

## **Analysis of the economic variables that determine strawberry exports from Mexico to the United States of America**

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### **Abstract**

The main strawberry-producing countries are China, the United States of America and Mexico, which account for about fifty-nine percent of the world's production. Also, the largest strawberry exporters are Spain, the United States of America and Mexico, which contribute about sixty-one percent of the exports in the world. The objective of the work is to analyze the relationship between Mexico's strawberry exports to the United States of America and their economic determinants, among which the following stand out: Mexico's unit export price, the gross domestic product of the United States of America and the total demand of the United States of America for strawberry imports in the world, and to calculate the price and income elasticities of demand for strawberry exports from Mexico. The signs of the estimated regression coefficients and the price and income elasticities are consistent with the demand theory, the variable with the greatest influence on the variations in export demand is the gross domestic product of the United States of America, the obtained price elasticity of the exports, less than one, reflects that the export strawberry is an inelastic product and the income elasticity of the exports, less than one, indicates that the strawberry is a normal good for the United States of America. The estimated regression model is consistent and congruent with the export demand theory.

**Keywords:** econometric model, export demand, income elasticity, price elasticity.

Reception date: February 2022

Acceptance date: April 2022

## Introduction

Strawberry (*Fragaria vesca*) is a product that contains a large amount of organic acids, mineral substances, vitamin C, folic acid, antioxidants, sugars, among others, which, through the consumption of strawberries, help lower cholesterol, strengthen the immune system, prevent cardiovascular and degenerative diseases such as cancer, among others (Santoyo and Martínez, 2010; Afrin *et al.*, 2016).

The main strawberry-producing countries are China with 2 851 100 t (35.3%), the United States of America (USA) with 1 234 134 t (15.3%) and Mexico with 658 436 t (8.2%), which contribute about 59% of world production. Likewise, the main strawberry-exporting countries are Spain with 304 314 t (32%), the United States of America with 146 385 t (15.4%) and Mexico with 126 157 t (13.3%), which concentrate about 61% of world exports. On the other hand, the main importers of strawberries are the United States of America with 166 576 t (17.6%), Canada with 110 487 t (11.7%) and Germany with 108 407 t (11.4%), which represent about 41% of the world's imports (FAOSTAT, 2020).

Strawberry production in Mexico is important, as it represents 3% of the agricultural gross domestic product and 8.1% of the value of fruit production nationwide (SIACON, 2019). Strawberry is the eleventh agricultural export product of Mexico, for the value it contributes to exports, and Mexico is the third producer and exporter of strawberry in the world market. Mexican strawberry exports are sent mainly to the United States of America, which imports 99.7% of Mexico's exports (FAOSTAT, 2020).

The strawberry-producing states in Mexico are Michoacán with 484 936 t (73.6%), Baja California with 91 660 t (13.9%) and Guanajuato with 57 667 t (8.8%), which together contribute about 96% of national production (SIACON, 2019). Mexico exported 126 157 t, which represented 19.2% of the 658 436 t of national strawberry production (FAOSTAT, 2020).

During the period from 1993 to 2017, the harvested area of strawberries in Mexico grew by 141.1%, going from 5 744 to 13 850 ha, the yield by 65%, going from 18.7 to 30.8 t ha<sup>-1</sup>, the production by 596%, going from 94 599 to 658 436 t (SIACON, 2019). The high growth rates of the production variables reflect the expansion of strawberry production in Mexico.

Likewise, during the period from 1993 to 2017, Mexico's strawberry exports grew by 876.9%, going from 12 914 to 126 157 t, imports grew by 178.8%, going from 6 272 to 17 485 t, the apparent national consumption of strawberry grew by 525%, going from 87 957 to 549 764 t and the export coefficient, the proportion of strawberry production that is exported, increased by 40.4%, going from 0.14 to 0.19 (FAOSTAT, 2020). The high growth rates of exports and the export coefficient indicate the competitiveness of strawberries on the world market.

The economic literature argues that the export price is interrelated with demand-shifting factors, such as the price of substitute products and income, while exports are a function of the gross domestic product of the importing country, the unit export price of the exporting country, and the total import demand of the importing country (García *et al.*, 2003). Therefore, the

variations in export demand will be determined by the changes caused by the effect of the main shifting factors, such as the income and price of substitutes, so that the shifting variables of demand are considered as determining factors of exports, except for the price of the good itself, which is established as an independent variable depending on the demand for exports (García *et al.*, 2003).

The theoretical basis for formulating the demand function of exports or imports is the theory of demand. Therefore, econometric estimates of the import and export function of countries are based on the demand model of international trade flows of imperfect substitutes (Goldstein and Khan, 1985). Likewise, the variables that influence exports can vary in the process of exchange of goods and services for each economy, since economies have different trade characteristics (Arroyo *et al.*, 2015).

In econometric models, a country's import flows are related to domestic income, the price of imports, the domestic exchange rate, the total population, among others (Murray and Ginman, 1976; Hooper and Marquez, 1993; Carone, 1996). On the other hand, export flows are related to the income of the country that receives the exported goods, the price of domestic exports, the unit labor cost of the exporting country, among others. The variables import price, export price and income are crucial to the definition and effectiveness of import trade policy, which depend largely on the price and income elasticities of demand (Goldstein and Khan, 1978; Leamer and Stern, 2006).

Demand elasticities are the analytical tool that allows measuring the degree of sensitivity of export demand to the change of some explanatory variable (Pérez *et al.*, 2015). In that sense, Fullerton *et al.* (1999) analyzed the empirical estimates of the income and price elasticities of import and export demand for the United States since 1976, the results were negative price elasticity and positive income elasticity.

The objective of this work is to identify and analyze the variables that determine the variations in strawberry exports from Mexico to the United States of America (USA) gross domestic product, unit export price of Mexico, USA total demand for strawberry imports and to calculate the price and income elasticities of strawberry exports from Mexico to the USA. The hypothesis is that some of the variables included in the model (USA gross domestic product, unit export price of Mexico, USA total demand for strawberry imports) explains the variations in strawberry exports from Mexico to the United States of America.

## Materials and methods

The basis for the formulation and estimation of the econometric model of export demand is the export demand function, which states that export demand depends on national income, producer price, export price, exchange rate, among others (Murray and Ginman, 1976; Sánchez *et al.*, 2011). In this paper, elements of multiple linear regression analysis models were considered: estimate of the demand for imports of Persian lime in the United States from Mexico (Sánchez *et al.*, 2011). Demand elasticities for Chilean apples in the European Union market: an econometric estimation (Cerdeira, 2004) and estimation of export supply and import demand for Mexican avocado destined for the European market (Mohamed *et al.*, 2008).

## Formulation of the econometric model

The formulation of demand model for exports from an exporting country (Mexico) to an importing country (USA) in a given period is a function of the unit export price of the exporting country, the income level of the importing country, the price of competitors in the market, the total import demand of the importing country, of the exchange rate of the exporting country, among other factors (Aravena, 2005). The export function assumes the existence of two countries, the exporting country (Mexico) and the importing country (United States of America), under the assumptions of perfect competition. It is also assumed that the consumer has no money illusion, so the variables of monetary value are expressed in real terms (Sánchez, 2011). The real monetary value variables were obtained by deflating the nominal values with the corresponding price index (GDP price index and export price index).

The multiple linear regression model that was developed to estimate the function of strawberry exports from Mexico to the United States of America and to identify the variables that explain the variations in exports is:  $TEXP_t = \beta_0 + \beta_1(RUEP_t) + \beta_2(RGDP_t) + \beta_3(TIMD_t) + e_t$  (1). Where:  $TEXP_t$  = total strawberry exports from Mexico to the USA (t) in year t;  $\beta_0$  = intercept of the function of strawberry exports from Mexico to the USA;  $\beta_1$ ,  $\beta_2$  and  $\beta_3$  = parameters of the model variables;  $RUEP_t$  = real unit export price of strawberries from Mexico to the USA (dollars per tonne) in year t;  $RGDP_t$  = USA real gross domestic product (millions of dollars) in year t;  $TIMD_t$  = USA. total import demand for strawberries (t) in year t;  $e_t$  = model error term in year t.

The multiple linear regression model was estimated with 60 quarterly observations from the period from 2003 to 2017, with consistent statistics and signs of the coefficients consistent with economic theory, it served as the basis for obtaining the price, import demand and income elasticities of export demand (Zenteno, 2013). The calculation procedures are: price elasticity of demand for strawberry exports.  $\varepsilon_{RUEP} = \frac{\partial TEXP}{\partial RUEP} \cdot \frac{RUEP}{\overline{TEXP}}$  (2). Income elasticity of demand for strawberry exports.  $\varepsilon_{RGDP} = \frac{\partial TEXP}{\partial RGDP} \cdot \frac{RGDP}{\overline{TEXP}}$  (3). Import demand elasticity of strawberry export demand.  $\varepsilon_{TIMD} = \frac{\partial TEXP}{\partial TIMD} \cdot \frac{TIMD}{\overline{TEXP}}$  (4). Where:  $\varepsilon_{RUEP}$  = real unit export price elasticity of demand for strawberry exports from Mexico to the USA.

$\varepsilon_{RGDP}$  = real income elasticity of the demand for strawberry exports from Mexico to the USA;  $\varepsilon_{TIMD}$  = import demand elasticity of export demand from Mexico to the USA;  $\partial TEXP$  = derivative of total strawberry exports from Mexico to the USA;  $\partial RUEP$  = derivative of the unit export price of strawberries from Mexico to the USA;  $\partial RGDP$  = derivative of the USA real gross domestic product;  $\partial TIMD$  = derivative of the USA total import demand for strawberries;  $\overline{TEXP}$  = average total strawberry exports from Mexico to the USA;  $\overline{RUEP}$  = average real unit export price strawberry from Mexico to the USA;  $\overline{RGDP}$  = USA average real gross domestic product;  $\overline{TIMD}$  = USA average total import demand for strawberries.

## **Econometric model variables**

Strawberry exports from Mexico to the United States of America (TEXP). It is the dependent variable of the model and strawberry exports are expressed in tonnes. They are quarterly data, which were obtained from the Commercial Information System Via Internet (SIAVI, for its acronym in Spanish) of Mexico, for the period from 2003 to 2017.

Gross domestic product of the United States of America (GDP). It is an explanatory variable of the model, it is expressed in millions of dollars in real terms with base year 2003, for the period from 2003 to 2017. They are quarterly data and were obtained from the Bureau of Economic Analysis (BEA) of the USA Department of Commerce, from the USA National Economic Accounts. GDP has a positive functional relationship with the dependent variable, as real GDP increases, exports from Mexico to the USA increase.

Demand of the United States of America for strawberry imports from the world (IMD). It is an explanatory variable of the model, is expressed in tonnes and covers the period from 2003 to 2017. They are quarterly data and were obtained from the Trade data of the Foreign Agriculture System (FAS) of the Global Agricultural Trade System (GATS) database of the United States Department of Agriculture (USDA). The functional relationship with the dependent variable is positive, since as the USA total demand for strawberry imports increases, strawberry exports from Mexico to the United States of America increase.

Unit export price of strawberry of Mexico (RUEP). It is another explanatory variable of the model. The unit export price is expressed in dollars per tonne, in real terms with base year 2003, for the period 2003 to 2017. The data are quarterly and were obtained from the Commercial Information System Via Internet (SIAVI) of Mexico. The functional relationship with the dependent variable is negative, since as RUEP increases, the demand for strawberry exports from Mexico to the United States of America decreases.

## **Estimation of the econometric model**

The multiple linear regression model of demand for strawberry exports from Mexico to the United States of America was estimated based on the assumptions and properties of the Ordinary Least Squares Method (Gujarati, 2010) and the regression procedures of the Statistical Analysis Software (SAS), with 60 quarterly observations from 2003 to 2017. The multiple linear regression generated consistent statistics and signs of the coefficients of the variables congruent with economic theory, so the estimators of the parameters obtained were used to obtain the price, import demand and income elasticities of the demand for strawberry exports from Mexico to the United States of America.

## **Results and discussion**

### **Behavior of the variables of the econometric model of the demand for strawberry exports from Mexico to the United States of America**

In the period from 2003 to 2017, the volume of strawberry exports from Mexico to the United States of America grew by 334.29%, from 42 415 to 184 205 t, the real export unit price had a growth of 111.46%, from 1 295 to 2 738 dollars per tonne, because the growth rates of nominal

strawberry prices grew in greater proportion than the growth rates of national consumer price indices; the USA total demand for strawberry imports grew by 306.51%, from 40 977 to 166 576 t, the USA real GDP increased by 26.44%, from 11.5 to 14.5 trillion dollars (SIAVI, 2018). The data reflect that the variables included in the multiple linear regression model had an increasing trend (Table 1), which is consistent in variables of agricultural production and trade.

**Table 1. Variables of the econometric model of demand for strawberry exports from Mexico to the United States of America.**

Year	EXP Mexico-USA (t)	RUEP Mexico (USD t)	USGDP (million dollars)	USIMD (t)
2003	42 415.44	1 294.65	11 510 670.00	40 976.9
2004	54 913.18	1 555.30	11 955 993.22	42 807.8
2005	52 117.14	1 559.42	12 338 232.76	55 661.3
2006	70 694.52	1 656.70	12 648 861.25	69 591.6
2007	66 787.11	1 545.53	12 847 647.86	71 517.6
2008	82 312.60	1 871.36	12 581 489.51	64 866.7
2009	82 944.62	1 897.85	12 364 794.34	84 890.2
2010	86 887.74	1 920.98	12 626 067.72	89 955.2
2011	104 401.72	1 724.13	12 694 559.40	110 457.5
2012	152 699.46	1 667.79	12 947 504.82	159 331.4
2013	148 921.53	1 602.84	13 184 013.98	149 944.4
2014	157 576.98	1 738.14	13 547 072.24	161 464.9
2015	139 114.87	2 042.11	14 068 832.81	142 593.5
2016	154 425.80	2 410.98	14 278 387.38	165 328.6
2017	184 204.78	2 737.66	14 554 467.80	166 576.1
OGR	334.29	111.46	26.44	306.51
AGR	10.29	5.12	1.58	9.8

SIAVI (2018), USA Bureau of Economic Analysis (2018) and USDA-Foreign Agricultural Service (2018).

### **Estimated econometric model of demand for strawberry exports from Mexico to the United States of America**

The results obtained of the estimation of the multiple linear regression model of the demand for strawberry exports from Mexico to the United States of America generated consistent statistics and signs of the coefficients of the explanatory variables consistent with the theory of export demand (Table 2).



**Table 2. Results of the estimated multiple linear regression model of the demand for strawberry exports from Mexico to the United States of America.**

Variable	Estimated parameter	Standard error	t value	Prob >  t
Intercept	-12538	8310.3905	-1.51	0.137
RUEP	-1.16964	0.55916	-2.09	0.041
RGDP	0.00127	0.00065784	1.92	0.0595
TIMD	0.92432	0.02307	40.06	<0.0001
R <sup>2</sup>	0.9715			
Adjusted R <sup>2</sup>	0.97			
Fc	636.84			<0.0001
X <sup>2</sup>	14.21			0.1152
DW	2.117			

Prepared based on the output of the regression estimated in SAS (2019).

The model is consistent and statistically significant, as the global f test (Prob > |f|) is less than zero point one, reflecting that the independent variables (RUEP, RGDP and TIMD) included in the model explain the variations of the dependent variable (TEXP). In particular, partial t tests (Prob > |t|) were less than zero point one of the estimated regression coefficients of  $\beta_1$ ,  $\beta_2$ ,  $\beta_3$ , so that the independent variables RUEP, RGDP and TIMD individually explain the variations of the dependent variable TEXP (Table 2).

Likewise, the coefficient of determination R<sup>2</sup> indicates a goodness of fit of 97%, which means that the independent variables (RUEP, RGDP and TIMD) explain the variations of the dependent variable (TEXP) in 97%. Also, the Durbin-Watson test and the normality statistics obtained allowed discarding the presence of autocorrelation, multicollinearity and heteroscedasticity problems in the model (Table 2).

On the other hand, the signs of the estimated parameters of the independent variables reflect positive relationships (positive sign) of RGDP and TIMD with TEXP and a negative relationship (negative sign) between RUEP and TEXP, relationships consistent with the theory of export demand (Table 2). The statistical and economic results of the model coincide with those obtained in other similar studies (Cerdeña, 2004; Sánchez *et al.*, 2011). Estimated demand function of exports from Mexico to the United States of America:  $TEXP = -12538 - 1.16964RUEP + 0.00127RGDP + 0.92432TIMD$  (5).

### Elasticities of demand for exports from Mexico to the United States of America

The elasticities of the model of demand for strawberry exports from Mexico to the United States of America were obtained based on the estimators of the parameters and variables of the multiple linear regression model, which coincide with the results of the elasticities obtained in other studies (Cerdeña, 2004; Sánchez *et al.*, 2011).

The coefficient (-12538) refers to autonomous exports, which do not depend on the independent variables. The elasticities obtained from the function of demand for strawberry exports from Mexico to the United States of America are consistent with the export demand theory (Table 3).

**Table 3. Elasticities of demand for strawberry exports from Mexico to the United States of America.**

Variable	Coefficient	Elasticity
RUEP	-0.02015	$ e_{RUEP}  < 1$ inelastic
RGDP	0.00001	$0 < e_{RGDP} < 1$ normal good
TIMD	0.92172	$ e_{TIMD}  < 1$ inelastic

Prepared based on the output of SAS (2019).

The real gross domestic product of the United States of America is the variable that explains in a smaller proportion the behavior of strawberry exports from Mexico to the USA, with a positive and less than one income elasticity of demand, placing strawberry as a normal good for the USA, reflecting that, in the event of a one percent increase in the USA real gross domestic product, the demand for strawberry exports from Mexico to the USA increases by 0.001%, which is far from the value obtained by Cerda (2004), who obtained an income elasticity of demand of 0.93%, classifying the Chilean apple as a normal good for the European Union.

The USA demand for strawberry imports from the world explains in a greater proportion the behavior of strawberry exports from Mexico to the USA, with a positive and less than one import demand elasticity, which means that in the event a one percent increase in the USA total demand for strawberry imports, strawberry exports from Mexico to the USA increase by 0.92%.

The real unit export price explains in a small proportion the behavior of strawberry exports from Mexico to the USA, with a negative and less than one elasticity, which means that, when the unit price of strawberry exports from Mexico increases by one percent, the demand for strawberry exports decreases by 0.02%, lower than the result obtained by Cerda (2004), who found that the price elasticity of the demand for Chilean apples in the European Union (EU) was -0.368%. The elasticity of the USA demand for imports in the world reflects that the variable that explains in greater proportion the variations in exports to the United States of America is the demand for imports from the world.

## Conclusions

The results obtained from the multiple linear regression model of the demand for strawberry exports from Mexico to the United States of America reflect that the determinants that explain in greater proportion the variations in strawberry exports from Mexico to the United States of America are the USA total demand for strawberry imports and the unit export price of strawberry from Mexico. The signs of the parameters estimated in the model are consistent with the economic theory of export demand, the relationship of the gross domestic product with exports is positive, the relationship of total import demand with exports is positive, and the relationship of export price with exports is negative. Additionally, from the statistical review, it is observed that Mexico is an important producer and exporter of strawberries worldwide, it exports about twenty percent of the national production of strawberries, with the United States of America being the main destination. The positive growth rate of strawberry production and export and the surplus trade balance in strawberries reflect that the crop is competitive in the world market.



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