Revista mexicana de ciencias agrícolas
ISSN: 2007-0934
Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias

Martínez Damián, Miguel A.; Téllez Delgado, Ricardo; Mora Flores, José Saturnino
Maíz blanco y maíz amarillo sustitutos o complementos
Revista mexicana de ciencias agrícolas, vol. 9, núm. 4, Mayo-Junio, 2018, pp. 879-885
Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias

DOI: 10.29312/remexca.v9i4.1404

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Investigation note

White corn and yellow corn substitutes or supplements

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Abstract

White corn (MB) and yellow corn (MA) can be seen simultaneously as supplements or substitutes. After estimating the elasticity of substitution, derived from data of prices and quantity by type of corn, the result of null elasticity of substitution is obtained, concluding therefore that both types of corn are foreign or complementary.

Keywords: corn, price ratio, ratio of quantities, substitution elasticity.

Reception date: May 2018
Acceptance date: June 2018

Introduction

Grain corn is an important crop in human and livestock feed for Mexico, with two main types of corn being planted: yellow corn (MA) and white corn (MB), with similar biological and genetic characteristics. However, in the market they present a differentiation in terms of prices, where the price of the MA is lower than the price of the MB. Also, from an external point of view there are two approaches that influence the perception of the two types of corn, a first approach is that both types of corn are complementary and the second that they are substitutes.

Under the first approach, the MB is used primarily for human consumption, which is transformed for the preparation of inputs for food and contributes to food security, while the MA is used for the manufacture of balanced feed for livestock and use industrial (SIAP, 2007), therefore, in this sense both types of corn are not replaced, but could be described as complementary.

According to FIRA (2015), in 2014, 23.27 million tons of corn were produced in Mexico, of which 10.4% of the total production represents the MA, while 89% of the production represents the MB, the latter highlighting the almost self-sufficiency for the country and main producer in the world.

Regarding exports, Mexico in the period 2005-2016 exported 3.5 million tons of corn, of which 99.6% were MB destined mainly to Venezuela, El Salvador, the United States of America, Colombia and South Africa; while 0.4% were from MA consigned to the United States of America, Canada, Cuba, the United Kingdom and Denmark (Table 1).

Table 1. Maize exports to various countries, 2005-2016.

Year	Thousands of tons				
	White corn	(%)	Yellow corn	(%)	Total
2016*	199.5	99.4	1.2	0.6	201
2015	711.9	99.2	5.5	0.8	717
2014	371.6	97.8	8.4	2.2	380
2013	553.5	100	0.1	0	554
2012	465.4	100	0	0	465
2011	28.9	99.8	0.1	0.2	29
2010	548.6	100	0	0	549
2009	277.7	100	0.1	0	278
2008	52.6	100	0	0	53
2007	212.5	100	0.1	0	213
2006	58.5	99.9	0	0.1	59
2005	18.2	99.9	0	0.1	18

*= January-May. Source: SIAVI (2016). White corn: fraction 1005.90.04. Yellow corn: fraction 1005.90.03.

On the other hand, imports for the same period were 99.7 million tons of corn, of which 92.5% correspond to MA from the United States, Brazil, Argentina, Canada and Belize, while 7.5% correspond to MB originating in the United States of America, Mozambique and South Africa, ratifying that Mexico is a net importer of MA (Table 2).

Table 2. Maize imports from various countries, 2005-2016.

Year	Thousands of tons				
	White corn	(%)	Yellow corn	(%)	Total
2016*	540.5	8.7	5 643.7	91.3	6 184
2015	896.4	7.4	11 156.1	92.6	12 052
2014	811.6	7.9	9 514.3	92.1	10 326
2013	511.5	7.2	6 573.8	92.8	7 085
2012	1 377.2	14.6	8 076.9	85.4	9 454
2011	1 466.6	15.6	7 944.1	84.4	9 411
2010	504.3	6.5	7 270.9	93.5	7 775
2009	162.9	2.3	7 044.7	97.7	7 208
2008	479	5.3	8 611.8	94.7	9 091
2007	346.7	4.4	7 561.7	95.6	7 908
2006	288.7	3.8	7 278.3	96.2	7 567
2005	92	1.6	5 614.8	98.4	5 707

*= January-May. Source: SIAVI (2016). White corn: fraction 1005.90.04. Yellow corn: fraction 1005.90.03.

In addition, the import of MA affects the producer price in Mexico of MB (and that of MA), causing a downward effect on the domestic price of corn, determining that the MA and the MB are implicitly substitutes under the second approach (Contreras, 2008; García *et al*., 2011; Martínez and Hernández, 2012; Moreno *et al*., 2016).

In order to recognize the degree of substitution between MA and MB, the present work estimates the elasticity of substitution between both types of corn. The main hypothesis to be tested is that the elasticity of substitution between MA and MB is equal to zero.

Methodology

The elasticity of substitution is a concept originally introduced by Hicks (Binger and Hoffman, 1998), it establishes the proportional change in the ratio of quantities for the proportional change in the price ratio:

$$\sigma_{ij}=\frac{d\ln(Q_i/Q_j)}{d\ln(P_j/P_i)}$$

This is a measure of the degree of curvature of an indifference curve, by detecting the speed at which Q_i is changed by Q_j when P_j rises relative to P_i. When two goods are substitutes γ_{ij} is delimited by $(0, \infty)$, a substitution elasticity of 0 implies that the goods Q_i and Q_j are foreign or are simply not substitutes, they can also be referred to as complements (Varian, 2010). On the other hand, if σ_{ij} is infinite this implies perfect substitution. In an empirical situation, it may turn out that σ_{ij} is negative, this indicates absence of substitution or that there are complementary goods.

Table 3 shows the information obtained from SIAP regarding prices and quantities of corn by variety, the price of yellow corn is on average approximately 7% lower than the price of white corn; likewise, the amount of white corn is on average 85% of the total production for both varieties. What sustains that the corn market in Mexico is dominated by white corn.

Table 3. Quantities and prices of corn, 2000-2014.

Year	Production		Price	
	Yellow corn (QA)	White corn (QB)	Yellow corn (PA)	White corn (PB)
2000	228 289.5	1 137 542.98	1 088.35	1 182.14
2001	366 294.38	3 796 629.88	1 284.98	1 197.13
2002	726 590.61	5 553 312.86	1 478.91	1 370.3
2003	631 547.97	7 883 570.01	1 465.4	1 578.65
2004	1 061 330.33	20 508 488.38	1 544.79	1 683.86
2005	1 330 127.71	17 961 283.54	1 400.05	1 589.52
2006	1 718 291.85	20 060 877.16	1 876.72	2 018.13
2007	1 574 675.11	21 777 449.4	2 100.23	2 462.66
2008	1 573 914.77	22 719 396.07	2 856.74	2 813.78
2009	1 713 432.11	18 332 643.86	2 482.94	2 831.49
2010	2 018 369.72	21 165 671.44	2 587.74	2 837.45
2011	1 692 409.67	15 873 783.26	3 877	4 100.87
2012	1 765 571.02	20 179 483.2	3 765.56	4 029.38
2013	2 230 190.14	20 296 176.06	3 058.23	3 398.82
2014	2 422 715.12	20 710 883.68	2 751.74	3 157.99

Source: SIAP (2015).

The substitution approach is generally approached through an aggregate function, for example, that of constant substitution elasticity (Berndt, 1976; Caddy, 1976). However, in the present case, the total of 15 observations obtained is limited, which prevents the estimation of the elasticity of substitution through econometric methods with an aggregate function. Therefore, a direct calculation of the quotient of logarithmic differentials was implemented in the following way:

$$\hat{\sigma}_{ab} = \frac{Ln\left(Q_a/Q_b\right)_t - Ln\left(Q_a/Q_b\right)_{t-1}}{Ln(P_b/P_a)_t - Ln(P_b/P_a)_{t-1}}$$

Where: $\hat{\sigma}_{ab}$ is the elasticity of substitution of yellow corn for white of period t-1 to t, $\mathrm{Ln}(Q_a/Q_b)_t - \mathrm{Ln}(Q_a/Q_b)_{t-1}$ is the percentage change in the ratio of quantities between period t and t-1, $\mathrm{Ln}(P_b/P_a)_t - \mathrm{Ln}(P_b/P_a)_{t-1}$ is the percentage change in the price ratio between period t and t-1. Note that in this way, we obtain a point estimator of the substitution elasticity $\hat{\sigma}_{ab}$ for 2 periods of yellow corn for white corn, with the purpose of having a global estimator, we take the arithmetic average of the adjacent logarithmic differentials per period. Also, note that $\hat{\sigma}_{ab} = \hat{\sigma}b_{ba}$; that is, the elasticity of substitution is a measure that expresses symmetry, therefore, the elasticity of substitution of MA per MB is the same as that of MB per MA.

For the first case, we have a variation period by period, the interest is to measure the distance of the average with respect to 0, this is done using a test of t under the null hypothesis that the elasticity of substitution is 0; that is, the following hypothesis set is contrasted:

$$\text{Ho: } \sigma_{ab}=0$$
$$vs$$
$$\text{Ha: } \sigma_{ab}\neq 0$$

A second form of estimation was obtained from the following regression (Battese and Sohail, 1976; Kwan, 2007):

$$\mathrm{Ln}(Q_a/Q_b)_t = \theta_0 + \theta_1 d\ln(P_b/P_a)_t + \varepsilon_t$$

For this case, θ_1 is the estimator of the elasticity of substitution, where both the value of the point estimator of θ_1 and the contrast of the following set of hypotheses are interesting:

$$\text{Ho: } \theta_1=0$$
$$vs$$
$$\text{Ha: } \theta_1\neq 0$$

The estimate of $\theta_1$was obtained through ordinary least squares, while the aforementioned hypothesis test was performed with the t statistic (Greene, 2004).

Results

For the first case, the direct estimation of the estimated elasticity of substitution was obtained a point value of -7.5163, with an estimated deviation of 18.1446 and a t-statistic of -0.4142 for the set of hypotheses referred to. For the second case, the minimum quadratic estimate of the substitution elasticity estimator resulted in -0.8466 with a standard deviation of 0.902, resulting in a hypothesis of t-statistics of -0.9386 for the hypothesis set.

In both cases the null hypothesis is not rejected, that is, the elasticity of substitution from MA to MB is equal to zero. Regarding the probability value, this is 0.6854 and 0.3651 respectively, where a value higher than 0.05 is confirmed, which does not reject the null hypothesis and therefore its elasticity is equal to zero (Table 4). These results from a point of view between the use of yellow corn and white corn, allow concluding with the available data of MA and MB that these show a

behavior of complementary goods. On a non-agricultural level (Kwan, 2007), it obtains positive substitution elasticities for private consumption and government consumption for East Asian countries, positive and high substitution elasticities are obtained by (Papageorgiou *et al*., 2013) for productive inputs.

Table 4. Elasticity of substitution of yellow corn and white corn.

Estimator	Standard deviation	Value of t	Value of p
-7.5163*	18.1446	-0.4142	0.6854
-0.8466**	0.902	-0.9386	0.3651

*= direct estimator; **= regression estimator.

According to the above, it is reaffirmed that the approach where the two varieties of corn are complementary, so the result encourages to deepen what is found with respect to the price depressant effect of corn imports, being these predominantly in MA. That is, the effect of imports primarily of MA have an effect on the domestic price of domestic MA, the effect on the price of MB is uncertain given the complementarity of varieties found here. Therefore, the effect of imports on the domestic corn price may refer to an effect on the average price of both types of corn.

Conclusions

It is necessary to have more data to give a robust answer to the problem of elasticity of substitution from MA to MB, with the available data of quantity and price it is concluded that both types of corn are characterized as complementary. This makes it imperative to refocus the problem of imports of corn and its effect on the domestic price of the same. If both types of corn are complementary and MA is primarily imported, then how is this transferred to the MB price.

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