

Profitability of Mexican Avocado Production in the Face of an Increase in Exports to the Canadian Market

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Abstract: Mexico is the main exporter of avocado in the world, while Canada is the seventh importer. To meet its domestic demand, Canada imports about 93.73% of avocados from Mexico. It is worth mentioning that, between 2003 and 2018, the average annual growth rate of Mexican avocado imports in Canada was 14.72%; while, from 2019 to 2021, this same rate averaged -4.65, that is, in this period Mexican avocado imports in Canada fell at an average annual rate of 4.65%. This research aims to determine the viability of increasing the annual growth rate of Mexican avocado exports to the Canadian market. To carry out the work, the avocado market between Mexico and Canada was represented in an econometric model and, with the results, a partial equilibrium analysis was carried out, simulating a 50% annual increase in exports. The results show that an increase in the amount of Mexican avocado exported to the Canadian market that results in an average annual growth rate of 50% is viable in terms of income. The simulation shows that the Benefit/Cost Ratio (B/C R) in avocado production for the states of Jalisco, Michoacan and the State of Mexico, in the hypothetical scenario, would be 1.4831, 1.4257 and 1.5322 respectively.

Keywords: Avocado, Exports, Imports, International Trade, Profitability

1. Introduction

In 2020, 8 059 359 t of avocado were produced in the world. Mexico was the main producer, and 2 393 849 t were harvested, which represented 29.70% of the world total.

Table 1. Avocado producing countries in 2020.

	Country	Tons	Annual rate %
1	Mexico	2 393 849	29.70
2	Colombia	876 754	10.88
3	Dominican Republic	676 373	8.39
4	Peru	660 003	8.19
5	Indonesia	609 049	7.56
6	Kenia	322 556	4.00
7	Brazil	266 784	3.31
8	Ethiopia	245 336	3.04
9	Haiti	191 713	2.38
10	United States of America	187 433	2.33
11	Chile	160 535	1.99
	Others	1 468 974	18.23
	Total	8 059 359	100.00

Colombia was ranked second with 876 754 t (10.88%), the Dominican Republic was third with 676 373 t (8.39%), Peru was fourth with 660 003 t (8.19%), Indonesia fifth with 609 049 (7.56%), Kenya sixth with 322 556 t (4.00%), Brazil seventh with 266 784 t (3.31%) and Ethiopia eighth with 245 336 t (3.04%) (as can be seen in Table 1) [1].

On the other hand, in 2020, 34.74% of avocado production in the world was exported, that is, 2 799 922 t; Mexico was the main exporter of avocado with 1 158 894 t, which represented 41.39% of the world total; Peru ranked second with 410 697 t (14.67%), the Netherlands was third with 375 685 t (13.42%) being the main non-producer exporter, Spain ranked fourth with 141 031 t (5.04%) as well as being the second non-producing exporter, Chile was fifth with 96 906 t (3.46%), Kenya sixth with 79 081 t (2.82%), Colombia seventh with 77 075 t (2.75%) and the United States of America (USA) eighth with 67 024 t (2.40%) (Table 2) [1].

Table 2. Avocado exporting countries in 2020.

	Country	Tons	Annual rate %
1	Mexico	1 158 894	41.39
2	Peru	410 697	14.67
3	Netherlands	375 685	13.42
4	Spain	141 031	5.04
5	Chile	96 906	3.46
6	Kenya	79 081	2.82
7	Colombia	77 075	2.75
8	United States of America	67 024	2.40
	Others	393 529	14.05
	Total	2 799 922	100.00

According to the Food and Agriculture Organization (FAO), in 2020 the USA was the main importer of avocado with 1 116 896 t, which represented 38.49% of the world total; while the Netherlands was ranked second with 414 175 t (14.27%), Spain was third with 174 266 t (6.01%), France fourth with 170 542 t (5.88%), Germany fifth with 122,340 t (4.22%), the United Kingdom sixth with 122,298 t (4.21%), Canada seventh with 106,651 t (3.68%) and Japan was eighth with 79,560 t (2.74%) (Table 3) [1].

Table 3. Avocado importing countries in 2020.

	Country	Tons	Annual rate %
1	United States of America	1 116 896	38.49
2	Netherlands	414 175	14.27
3	Spain	174 266	6.01
4	France	170 542	5.88
5	Germany	122 340	4.22
6	United Kingdom	122 298	4.21
7	Canada	106 651	3.68
8	Japan	79 560	2.74
	Others	594 745	20.50
	Total	2 901 473	100.00

In 2020 Canada imported 106,651 t of avocado, and according to the Trade Data Online (TDO), 93.73% was originated in Mexico, that is, 99 964 t; 3.75% came from Peru (3 999.4 t), 1.09% from the USA (1 162.5 t), 0.7% from Colombia (746.56 t), 0.5% from the Dominican Republic (533.26 t), 0.09% from Brazil (95.99 t) and 0.03% from Jamaica (31.99 t) (Table 4) [2].

Table 4. Avocado exporting countries to Canada in 2020.

	Country	Tons	Annual rate %
1	Mexico	99 964.00	93.73
2	Peru	3 999.41	3.75
3	United States of America	1 162.50	1.09
4	Colombia	746.56	0.70
5	Dominican Republic	533.26	0.50
6	Brazil	95.99	0.09
7	Jamaica	31.99	0.03
	Others	117.32	0.11
	Total	106 651.00	100.00

In the same way, data from the Ministry of Economy (SE) show that, between 2003 and 2021, the average annual growth rate of Mexican avocado exports to Canada was 11.24% (Table 5) [3].

Table 5. Imports of Mexican avocado in Canada from 2003 to 2021.

Year	Tons	Annual rate %
2003	11 419.77	
2004	18 474.74	61.78
2005	17 468.90	-5.44
2006	17 148.24	-1.84
2007	19 604.01	14.32
2008	18 095.00	-7.70
2009	22 583.24	24.80
2010	25 180.93	11.50
2011	22 891.17	-9.09
2012	33 225.54	45.15
2013	34 079.18	2.57
2014	36 411.24	6.84
2015	54 459.08	49.57
2016	66 480.36	22.07
2017	76 936.87	15.73
2018	89 614.14	16.48
2019	87 798.72	-2.03
2020	91 932.59	4.71
2021	77 681.47	-15.50
Annual average rate		11.24

Likewise, it is worth mentioning that between 2003 and 2018, Mexican avocado exports to the Canadian market grew at an average annual rate of 14.72%. While, from 2019 to 2021, this same average annual rate was -4.65%; that is to say, Mexican avocado exports to Canada fell at an average annual rate of 4.65%. It should be said that the growth rate in the years 2019, 2020 and 2021 was -2.03%, 4.71% and -15.50% respectively (Table 5). This decrease in Mexican avocado exports to the Canadian market in the last three years is contrary to the intentions of the North American Free Trade Agreement (NAFTA) 1993-2020, as well as in the Agreement between Mexico, USA and Canada (T-MEC) that entered into force on July 1, 2020. In this framework, expectations are of sustained growth in Mexican avocado exports to Canada as an indicator of improved competitiveness, taking advantage of the tax relief tariff and the increase in the exportable supply of avocado in Mexico.

It is necessary to say that the work was carried out during the COVID-19 pandemic period, so the imports for the years 2020 and 2021 have been affected by the decrease in consumption due to confinement and the closure of large part of human activities. However, and despite these obstacles, the work allows to internalize the information generated during the pandemic period, granting it an even greater level of pragmatism, allowing the simulated scenario to serve as a diagnosis within the period of affectation, that is, within a scenario even more real. In this context, it is possible to transfer the real information to a partial equilibrium analysis of the export of Mexican avocado, and to know the economic viability of increasing the quantity exported to the Canadian market.

In this context, the research presents the opportunity to transfer the impact of an increase in exports to the Canadian market to know the financial situation of the producers of the three main exportable production areas: Michoacan, Jalisco and the State of Mexico. In this same sense, the research question asks if it is viable for avocado producers to increase

exports to the Canadian market in such a way that the annual average growth rate is 50% (approximately the growth rate observed in 2015 with respect to 2014). That is, if it is viable for the Mexican economy to encourage exports of Mexican avocados to Canada to take advantage of the opportunities that this market offers.

In the same way, and due to the decrease in exports in the last three years, a general objective was established to determine the economic viability, for Mexican producers, of an increase in the amount of avocado exported to the Canadian market. To achieve this, it was proposed to represent the export market for Mexican avocado destined for Canada in a partial equilibrium model, calculating the price flexibility of demand based on an econometric model, establishing a scenario that simulates an increase of 50% in the quantity exported and, with the results, carry out an international trade analysis of Mexican avocado for export to Canada. Additionally, and transferring this impact to the field of production, determine the viability for Mexican producers to encourage said increase.

In the same sense, the first hypothesis states that it is viable, from an economic perspective, to increase the amount of Mexican avocado exported to the Canadian market, in a magnitude that represents an annual increase of 50%, although this increase contributes to the price of exports decreases. In the same way, the second hypothesis states that producing Mexican avocado for export to Canada continues to be profitable in terms of income for producers, given a 50% increase in the amount exported.

2. Literature Review

The partial equilibrium analysis is a scheme that allows to represent the market of a good between two national economies. In addition to the static analysis, the model allows the development of alternative scenarios with the purpose of simulating individual changes in the fundamental variables, as well as their repercussions on the represented economic environment. It is important to mention that the basis on which this model is based are real quantities in the international market generated by the interaction of the two national markets of the analyzed good. On this basis, the impacts in the simulated scenario can be calculated from an econometric model that represents the international market of the two economies in question, based on the calculation of the price elasticity of demand or the corresponding price flexibility of demand.

Williams states that the partial equilibrium model can be understood through a graph, in which three economic scenarios are represented for the market of a good between two nations: an economy that represents the exporting nation, an economy that represents the importing nation and, an international market that represents the corresponding commercial interaction between both. With this base, changes in the market can be simulated through the displacement in the offer or in the demand of one of the two nations, and transferring this change to the international

market. In other words, and through the price flexibility of demand, it is possible to quantify specific impacts on supply or demand, and their repercussions on the international market [4]. Although the partial equilibrium model is a simplification of reality, being fed with real information allows transferring the conclusions of the theoretical analysis to the concrete reality with a high level of accuracy.

In this regard, Hernandez, Alejos and Casique developed a partial equilibrium analysis of Mexican strawberry imports in USA [5]. In this research, they simulate an annual increase in 2019 compared to 2018. Based on the calculation of the price flexibility of demand, they state that an increase that results in an annual growth rate of 18% in strawberry exports in Mexico to the US market causes a decrease in the price of 6.60%. The balance between both effects is an increase in the total value of exports in a magnitude of US\$ 59 703 057.26. With this result, they say, it is viable to increase the quantity of Mexican strawberries exported to the US market by a magnitude that represents an average growth rate of 18% per year.

Now, considering that a value of the B/C R greater than 1 means that the activity is profitable, they estimate that the B/C R for the producer in the states of Baja California, Michoacan and Guanajuato for the simulated 2019 scenario would be 1.9813, 1.9020 and 0.9234. With these results, they conclude that an 18% annual increase in Mexican strawberry exports to the US market is profitable for producers in Baja California and Michoacan. While the final effect for producers in Guanajuato means that, under the conditions in which they produce strawberries, an increase in production that allows an increase in strawberry exports to the US market at an annual rate of 18%, would reduce profitability even more.

In this sense, they recommend the implementation of improvements in production technology with the purpose of making strawberry production profitable in the state of Guanajuato and increasing the quality of the product to contribute to the increase in the exportable supply of Mexican strawberries.

On the other hand, through a partial equilibrium model, Williams, Capps and Bessler analyze the market for the production of orange juice for export in USA [6]. With the results, they affirm, the benefits obtained by the producers come from the high levels of investment in advertising that are deployed in the orange juice market, obtaining positive effects in two markets integrated in the product system of orange juice. The significant levels of advertising developed cause increases in the demand for orange juice in the market, with an increase in the price of the processed product. In this context, the industry (in order to respond to this growing need) increases the consumption of fresh orange juice, so this situation also causes an increase in the market price of fresh oranges. So the benefits of this increase, in the second instance, are also transferred to the producers.

It is convenient to comment on a second alternative effect: the processed orange juice industry, by increasing its consumption of oranges (described above), causes a smaller

quantity to be available in the fresh product market; This decrease in supply causes an additional increase in the producer price, improving their conditions and increasing growth prospects.

On the other hand, Hernandez, Lopez and Casique applied a partial equilibrium analysis to simulate an increase in Mexican mango imports in the US market equivalent to 20% per year for 2017 compared to those made in 2016 [7]. As a result of the investigation they find that, in the simulated scenario, the final balance is an increase in the total value of the amount of mango exported between Mexico and USA in a magnitude of US\$ 20 955 114.70. With this estimate, they conclude, an annual average growth rate in Mexican mango exports to the US market is viable in the sense of income.

As part of the simulation, they transfer the impacts in quantity and price (as a result of calculating the price flexibility of demand) to the production sphere, finding that the B/C R for the states of Michoacán, Sinaloa and Nayarit would be: 1.1806, 1.1543 and 0.9171 respectively. With these results, they affirm that increasing the amount of Mexican mango exported to USA is viable for producers in the states of Michoacan and Sinaloa, so it is profitable to produce mango for export and continue increasing the mentioned amount.

Regarding the state of Nayarit, an increase of 20% per year in the amount to be exported to the US market deteriorates the profitability for producers, mainly due to the traditional conditions in which mango production is developed since, on the final balance, revenues are less than expenses.

With these results, they recommend carrying out corrective actions to improve production technology, such as improved seed, fertilization, product safety, as well as investment for proper post-harvest handling of the product. This with the purpose of improving the quality and price of the product, as well as increasing the exportable supply that contributes to making mango production profitable in this entity. With this perspective, it is important to mention that the partial equilibrium analysis of a good between two nations allows simulating effects on the economy that would not otherwise be possible to visualize.

3. International Trade of a Good

The trade of a good is based on the principle that countries are different, and have different physical, edaphological, climatic and biological characteristics. The endowment of resources is different, with its own conditions, and different from any other on earth, which means that each country has the capacity to efficiently produce certain goods. In addition to this diversity, it is necessary to add that the productive vocation of the factors of production (land, work, capital, technology, business skills and innovation) is developed to a great extent under these conditions, so that the endowment of resources plays a fundamental role in determining the competitive advantage of those goods that it produces efficiently in a nation [8].

In the same sense, Carbough states that, if a national

economy A can produce a good cheaper than a national economy B, and this in turn, can produce another good cheaper than national economy A, it is beneficial for both economies allocate their factors to the good they can produce more efficiently than the other [9]. This productive orientation causes the quantities produced of each good to exceed the domestic consumption needs of each nation where they are produced. The production surplus of each good in each country can be destined to the other nation, when the internal demands are satisfied. Exchanging surpluses on the international market benefits efficiency in both national economies. Then, both nations, by naturally developing this international division of labor, and producing the good in which they have an absolute advantage, can carry out international trade [10].

A national economy must buy from another country, then, the good in which its absolute disadvantage is greater; and it would do so at a lower price than what would be generated by producing it internally. In this way, each nation specializes in the export of those goods in which it achieves a higher relative productivity (compared to other countries). All this is also an explanation of how it is possible to obtain general benefits in international trade, even if one of the countries manages to produce all the goods at a lower cost than the other countries (it is better for it to specialize in those in which its advantage comparison is greater, and to buy in the international market the goods in which said advantage is less; since, moreover, it would not be able to produce all of them with absolute efficiency, and consume all of them).

In this context, the Hecksher-Ohlin model shows how each national economy must specialize in the production and export of those goods that require a greater quantity of factors of production that are relatively cheaper than in other countries. Then, a country that has a lot of capital will tend to specialize in industrial productions that are as technologically advanced as the capital at its disposal allows. On the other hand, a country that has little capital will specialize in light industries such as textiles or agricultural production if it also has abundant land as a natural factor, for example [8].

Krugman and Wells affirm that the goal of a national economy is focused on providing the best standard of living for its citizens given the endowment of resources that it has. This will depend on the productivity capacity with which these resources (labor and capital) are used. Productivity, they say, is the main determinant, in the long run, of a nation's standard of living, because it is the root cause of per capita national income [11].

The productivity of human resources determines their wages, while the productivity of capital determines the return to the capitalist [9]. And so, in international trade it is possible for a country to raise its productivity by eliminating the need to produce all goods and services within the same nation. For this reason, a nation can specialize in those sectors and segments in which its companies are relatively more productive and import those products and services in which its companies are less productive than their foreign

rivals, thus raising the average level of productivity in the economy. In this way, imports and exports are a joint factor of productivity growth [8].

In this context, Carbough states that the trade of a good X between two countries in the international market is

generated when a national economy A produces it at a cost that allows it to offer good X at a lower price than the country B [9]. The difference in prices makes it more convenient for national economy B to import it than to produce it internally, as can be seen in Figure 1.

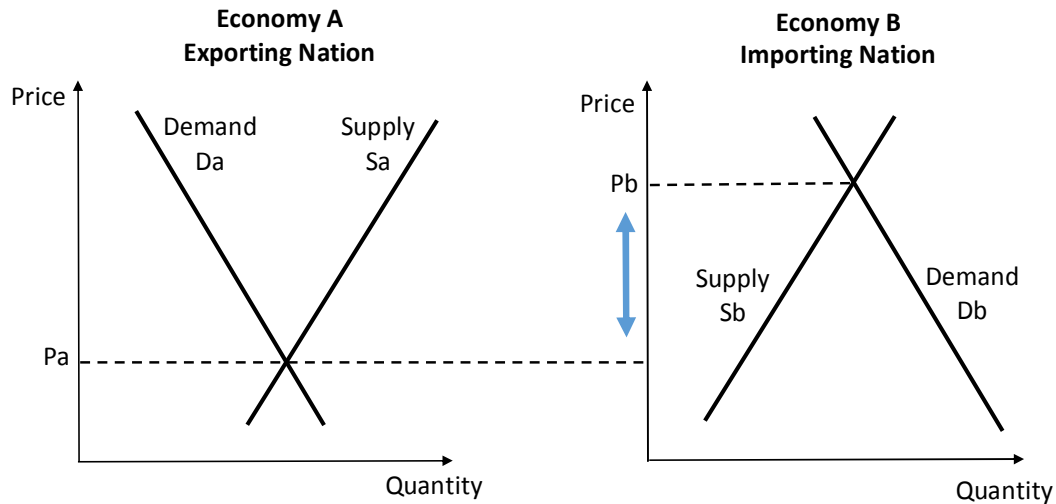


Figure 1. Difference in internal prices between the Exporting Nation and the Importing Nation.

In the same way, the trade of a good between two nations can be understood through a partial equilibrium model of two economies and one good. This model can be understood, in the first instance, through a graph of economy A (Exporting Nation) that maintains a competitive advantage in the production of good X [4]. If the equilibrium price P_a in economy A is taken as a base, and if this price were to

increase, the difference between supply S_a and demand D_a for good X would tend to increase. As can be seen in Figure 2, the excess supply ES generated at different prices above the equilibrium price P_a can be transferred to a second scenario that represents the international market and draw a horizontal line that represents the quantities of good X available in the international market.

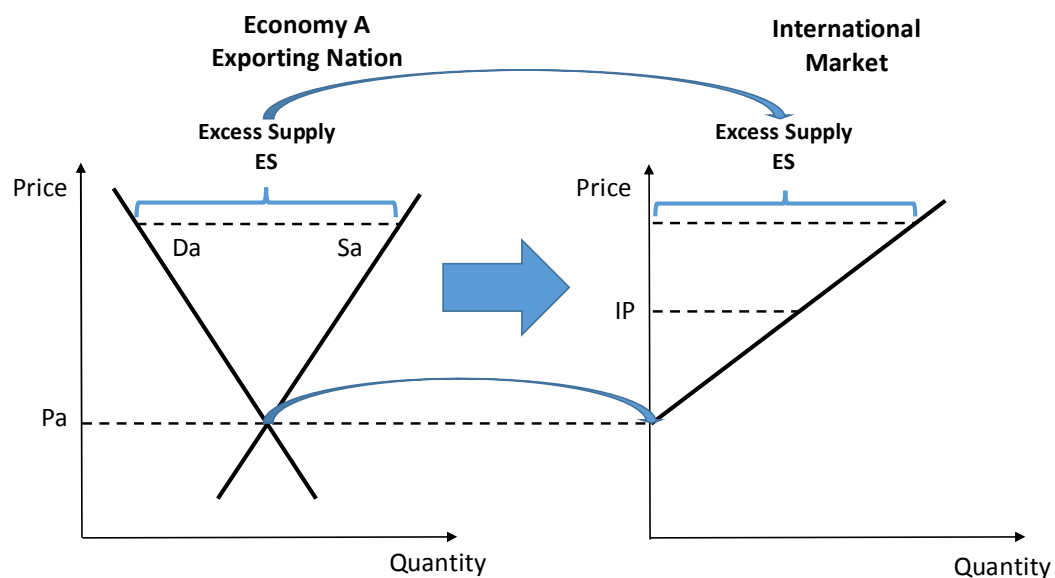


Figure 2. Excess Supply of a good in the international market.

On the other hand, in the graph of economy B (Importing Nation B), which is at a competitive disadvantage in the production of good X compared to Exporting Nation A, it can be seen that the price P_b at which it is produced in economy B is higher than the international price IP (and

higher than the equilibrium price P_a of good X in Exporting Nation A). It is worth mentioning that at the equilibrium price P_b in Importing Nation B, the quantity demanded D_b and the quantity supplied S_b of good X are equal, as shown in Figure 3.

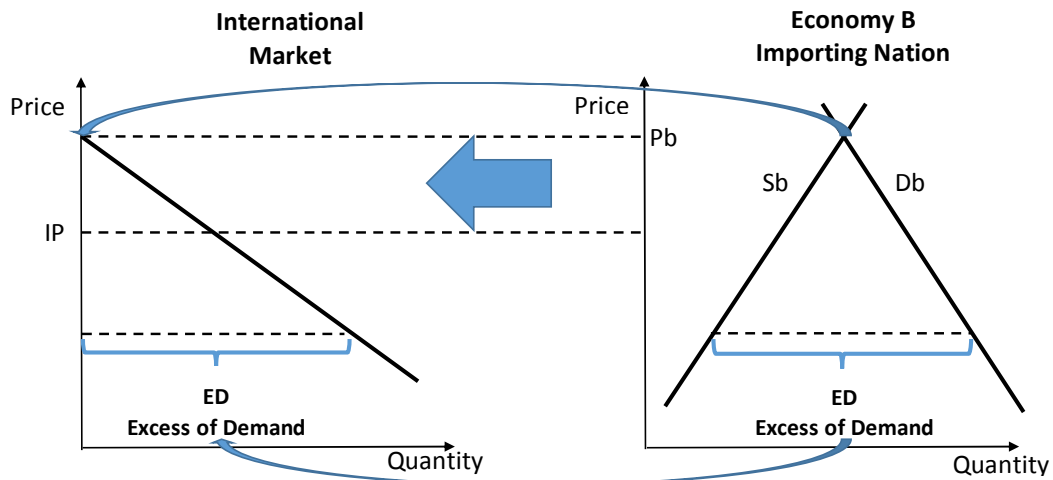


Figure 3. Excess of Demand of a good in the international market.

If the equilibrium price P_b in the Importing Nation B is taken as a base and, if this price were to fall, a difference would be generated between the demand D_b and the supply S_b of good X, which would tend to increase. This growing difference can be considered as excess demand ED; that is, at a Price P below the equilibrium price P_b , greater quantities of demand are generated that exceed the national supply of good X in Importing Nation B. These excess demand ED generated at different prices can be transferred to the scenario that represents the international market by drawing a line that represents the quantities demanded of good X, as can be seen in Figure 3.

In the same way, and focusing on the international market scenario, it can be seen in Figure 4 that there is a point where excess supply ES and excess of demand ED intersect. At this point, the equilibrium conditions of the market are met, since ES and ED are equal. Here, the International Price IP (equilibrium price of good X) is generated, as well as the International Quantity IQ (equilibrium quantity of good X in the international market at the International Price IP).

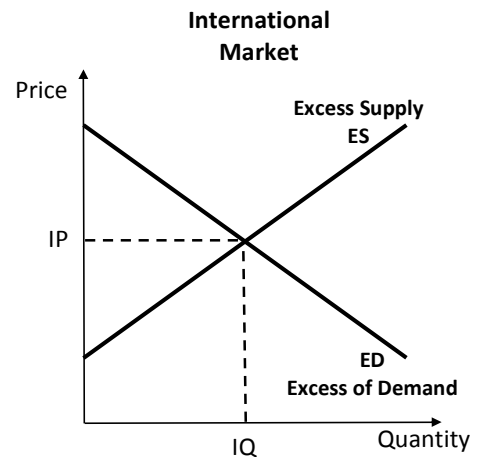


Figure 4. International market of a good.

At this level of IP, then, excess supply ES and excess demand ED are equivalent. Therefore, the excess supply $S_a - D_a$ in Exporting Nation A is equal to the excess demand $D_b - S_b$ in Exporting Nation B, as can be seen in Figure 5.

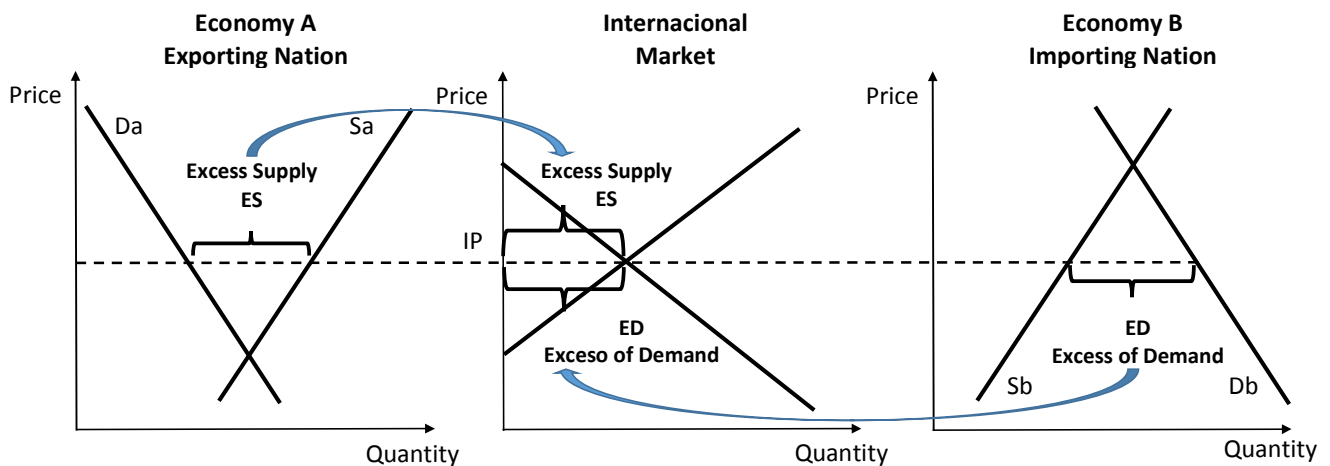


Figure 5. Exporting Nation A, International Market and Importing Nation B of a good.

It is worth mentioning that an increase in the quantity supplied in the international market is shown graphically as a displacement of the excess supply curve ES in the positive direction, that is, to the right (for any price level). This displacement of the ES curve causes a decrease in the International Price IP, as can be seen in Figure 6. The magnitude of the final effect that the displacement of the excess supply ES has on the decrease in the international price IP is defined by the price flexibility of demand [12], since by increasing the quantity traded in the international market IQ, the international price IP decreases.

In this sense, the price flexibility of the demand for a good is defined as the percentage change in the price when there is a change of 1% in the quantity demanded, that is, the price is sensitive to a change in the quantity [7]. It is important to mention that there is an inverse relationship between quantity and price, and the final effect can be classified as follows:

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

4. Methods

In order to carry out the research, a descriptive study was carried out in which a narrative is developed to show the impact of an increase in Mexican avocado exports to the Canadian market. To carry it out, a partial equilibrium analysis was carried out for one good and two economies, based on the price flexibility of demand estimated with the results of an econometric model.

In this sense, the study is causal, since in order to develop the study it is necessary to determine the impact that the exported quantity of Mexican avocado for export destined for the Canadian market has on its price.

The research is quantitative in nature since the Mexican avocado market for export to Canada is represented in an econometric model of simultaneous equations, which is based on the relationship that exists between the variables that operate in the international avocado market between Mexico and Canada in the statistical sense.

4.1. The Econometric Model

Considering these interrelationships, the econometric model of two economies that represents the export avocado market destined for Canada, is made up of two main equations:

$$PIAMCan_t = \beta_{10} + \beta_{11}QIAMCan_t + \beta_{12}GDPRCanPC_t + \varepsilon_{1t} \quad (1)$$

$$PEAM_t = \beta_{20} + \beta_{21}QEAM_t + \beta_{22}PPAMR_t + \varepsilon_{2t} \quad (2)$$

Equation 1 is a demand function for Mexican avocado imports in Canada, where the real CIF unit import price $PIAMCan_t$ is the dependent variable, and is determined by: $QIAMCan_t$, which is the imported quantity of Mexican avocado in Canada, and $GDPRCanPC_t$, which is Real Gross Domestic Product per capita, as a proxy variable for the income of Canadian consumers.

Equation 2 is a supply function of avocado exports in Mexico where $PEAM_t$ is the real unit price of avocado exports in Mexico is the dependent variable, and is determined by: $QEAM_t$ which is the quantity of avocado exported in Mexico, and by $PPAMR_t$ which is the real unit price for avocado producers in Mexico.

It is worth mentioning that the 3-Stage Least Squares method was implemented to the simultaneous equations model in order to calculate the β_{11} - β_{22} coefficients. The β coefficients are calculated simultaneously based on the relationship of the variables within the model. The time series are made up of 18 observations. Additionally, it is necessary to say that the $PIAMCan_t$ and $QIAMCan_t$ variables were constructed with information from the Trade Data Online (TDO) of Canada [2], the $GDPRCanPC_t$ variable was constructed with data from the Bank of St. Louis [13]. The $PEAM_t$ and $QEAM_t$ variables were constructed with data from the Via Internet Tariff Information System (SIAVI) of the Ministry of Economy [3]; the $PPAMR_t$ variable was constructed with data from the Agrifood and Fisheries Information Service (SIAP) of the Ministry of Agriculture and Rural Development [14].

4.2. The Partial Equilibrium Model

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

1. A good, the avocado.
2. An international market of two economies: Mexico and Canada.
3. The excess of demand for avocado in Canada is equal to the imports of Mexican avocado.
4. The excess supply of avocado in Mexico is equal to the exports to Canada.
5. Prices and values in real terms.
6. Monetary values in Canadian dollars C\$.
7. A simulated increase of 50% in Mexican avocado exports to the Canadian market in 2021 compared to those made in 2020.

In this regard, it is worth mentioning that an increase in the quantity offered in Mexico of avocado for export to Canada is expressed in the international market scenario as a displacement of the excess supply curve from ES_0 to ES_1 , as shown in Figure 6. This also causes a decrease in the International Price from IP_0 to IP_1 , and in turn, an increase in the quantity marketed from IQ_0 to IQ_1 , also observing an increase in the excess of demand ED for avocado in the international market, as can be seen in Figure 6.

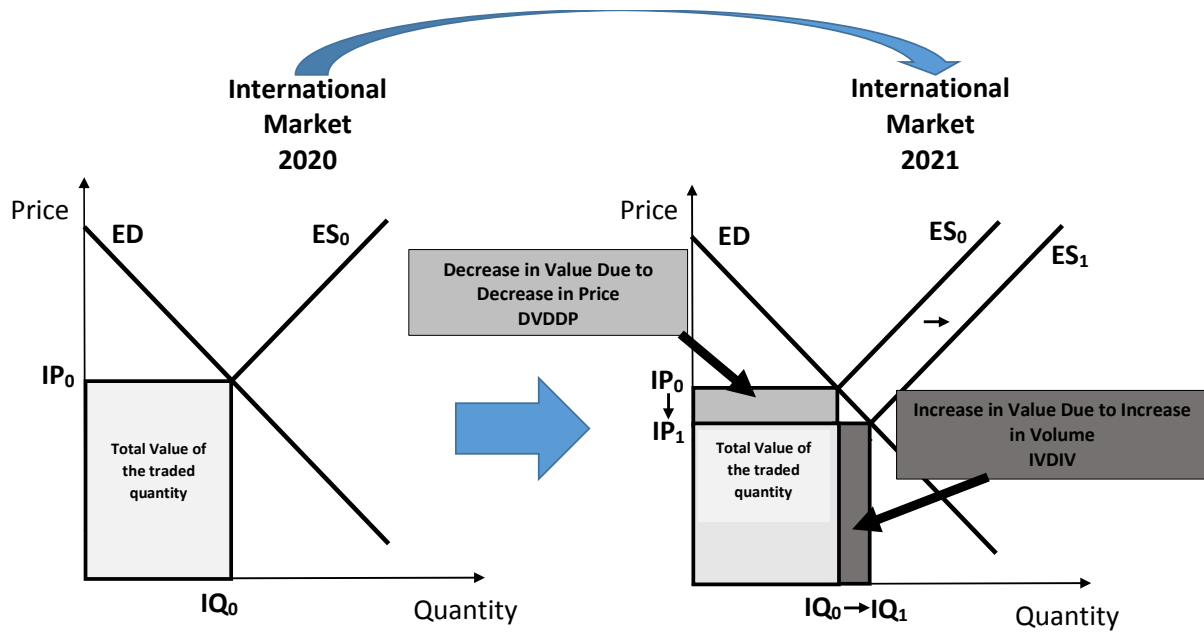


Figure 6. Changes in the total value of Mexican avocado exports to the Canadian market.

4.3. Viability of Increasing the Export Quantity

As mentioned above, the magnitude by which a change in quantity influences price is given by the price flexibility of demand, which is calculated as follows:

$$F=(dPIAMCan/dQIAMCan)*(QIAMCan/PIAMCan) \quad (3)$$

The price flexibility of the demand allows to know the percentage decrease in the International Price PI when the quantity QI increases by 1%.

The simulation starts from the real scenario in the 2020 international market, where the imported quantity of avocado in the international market (destined for Canada) is IQ_0 , while its price is given by IP_0 . The simulated 2021 scenario will include a 50% increase in the imported quantity of avocado in the international market IQ_1 with respect to the actual imported quantity in 2020, while its price is given by IP_1 (a price decreased by a percentage with respect to the price IP_0 in 2020, and denoted by the magnitude of the demand price flexibility).

As can be seen in Figure 6, an increase in the quantity imported causes an increase in the total value of imports, while a decrease in price causes a decrease in the total value of imports. To determine the final impact, both effects were calculated as follows:

Increase in Value Due to Increase in Volume

$$IVDIV=(Q_1 - Q_0) * P_1 \quad (4)$$

Decrease in Value Due to Decrease in Price

$$DVDDP=(P_0 - P_1) * Q_0 \quad (5)$$

The difference between the increase and the decrease in income will allow knowing the balance of both impacts, it is

then calculated as follows:

$$IVDIV - DVDDP = \text{balance} \quad (6)$$

The value of the calculated balance allows determining the final effect of the 50% increase in the amount of Mexican avocado exported to Canada. So, the criteria to determine the viability of the increase in the quantity are:

1. IVDIV greater than DVDDP, then the balance will be positive, that is, the total value of the quantity traded will increase. Thus, an annual increase of 50% in Mexican avocado exports to Canadian market is viable.
2. IVDIV less than DVDDP, then the balance will be negative, that is, the total value of the quantity traded will decrease. Thus, an annual increase of 50% in Mexican avocado exports to Canadian market is not viable.

Now, the simulated final effect of the quantity increase (50%) and the price decrease (4.73%) can be transferred to the profitability for the producers of avocado in Michoacan, Jalisco and the State of Mexico, in order to determine the final impact on them.

In this sense, Rodriguez, Bao and Cardenas [15] affirm that the Benefit/Cost Ratio (B/C R) can be calculated as follows:

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

In order to determine the viability of an increase in the amount of avocado exported from the perspective of the Mexican producer, the criteria are:

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

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

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

According to equation 8, if the B/C R is greater than 1, this result means that revenues are greater than expenses, so the referred activity is profitable. For the specific case of this research, the result would mean that avocado production in Mexico for export to Canada is profitable under the conditions set forth. Now, in relation to equation 9, if the B/C R is equal to 1, the result shows that the income is equal to the expenses, so that the aforementioned activity does not produce profits or losses. In other words, for this research, this result would mean that the production of avocado in Mexico for export to the Canadian market does not produce benefits in the economic sense. With regard to equation 10, if the B/C R is less than 1, this result expresses that income is less than expenditure, so the activity analyzed is not profitable. In the context of this research, it would mean that producing avocado in Mexico to export to Canada is not profitable.

5. Results and Discussion

Based on the results of the econometric model, the coefficients β were calculated, as can be seen in Table 6.

Table 6. Coefficients β calculated.

	Value	t	Pr > t
β_{11}	-0.0000057	-2.03	0.0602
β_{12}	-0.0381000	-1.51	0.0951
β_{21}	2538.8440000	9.61	0.0001
β_{22}	168.1994000	1.64	0.0981

Regarding the results of the application of 3-Stages Least Squares to the econometric model, it is necessary to say that the critical value of t with a level of 0.1 is equal to 1.33. In this sense, the hypothesis test for the t value of the coefficient β_{11} is equal to -2.03, that is, it is less than -1.33, so the probability of the referred t (0.0602) is less than 0.1. Likewise, the value of t for the coefficient β_{12} is equal to -1.51, that is, it is less than -1.33, so the probability of the respective t (0.0951) is less than 0.1. In the same way, the value of t for the coefficient β_{21} is equal to 9.61, that is, it is greater than 1.33, so the probability of the t analyzed is equal to 0.0001, that is, less than 0.1. While, in the same sense, the value of t for the coefficient β_{22} is equal to 1.64, that is, it is greater than 1.33, so the probability of the respective t (0.0981) is less than 0.1. According to the results described, it is possible to affirm that the estimated values of β_{11} , β_{12} , β_{21} and β_{22} are statistically significant.

Now, the calculated value of the QIAMCan_t coefficient (β_{11}) allow to build the demand function as follows:

$$\text{PIAMCan}_t = \beta_{10} - 0.0000057 \text{QIAMCan}_t - \beta_{12} \text{GDPRCanPC}_t + \varepsilon_t \quad (11)$$

Thus, the partial derivative of the demand function (11)

with respect to QIAMCan_t was calculated:

$$(\text{dPIAMCan}/\text{dQIAMCan}) = -0.0000057 \quad (12)$$

Now, in order to obtain the price flexibility of the demand, the partial derivative was multiplied by the quotient of the average values of QIAMCan_t and PIAMCan_t.

$$F = (-0.0000057) * (41322427.5 / 2487.769873) = -0.094678306 \quad (13)$$

Regarding the price flexibility of the demand, it is possible to affirm that the imported quantity of Mexican avocado in Canada QIAMCan_t has a negative and inflexible relationship with respect to the import price of Mexican avocado in Canada PIAMCan_t. Likewise, it can be established that when the imported quantity of Mexican avocado increases 1%, the price decreases 0.0946%. Now, in order to determine the final effect as a result of a 50% increase in the exported quantity, the price flexibility of the demand calculated was -4.7339%, as can be observed in Table 7.

Table 7. Price flexibility of the demand for Mexican avocado imports in Canada.

Change in quantity	Change in price
1.0000%	-0.0946%
50.0000%	-4.7339%

That is, if the imported quantity of Mexican avocado in Canada increases 50% in 2021 compared to the imported quantity in 2020, the effect on the price is a decrease of 4.7339%. These results were applied in the simulated scenario.

Table 8. Simulated scenario with 50% increase in the imported quantity.

Year	Quantity Q	Price P	Total Value (Q)*(P)
2020	Q ₀ =91 932.58	P ₀ =2 982.35	274 175 258.15
2021	Q ₁ =137 898.87	P ₁ =2 841.17	391 794 050.54
			Increase 117 618 792.39

As Table 8 shows, in 2020, the total value of Mexican avocado imports in Canada was C\$ 274 175 258.15; while the total value of simulated imports in the year 2021 of Mexican avocado in Canada would be C\$ 391 794 050.54. In this way, the final effect would be an increase in a magnitude of C\$ 117 618 792.39. In other words, there would be a global positive impact on the total value of imports.

As can be seen in Figure 6, an increase in the quantity of avocado supplied in Mexico for export to Canada from IQ₀ to IQ₁ causes a shift in the excess supply curve from ES₀ to ES₁. This also causes a decrease in the international price from IP₀ to IP₁. As a consequence, an increase in the total value of the traded quantity is generated due to an increase in volume, and at the same time a decrease in the total value of the traded quantity is generated due to the decrease in price. Then, the areas were calculated.

Table 9. Increase in the total value of the avocado imports in the face of 50% increase in the imported quantity.

Increase in Value Due to Increase in Volume	(Q ₁ -Q ₀)*P ₁	130 598 016.85
Decrease in Value Due to Decrease in Price	(P ₀ -P ₁)*Q ₀	-12 979 224.46
Difference		117 618 792.39

So, given a 50% increase in the quantity of imported Mexican avocados in the Canadian market, the Increase in Value Due to the Increase in Volume IVDIV calculated is C\$ 130 598 016.85, while the Decrease in Value Due to the Decrease in Price DVDDP is C\$ 12 979 224.46, as can be seen in Table 9. The difference between the two values is an increase of C\$ 117 618 792.39. With these results can be affirmed that an increase in the amount of Mexican avocado exported to the Canadian market that results in an average annual growth rate of 50% is viable in terms of income.

Now, to determine the viability for the Mexican producer of a 50% increase in the amount of avocado exported to the Canadian market, the B/C R of the year 2020 and the simulated scenario for the year 2021 were compared. In that sense, the cost calculation assumes a linear function, so the cost per t is constant.

It is worth mentioning that, according to information from the Ministry of Economy, in Mexico in 2020, 91 932.58 t of avocado were exported to Canada. Of these, 36.55% (33 600.00 t) were made from Jalisco, while 63.45% (58 332.58 t) were exported by Michoacan [3], as can be seen in Table 10. It is important to say that the State of Mexico exports avocado to Europe and South America, but it has not exported avocado to Canada.

Table 10. Benefit / Cost Relationship for the avocado producer in Mexico in 2020.

Province	Benefits MXN	Costs MXN	B/C R
Michoacan	1 284 061 083.61	858 013 919.22	1.4965
Jalisco	566 835 024.00	364 102 368.00	1.5568
State of Mexico	0.00	0.00	0.0000

With these results (Table 10) it can be affirmed that the B/C R calculated for the producers of Jalisco and Michoacan had a magnitude of 1.5568 and 1.4965 for the year 2020. That is, for the producers of Jalisco and Michoacán it is profitable to produce avocado for export to Canada.

Now, to propose the hypothetical 2021 scenario, a Mexican avocado export to Canada of 137 898.88 t was simulated. An export quantity of 49 021.01 t (35.55%) of avocado was assigned to Jalisco, 86 119.89 t (62.45%) to Michoacan, and 2 757.98 (2.00%) to the State of Mexico, as can be seen in Table 11. It should be mentioned that, considering the participation of the State of Mexico in the export of Mexican avocado to the Canadian market, and taking into account that avocado is already exported from this entity to other destinations, it was included in the analysis.

Table 11. Benefit / Cost Relationship for the avocado producer in Mexico in the simulated scenario 2021.

Province	Benefits MXN	Costs MXN	B/C R
Michoacan	1 805 993 911.23	1 266 737 462.02	1.4257
Jalisco	787 839 898.96	531 210 292.34	1.4831
State of Mexico	47 531 149.69	31 021 124.70	1.5322

With the results of the simulated scenario (Table 11), the B/C R for producers from Jalisco, Michoacan and the State

of Mexico would be 1.4257, 1.4831 and 1.5322 respectively, which indicates that for the producers of these States the increase of 50% in the quantity exported avocado to Canada is profitable.

The approach of a hypothetical scenario allows visualizing the repercussions of a change in the fundamental variables of the modeled reality. In this sense, the partial equilibrium analysis of a good between two national economies provides the opportunity to observe the repercussions of specific changes in the economic environment in which international trade takes place, as well as the effects of the changes that are to be applied. It is important to mention that the fundamental changes in quantity and price are determined by the magnitude of both the price elasticity of demand and the price flexibility of demand. In the market for a specific good, and based on this quantitative relationship, it is possible to simulate individual impacts in quantity or price, and transfer them to the international market (which represents the interaction of both national economies in the trade of a good in which have a close trading relationship). In the partial equilibrium model, this impact affects the total value of the quantity traded between both nations; if this effect on the total value is positive, the proposed change is viable in the economic sense, while if the effect on the total value is negative, the proposed change decreases the value of trade in the good between both nations, that is, it is not viable to do it.

In Mexico, avocado is one of the most important export markets, and in 2020 it represented US\$ 2 746 170 approximately. In that year, Mexico exported 1 158 894.00 t of avocado, that is, 48.41% of the total produced (2 393 849.00). In that same year, of the total exported (1 158 894 t) Mexico destined 86.68% to the US market (1 004 605.20 t), while Canada is the second market for Mexican avocado, and represented 8.63% (99 974 t) of the total export market. In this regard, Hernandez and Gonzalez carried out a partial equilibrium analysis of two economies on the Mexican avocado market for export to the US market [16]. With the price flexibility of the demand for Mexican avocado imports in USA, they calculate that in the face of a 30% increase in quantity, the final balance of both impacts has a positive sign, since the result is a profit of US\$ 595 556 756.00 in the international market. With this result, they say, a 30% annual increase in Mexican avocado exports to the US market is viable in terms of income. The result shows that the US market represents a great opportunity for Mexican avocados, supporting an annual increase of 292 978.26 t. However, the supply in the international market does not respond sufficiently to the growing demand in the US market. It is worth mentioning that the analysis also shows that avocado production in Mexico is capable of increasing exports in significant quantities (292 978.26 t), which allows determining that the simulated increase of 45 966.29 t to the Canadian market is absolutely viable.

Capps, Williams and Dang carried out a partial equilibrium analysis for the lamb market in USA in which they show that

the income derived from the investment in advertising in this market is greater than the advertising expenses made, so that the B/C R is greater than 1 showing that the strategy was profitable [17]. The results show that investment in advertising causes a positive shift in the demand curve for lambs in the US market. This displacement causes the producer price of lamb to increase, improving the income for the producer.

Hernandez, Alejos and Casique state that an 18% increase in Mexican strawberry exports to the US market is viable in the economic sense, increasing the total value of the amount sold [5]. In this simulated scenario, the B/C R is equal to 1.9813, 1.9020, and 0.9234 for the producer from Baja California, Michoacán, and Guanajuato. So this simulated increase in the amount of Mexican strawberry exports to the US market is feasible for producers from Baja California and Michoacán, while for the producers in the state of Guanajuato is not profitable. Based on these results, they affirm, it is necessary to improve the production technology in Guanajuato, since being traditional, the product does not meet the organoleptic characteristics or the quality standards that strawberry production requires to enter the strawberry US market.

This case allows identifying that the state of Guanajuato does not have the technological or productive conditions to contribute to the increase of the exportable supply of strawberries in Mexico, and thus take advantage of the opportunities that the international market offers.

The partial equilibrium analysis allows the identification of the viability for the application of a policy to increase the export of a good, which implies the application of mechanisms to improve the productive capacity of the productive system at the national level for the increase of the exportable supply. Additionally, the national supply must cover the domestic consumption market, so the viability analysis is of great importance for commercial and agricultural policy decisions, as well as regional development in the production of the analyzed good.

In this sense, it is important to point out that in the aforementioned examples, the results show that the increase in the traded quantity in the international market is viable from an economic perspective. An alternative scenario would be that given the simulated increase in exports, the final effect would be a decrease in the total value of the traded quantity; that is to say, that increasing the exportable supply in the exporting country will cause a decrease in the price in such a magnitude that the total value of the traded quantity decreases. In this case, the increase proposed in the simulation is not viable, since the result would show that, in the relationship between both nations, the import country market would no longer support large additional quantities of imports from the international market; that is, carrying out the increase in exports would reduce the benefits for the consumer in the importing nation, as well as the benefits for the producer in the exporting nation.

The partial equilibrium analysis, then, allows to identify the opportunities for carrying out international trade of a

good between two economies. If the result shows that the losses in the market derived from the decrease in price are greater than the benefits derived from the increase in volume, the international trade between the two nations is not convenient, which would lead to the exploration of other commercial alternatives, such as the diversification of the market to export to other nations, or the investment in advertising to increase the demand in the market of the importing nation (as in the case of the consumer market for lambs in USA). The effectiveness of the partial equilibrium analysis depends to a large extent on the magnitude of the price flexibility of demand in the international market (made up of the two nations), since this calculation is carried out with real information, so the simulated scenario has elements with a high pragmatic content for prospective analysis.

6. Conclusion

The price flexibility of demand shows that in the face of a 50% increase in the amount of imported Mexican avocado in Canada, the price decreases 4.7339%. With this result, it is estimated that the Increase in Value Due to the Increase in Volume is C\$ 130 598 016.85, while the Decrease in Value Due to the Decrease in Price is C\$ 12 979 224.46. The difference between the two values is a final positive impact of C\$ 117 618 792.39. This result shows that increasing the amount of Mexican avocado imported in Canada by 50% in one year is viable.

On the other hand, for the year 2020, the B/C R calculated for avocado producers destined for the Canadian market in Jalisco and Michoacán was 1.5568 and 1.4965, respectively. While for the simulated 2021 scenario, it was estimated that the B/C R would be 1.4831, 1.4257 and 1.5322 for the producers of Jalisco, Michoacán and the State of Mexico respectively. With these results, it can be affirmed that for the producers of these states it is still profitable to grow avocado to export to Canada in the face of an increase in the quantity that results in an average annual growth rate of 50%.

In this condition, in Mexico it is convenient to apply an agricultural policy that allows increasing the production of first quality fresh avocado to export to markets such as Canada and take advantage of the opportunities offered by the international market for avocado, a product in which Mexico has a competitive advantage. This policy must allow the incorporation of technology that increases production (improved seed, fertilizers, pesticides, systems to maintain product safety, packaging, etc.), as well as the efficiency of existing marketing channels and the development of schemes that allow the productive system is developed not only in Jalisco, Michoacán and the State of Mexico. It is convenient to improve avocado production systems in order to generate a product with the organoleptic characteristics that allow it to enter the international market for export, for example in states like Nayarit, Morelos, Guerrero, Sinaloa and Chiapas.

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