S_{a0} to S_{a1}. This causes a shift in the excess supply curve in the international market from ES_0 to ES_1. This in turn situation causes the international price of mango decreases from IP_0 to IP_1, at the same time as an increase in the traded quantity in the international market from IQ_0 to IQ_1, and finally reflecting in an increase in excess demand for mango in the Canadian market, as can be seen in Figure 6.

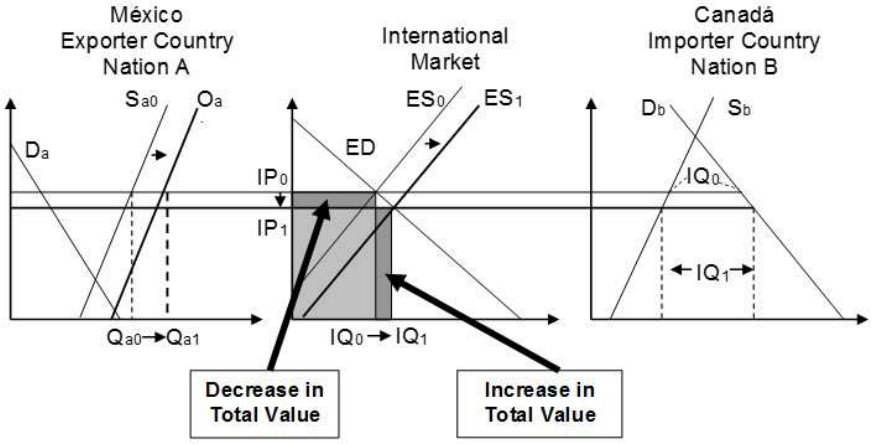

Figure 6. *Changes in the international market of the Mexican mango to Canada.*

Likewise, with the results of the three-stage least squares method to the econometric model, the price flexibility of the demand was estimated, as follows:

$$F = (dPIMMCANR / dQIMMCAN) (QIMMCAN / PIMMCANR) \quad (3)$$

With the calculation of the price flexibility of the demand, it is possible to know the inverse quantitative effect of a 1% increase in the quantity supplied of mango in the international market on a percentage decrease in the international price.

Now, to determine the final effect on total income, it is necessary to calculate the value of the two quantities that are generated due to the impact caused by the increase in the supplied quantity: the Increase in Total Value (ITV due to the increase in the quantity eq. 4), and the Decrease in Total Value (DTV due to the decrease in price eq. 5).

$$\text{Increase in Total Value (ITV)} = (Q1\text{-}Q0)*P1 \quad (4)$$

$$\text{Decrease in Total Value (DTV)} = (P0\text{-}P1)*Q0 \quad (5)$$

Then, the difference between the increase and the decrease allows to know the final effect, calculating it as follow:

$$\text{ITV - DTV} = \text{Final Balance} \quad (6)$$

The criteria to determine if the increase in the exported quantity of mango to the Canadian market is viable in the economic sense is:

1. If the Increase in Total Value (ITV) is greater than the Decrease in Total Value (DTV), the final balance will be positive, so an increase in the exported quantity of mango to the Canadian market is viable, since, in the final combined effect the total value will be increased.
2. If the Increase in Total Value (DTV) is less than the Decrease in Total Value (DTV), the final balance will be negative, so an increase in the exported quantity of mango to the Canadian market is not viable, since, in the final combined effect the total value will be decreased.

Now, both the increase in quantity and the decrease in price simulated in the hypothetical scenario can be transferred to the environment of mango producers in Michoacán, Sinaloa, Nayarit and Oaxaca in order to determine the final effect of the impacts on them.

Rodriguez, Bao & Cardenas [18] state that the Benefit/Cost Ratio can be calculated as follows:

$$\text{B/C R} = \text{Benefit / Cost} \quad (7)$$

To determine the viability of an increase in the exported quantity from the perspective of the Mexican mango producer, the criteria are:

$$\text{B/C R} > 1 \text{ Profitable} \quad (8)$$

$$\text{B/C R} = 1 \text{ No profit or loss} \quad (9)$$

$$\text{B/C R} < 1 \text{ Not profitable} \quad (10)$$

In this way, the final impact on profitability for the mango producer is determined.

4. Results and Discussion

The results of applying three-stage least squares to the simultaneous equations econometric model allowed us to calculate the following β coefficients of the demand equation:

Table 8. *Coefficients β calculated with three-stages least squares.*

Variable	β	Value	t	Pr > t
Intercept	β_{10}	1790.50000	15.47	0.0001
$QIMMCAN_t$	β_{11}	-0.05344	-6.35	0.0001
$PEMMR_t$	β_{12}	0.000000003023	4.31	0.0008
$QEMM_t$	β_{21}	974.94290	24.21	0.0001
$PPMMR_t$	β_{22}	917.20820	12.66	0.0001

Now, the critical values for performing the t-test at the 0.01 level of significance are 2.552 and -2.552. The results of the application of three-stages least squares method to the econometric model show that the value of t for the coefficient β_{10} is equal to 15.47; that is, it is greater than 2.552, so the respective probability (0.0001) is less than 0.01.

Likewise, the value of t for the coefficient β_{11} is equal to -6.35; that is, it is less than -2.552, so the probability of the corresponding t (0.0001) is less than 0.01. Regarding the value of t for the coefficient β_{12}, it is equal to 4.31; that is, it is greater than 2.552, so the probability of the respective t (0.0008) is less than 0.01.

The results show that the value of t for the coefficient β_{21}, it is equal to 24.21; that is, it is greater than 2.552, so the corresponding probability (0.0001) is less than 0.01. Finally, the value of t for the coefficient β_{22} is equal to 12.66; that is, it is greater than 2.552, so the corresponding probability (0.0001) is less than 0.01.

These results show that the estimated value of β_{10}, β_{11}, β_{12}, β_{21} and β_{22} are statistically significant, and allow the construction of the specific demand equation:

$$PIMMCANR_t = 1790.5 - 0.05344QIMMCAN_t + 0.0000000003023PEMMR_t + \varepsilon_{1t} \quad (11)$$

In order to calculate the price flexibility of demand, the partial derivative of the demand equation (eq. 11) was calculated for $PIMMCANR_t$ with respect to $QIMMCAN_t$:

$$(dPIMMCANR / dQIMMCAN) = -0.05344 \quad (12)$$

With the calculation of the partial derivative, the demand price flexibility was calculated:

$$F = (-0.05344)\ (31095.906/853.6565122) = -1.94664387 \quad (13)$$

Now, with this calculation it can be stated that, when the demanded quantity increases 1%, the price decreases 1.94664387%. In other words, the demand for Mexican mango imports in Canada is flexible. In the same sense, for the simulated 2022 scenario, when the demanded quantity increases 10%, the price decreases 19.4664387%, compared to the 2021 price, as can be seen in Table 9.

Table 9. *Price flexibility of the demand for Mexican mango in Canada.*

Change in quantity	Change in price
1%	1.9466439%
10%	19.4664387%

As can be seen in Figure 6, when the imported quantity of mangoes increases in Canada from IQ_0 to IQ_1, there is an increase in the income generated by the international trade of mango between Mexico and Canada, but at the same time there is a decrease in this same income caused by the decrease in price from IP_0 to IP_1.

The final effect on total income is a negative balance (a decrease) of C$6,579,991.75 (as can be seen in Table 10).

Table 10. *Simulated scenario 2022 with 10% increase in the imported quantity compared 2021.*

Year	Quantity Q	Price P	Q*P
2021	Q_0 = 44 677.99	P_0 = 1 129.01	63 230 698.36
2022	Q_1 = 49 145.78	P_1 = 907.97	56 650 706.61
		Decrease	-6 579 991.75

The two areas shown in Figure 6 were calculated: the Increase in Total Value (ITV) due to the increase in quantity, and the Decrease in Total Value (DTV) due to the decrease in price, verifying the negative value in the final balance of C$6,579,991.75 (as can be seen in Table 11).

Table 11. *Final balance in total value of the mango imports in the face of 10% increase in the imported quantity in Canada.*

	Area	Value
Increase in Total Value (ITV)	$(Q_1-Q_0)*P_1$	5,150,064.24
Decrease in Total Value (DTV)	$(P_0-P_1)*Q_0$	11,730,055.98
Difference		-6,579,991.74

These results show that a 10% increase in the exported quantity of Mexican mango to the Canadian market is not viable in the economic sense, since the final effect is a decrease in the total value of the traded quantity in the international market.

At this point, the calculation of the B/C R was carried out for the producers of Michoacan, Sinaloa, Nayarit and Oaxaca for 2021. It is worth mentioning that, in the year 2021, Canada imported 44,677.98 t of Mexican mango [3], of which approximately 32% originated from Michoacan, 28% from Sinaloa, 22% from Nayarit and 18% from Oaxaca.

The results show that, in the year 2021, the B/C R of mango production for export to Canada in the provinces of Michoacán, Sinaloa, Nayarit and Oaxaca was 1.3986, 1.5491, 1.1389 and 1.3725 respectively. Therefore, it can be stated that

producing mango for export to Canada in the four states was profitable in 2021, as can be seen in Table 12.

Table 12. *Benefit / Cost Relationship for the mango producer in Mexico in 2021.*

Province	Quantity	Benefits MXN	Costs MXN	B/C R
Michoacan	14,296.96	$87,694,524.76	$62,700,586.56	1.3986
Sinaloa	12,509.84	$51,858,776.04	$33,476,322.10	1.5491
Nayarit	9,829.16	$28,736,228.94	$25,231,226.21	1.1389
Oaxaca	8,042.04	$38,654,858.22	$28,163,215.89	1.3725

Now, to propose the simulated 2022 scenario, the exported quantity of mango to Canada increased by 10% compared to 2021, that is, 49,145.78 t. At this point, the assumption is that the cost function is linear, so the cost per t is constant. As can be seen in Table 13, the results of the simulated scenario show that the B/C R for the producers of Michoacan, Sinaloa, Nayarit and Oaxaca are 1.1264, 1.2475, 0.8543 and 1.1053, respectively.

With these results, it can be affirmed that, for mango producers to export to the Canadian market in Michoacán, Sinaloa and Oaxaca, an annual increase of 10% in 2022 with respect to the exported quantity in 2021 would allow them to produce profitably. However, it is necessary to say that, for mango producers in Nayarit, a 10% increase in the exported quantity to Canada would not be profitable.

Table 13. *Benefit / Cost Relationship for the mango producer in Mexico in the simulated scenario 2022.*

Province	Quantity	Benefits MXN	Costs MXN	B/C R
Michoacan	15,726.65	$77,685,876.24	$68,970,645.22	1.1264
Sinaloa	13,760.82	$45,940,091.11	$36,823,954.31	1.2475
Nayarit	10,812.07	$25,456,539.40	$29,797,068.90	0.8543
Oaxaca	8,846.24	$34,243,147.33	$30,979,537.47	1.1053

Now, based on the simulation scenario, iterations were performed through increases in quantity and decreases in price to find the maximum annual growth level of Mexican mango exports to Canada in 2022 (compared to those made in 2021).) from which the final effect begins to be negative. The results show that the value of this maximum growth rate is 1.296626%.

This second result allows us to conclude that the exported quantity of Mexican mango to Canada should not increase beyond 1.296626% annually, since, if the annual increases with respect to the previous year are greater than this rate, the final effect will be a decrease in the final value of the traded quantity of mango in the international market. In other words, annual increases in Mexican mango exports to the Canadian market of more than 1.296626% would not be viable, from de economic perspective.

Now, it is worth mentioning Hernandez & Martinez who carried out a partial equilibrium analysis of mango exports from Mexico to the US market. In this research, they calculate that the price flexibility of the demand for Mexican mango imports in USA is -0.078%. In a simulation scenario, they estimate that a 20% increase in quantity in 2006 respect 2005, with the consequent decrease in price, the final effect would be an increase of US$ 17,372,358.00 in the total value of the traded quantity. With this result, they determine that it is viable to increase Mexican mango exports to USA in quantities that represent an average annual growth rate of 20% [9].

With the simulated impacts, they calculate that the B/C R for producers in Michoacan, Sinaloa, and Nayarit would be 1.003, 1.514, and 3.211. In other words, in the face of a 20% increase in the exported quantity, producing mango would continue to be profitable in the provinces of Michoacan, Sinaloa and Nayarit.

In the same sense, Hernandez, Lopez & Casique carried out a partial equilibrium analysis of mango exports from Mexico to the US market. They calculate that the price flexibility of the demand for Mexican mango imports in USA is equal to 0.506187%.

With this estimate, they propose a simulation scenario, with an increase in the exported quantity equivalent to 20% annual in 2017 compared to 2016, also considering the decrease in price.

The results show that the final effect on the total value of the traded quantity is an increase of US$ 20,955,114.70, with which, they conclude, an increase in the exported quantity of Mexican mangoes to the US market is viable from an economic perspective [9].

With the results of this first scenario, they transfer the simulated impacts in quantity and price to the environment of the mango producer in Mexico. The results show that the B/C R for the producers of Michoacán, Sinaloa and Nayarit would be 1.1806, 1.1543 and 0.9171.

Based on these results, they recommend improving production technology in Nayarit, with the purpose of increasing yield to lower the cost per t through improved seed, fertilizers, safety and irrigation systems. They also recommend increasing the exportable supply in Michoacán and Sinaloa, to take advantage of export infrastructure, and take advantage of opportunities in the international market, with production that meets quality standards, organoleptic characteristics and regulations in foreign trade.

The background of these research works show that it is viable to increase mango exports to the US market. The proximity between USA and Canada allows us to interpret that these results can be extended to the Canadian market; however, this is not the case, the mango import market in Canada behaves differently, as it has different characteristics from the US market, in addition to being supplied by a greater number of suppliers from various countries. With this base, it is convenient not to assume and extend conclusions from one nation to another, if not through an own analysis.

The partial equilibrium analysis allows to identify impacts of the variables in the market. In this way, it is a model that allows preventing the implementation of strategies to increase the exportable supply to the analyzed markets, until it is verified that it is viable to carry out these increases.

It is worth mentioning that, if in the analysis of the target nation it is not viable to increase the exportable supply, this result allows us to propose export strategies to other markets. The possibility of exporting a good to other countries generates the need for a partial equilibrium analysis to determine the viability to these new destinations. This analysis is then preventive to the increase in exports, previously

determining the economic viability.

5. Conclusion

The results show that the price flexibility of the Mexican mango demand in Canada is equal to -1.9466%. That is, the price flexibility of demand can be classified as flexible. With this calculation, it was estimated that a 10% increase in the exported quantity of Mexican mango to Canadian market causes a 19.4664% decrease in price. With these impacts, in a simulated scenario it is estimated that an increase of 4,467.80 t in 2022 with respect to the exported quantity of Mexican mango to Canada in 2021, the price would decrease C$219.78 per t. The final effect on the total value of the traded quantity of mango in the international market between Mexico and Canada would be a decrease of C$6,501,688.69, so a 10% increase in the exported quantity of Mexican mango to the Canadian market would not be viable, from de economic perspective.

On the other hand, the simulated impacts on quantity (10% increase) and price (-19.4664%) were transferred to the environment of mango producers in Michoacan, Sinaloa, Nayarit and Oaxaca. In the simulated scenario, the B/C R would be 1.1264, 1.2475, 0.8543 and 1.1053 respectively. The results show that, given a 10% increase in the exported quantity, producing mango in Michoacán, Sinaloa and Oaxaca to export to the Canadian market continues to be profitable, even with the decrease in price, and the decrease in the total value of the traded quantity.

Now, as far as Nayarit is concerned, in the simulated scenario, the B/C R for mango growers to export to Canada would be 0.8543. In other words, given a 10% increase in the exported quantity, producing mango for the Canadian market would no longer be profitable in the province of Nayarit.

It is important to mention that, based on the simulation scenario, iterations were carried out to find the maximum annual growth rate of Mexican mango exports to Canada from 2021 to 2022, from which the final effect begins to be negative. The value of this maximum growth rate is 1.296626%. This second result allows us to conclude that the exported quantity of Mexican mango to Canada should not increase beyond 1.296626% annually, since, if the annual increases with respect to the previous year are greater than this rate, the final effect will be a decrease in the final value of the traded quantity of mango in the international market. In other words, annual increases greater than 1.296626% would make such an increase non-viable.

6. Recommendations

Then, it is convenient that the commercial strategy of the production of Mexican mango for export is oriented to other markets such as Japan or the European Union, maintaining a stable growth of mango exports to Canada of no more than 1.296626% annual. This is so that this strategy allows the import price of Mexican mango in Canada to recover (that is, to increase gradually), and the price flexibility of demand decreases.

The strategy of increasing the exportable supply in Mexico can be implemented. However, it is necessary that, in provinces like Nayarit, technological improvements in production (improved seed, fertilizer, safety mechanisms, pumped irrigation, etc.) be implemented in such a way that mango production that meets the quality and the characteristics required in international markets achieve a higher price in international markets that compensates for the investment in technology. In addition, the implementation of technological improvements in production will allow to increase the productivity of the plantations, improving the yield, and reducing the cost per hectare, thereby improving the B/C R for the producer.

Additionally, it is necessary to carry out a partial equilibrium analysis of international trade in specific markets. This, as a preventive mechanism, with the purpose of determining the feasibility of implementing a commercial strategy to increase exports. If it is not viable, the study will allow the decision to explore other markets, in addition to developing the most appropriate strategy in the analyzed market (international marketing, advertising, tariff policy between the two countries, etc.).

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