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Article

Determinants of corn demand in Mexico, 1970-2020

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Abstract

Corn is one of the most demanded agricultural products due to its importance in the human nutritional diet and the livestock sector and because it is the raw material for more than four thousand products. In 2020, Mexico ranked fourth worldwide in the consumption of this grain. In the 1970-2020 period, corn's demand and production had an average annual growth rate (AAGR) of 3.03% and 2.28%. Corn imports were used to satisfy the demand; these had an AAGR of 6.27%. The objectives were to identify the main variables that determine the demand for corn grain in Mexico and to evaluate the sensitivity of the quantity demanded to changes in exogenous variables. Annual data were used in the estimation of three multiple linear regression models. The determinants of demand were analyzed through the magnitude and sign of the elasticities. The results showed that the demand for corn is inelastic; the price elasticities were -0.7529, -0.7994, and -0.7552. The income elasticities were 0.516, 0.3007, and 0.5016; therefore, the corn grain was classified as a necessary normal good. The cross-price elasticity with respect to the price of beans was -0.0871; this grain was cataloged as weak complementary. The cross elasticities with respect to sorghum (0.1079), rice (0.2568), and wheat (0.1755) showed that there is a weak substitution of corn with these products. The models and elasticities were congruent and consistent with the theory of demand; in addition, appropriate and statistically significant forecasts were obtained.

Keywords:

consumption, elasticities, multiple linear regression.

Introduction

Corn is one of the most important cereals in the world; it supplies nutrients to humans and animals and is a basic raw material for the industry (ASERCA, 2018). It is a fundamental crop for Mexico due to the levels of production it reaches, its consumption, the impact on agricultural imports, and its presence in the production of more than four thousand products (CEFP, 2007). Globally, yellow corn has the largest sown area and production.

In contrast to Mexico, where white corn ranks first, its production fully meets national demand and its main use is for human consumption. The supply of yellow corn covers 24% of the national requirements (SIAP, 2019) and is destined for the livestock and industrial sector (CEFP, 2007).

In 2020, the United States of America was the leading producer, exporter, and consumer of corn in the world. China consolidated its position as the second largest global producer and consumer. Mexico was the leading importer of corn, ranked seventh in production and fourth in consumption (FAO, 2022). From 1970 to 2020, apparent corn consumption had an average annual growth rate (AAGR) of 3.03%, from 9.64 to 43.06 million tonnes.

In this period, national production did not increase at the same rate as consumption, it grew from 8.87 to 27.42 million tonnes, at a AAGR of 2.28%. To meet the demand, it was necessary to resort to importing grain corn, which presented a AAGR of 6.27%. In 2020, about 37% of the corn consumed was imported. In developing countries, demand for cereals has grown faster than production over the past three decades (FAO, 2021). In Mexico, corn consumption has been sensitive to international trade policy, where the main effect has been reflected in prices.

The corn market became in deficit at the end of the 1980s; since then, imports from the United States of America have shown an increasing trend (CEFP, 2007). With trade opening due to the North American Free Trade Agreement (NAFTA), there were differences in prices. Mexico had a higher price in basic products such as: corn, beans, sorghum, wheat, and rice. Low prices in other countries caused imports of these products to grow (Martínez and Hernández, 2012).

Starting in 2013, China’s agricultural and trade policies focused on protecting its corn producers through production subsidies, government purchases, and import restrictions. This resulted in China demanding less grain from the United States of America. This created a surplus of grain, therefore causing international corn prices to decline, which caused Mexico to increase imports of this cereal (Tran *et al*., 2015).

Most of the corn imported into Mexico corresponded to the yellow variety, the demand of which showed sustained growth in the period that covered the production cycles from 2012-2013 to 2020-2021 (Araujo, 2022). Dependence on imports has placed the country in a vulnerable situation (Massieu and Lechuga, 2002). According to FAO (2022) data, global demand will grow steadily, driven by fodder, human, and industrial consumption. Related studies relied on econometric models and market theory to explain the demand for corn.

The research carried out by Pérez and Venegas (2017) on the impact of bioethanol production on the prices of agricultural products in Mexico. From the application of an almost ideal demand system, they estimated Marshallian and Hicksian elasticities. The price elasticities of corn were inelastic in both methodologies. A study conducted by Anindita *et al*. (2022) on the demand for carbohydrate-based foods in households used an almost ideal demand model of linear approximation.

It was found that demand is determined by price, income, and the number of household members; likewise, corn turned out to be an inelastic good. Reyes *et al*. (2022) analyzed the corn market in Mexico through simultaneous equations. Regarding the demand model, the variables used were income and consumer prices of corn and beans.

The results showed that the demand for corn responds inelastically to the variation in its price and that beans are a complementary good. Bautista *et al*. (2019) evaluated the effect of PROAGRO and NAFTA on corn self-consumption using a simultaneous equation model. The quantity demanded was modeled based on disposable income, human population, and consumer prices of corn and beans.

It was found that demand is inelastic in relation to price, corn was a necessary normal good, and beans were complementary. Egwuma *et al*. (2019) conducted a study on the factors influencing the supply and demand of corn in Nigeria for the period 1995 to 2017. They used an autoregressive distributed lag model, where the main determinants of demand were the retail price of corn, the retail price of sorghum, and per capita income.

They found that the demand for corn is inelastic and that sorghum is a substitute good. Moreno *et al*. (2016) studied Mexico's dependence on corn imports since the entry into NAFTA. The demand for the grain was modeled according to price, income, population, and a dichotomous variable for the period of trade liberalization. The results showed that the domestic market depends on the expected price and income.

Therefore, the objective was to identify and analyze the variables that determine the demand for grain corn in Mexico from 1970 to 2020. It was hypothesized that the variables that influence the quantity demanded of corn are its price, disposable income, human population, and the prices of rice, beans, sorghum, and wheat. Similarly, it was considered that the demand for corn can be affected by national and international agricultural policies.

Materials and methods

This research focused on analyzing the demand for corn in Mexico from 1970 to 2020 through the fitting of three multiple linear regression models, which include the variables specified by economic theory. According to Tomek and Kaiser (2014), the determinants that influence the quantity demanded are: the price of the product, demographic factors such as the size of the population, economic factors such as income and its distribution, prices, and availability of other products.

Consumer tastes and preferences that can be influenced by levels of education, life experiences, information, and advertising. The formulation of the models was based on previous studies and demand theory. A model with nine independent variables was estimated; nevertheless, not all of them were significant. The solution was to develop three models, where the quantity demanded as a function of its own price and income was considered as a basis. On the other hand, the variables corresponding to population, prices of related goods, and dichotomic variables were distributed among the three models.

The functional form in models one and two was linear, while the third was log-log. The mathematical form of the models is presented below:

model 1:

$$QDC_t = \beta_0 + \beta_1 RWPC_t + \beta_2 RNY_t + \beta_3 POP_t + \beta_4 RWPB_t + \beta_5 RWPR_t + \beta_6 D1_t + e_i.$$

Model 2:

$$QDC_t = \beta_7 + \beta_8 RWPC_t + \beta_9 RNY_t + \beta_{10} POP_t + \beta_{11} RWPW_{tt} + \beta_{12} D1_t + \beta_{13} D2_t + e_i$$

Model 3:

$$Log(QDC_t) = \beta_{14} + \beta_{15} Log(RWPC_t) + \beta_{16} Log(RNY_t) + \beta_{17} Log(RWPS_t) + e_i$$

Where: QDC_t = quantity demanded of grain corn (tonnes); $RWPC_t$ = real wholesale price of corn (pesos per tonne); RNY_t = real national disposable income (billions of pesos); POP_t = population (inhabitants); $RWPB_t$ = real wholesale price of beans (pesos per tonne); $RWPR_t$ = real wholesale price of rice (pesos per tonne); $RWPW_t$ = real wholesale price of wheat (pesos per tonne); $RWPS_t$ = real wholesale price of sorghum (pesos per tonne); $D1_t$ = dichotomous variable 1 (Covid-19 pandemic period); $D2_t$ = dichotomous variable 2 (protectionist policies applied by China); β_0, β_1, β_2,…,β_{17}, regression coefficients; e_i = error terms.

In Mexico, the quantity demanded of corn (QDT_t) is not reported; instead, an approximation was made through the apparent national consumption (ANC_t) of this grain.

$QDT_t = ANC_t = DP_t + IMP_t - EXP_t$; where domestic production (DP_t), imports (IMP^t) and exports (EXP_t) of grain corn were obtained from FAO (2022). The annual human population of Mexico was consulted in the World Bank (2022a).

Income was estimated as follows: the gross domestic product (GDP), information obtained from the World Bank (2022b), was transformed into Mexican pesos through the exchange rate, which was taken from BANXICO (2022a). The national consumer price index (INPC, for its acronym in Spanish) was obtained from BANXICO (2022b). Information on wholesale prices of the following five agricultural products was used: corn, beans, sorghum, rice, and wheat, which came from Salís (1990); INEGI (2009); CEDRSSA (2020); SNIIM (2022).

The monetary variables were deflated with the INPC base second half of July 2018. The first dichotomous variable took a value of 0 from 1970 to 2019 and a value of 1 for the pandemic period in Mexico; that is, from 2020 onwards. The second dichotomous variable took value from 0 from 1970 to 2012 and 1 during the effect of China's protectionist policy (2013-2020).

Once the multiple linear regression models were defined, the coefficients were estimated. According to Gujarati and Porter (2010), regression analysis deals with the study of the dependence of a dependent variable on one or more explanatory variables, with the aim of generating the average value of the former in terms of the known values of the latter.

It is expressed in matrix form as follows $y= X\beta+\varepsilon$;; where: y= column vector n × k of observations on the dependent variable Y; X = data matrix n × k, with *n* observations on the k - 1 variables X_1 to X_k, and the first column of numbers 1 represents the term of the intercept; β = column vector k × 1 of unknown parameters β_1, β_2 ,..., βk; β= column vector n × 1 of disturbances ε_i.

To estimate the parameters of the regression model, the ordinary least squares method was used: $\hat{\beta}= (X'X)^{-1}X'y$, in addition to meeting the assumption of $\varepsilon_i \sim N(0,\sigma^2)$. The above provides a compact method to analyze and obtain the solution of linear regression models with any number of variables. Hypothesis testing constituted the second part of the regression analysis.

The p-value is the exact probability of obtaining the estimated test statistic according to the null hypothesis. α is set at some level of significance and the null hypothesis is rejected if the *p*-value is less than α (Gujarati and Porter, 2010). The following criteria were considered in the statistical analysis: the probability value (value of $p > 0.05$) to test the hypotheses of the regression model assumptions. The calculated F criterion was used to assess the overall significance of the model.

In the individual significance of the parameters, the t-statistic was used. The models with the highest adjusted R^2 were chosen. To find the presence of autocorrelation in the models, the *d*-statistic of Durbin-Watson was used. The White test and the Breusch-Pagan test were used to detect heteroskedasticity. To check the normality of the residuals, the Shapiro-Wilk and Kolmogorov-Smirnov tests were used.

The estimated models were validated based on the signs of each parameter, in accordance with what was established by economic theory. Once the determinants of demand had been defined, it was necessary to know by what magnitude the quantity demanded increases or decreases when one of its determining factors varies, *ceteris paribus*. The magnitude of such changes is measured with the so-called coefficient of elasticity.

According to García *et al*. (2003), the price elasticity of demand (E_p) is a relationship that expresses the percentage change in the quantity demanded of a product per unit of time associated with a percentage change in the price of the product when other factors are kept constant. When the function is known, it is expressed as follows:

$$E_p=\frac{\partial Q_i}{\partial P_i}*\left[\frac{\bar{P}_i}{\bar{Q}_i}\right]$$

The income elasticity of demand coefficient (E_I) measures the percentage change in the quantity demanded of a good per unit of time as a result of a given percentage change in consumer income, *ceteris paribus*. When the function is known:

$$E_I = \frac{\partial Q}{\partial I} * \left[\frac{\bar{I}}{\bar{Q}}\right]$$

The cross elasticity of demand coefficient (E_{ij}) measures the percentage change in the quantity demanded of a given good (i) given a percentage change in the price of a related good (j), *ceteris paribus*. When the demand function is known:

$$E_{ij} = \frac{\partial Q_i}{\partial P_j} * \left[\frac{\bar{P}_j}{\bar{Q}_i}\right]$$

In the log-log model, all variables are expressed in logarithmic form. The regression coefficient associated with the logarithm of an independent variable is interpreted as elasticity (Gujarati and Porter, 2010). The PROC REG, PROC AUTORREG, and PROC UNIVARIATE procedures of the Statistical Analysis System version 9.4 software (SAS Institute, 2014) were used in the fitting of the models and in the verification of the basic assumptions.

Results and discussion

The results of the first model are presented in Table 1. The signs of the estimated coefficients are consistent with demand theory. The parameters of the variables $RWPC_t$, RNY_t, $RWPB_t$ and $D1_t$ were significant at a confidence level of 95% (0.05), the variables POP_t and $RWPB_t$ were also considered since the *t*-value was greater than one, as well as to comply with the correct specification of the model.

Table 1. Estimated parameters for the first linear model of grain corn demand in Mexico, 1970-2020.

	Intercept	$RWPC_t$	RNY_t	POP_t	$RWPB_t$	$RWPR_t$	$D1_t$	
Parameter	14577725	-2329.51	896.659	0.09708	-84.6132	272.3908	7634108	
t-value	1.89	-4.43	4.44	1.44	-1.98	3.58	3.09	
Pr > |t|	0.0649	<0.0001	<0.0001	0.156	0.0544	0.0009	0.0034	
F-value								<0.0001
R^2								0.9624
Adjusted R^2								0.9573

Model 1. $RWPC_t$= real wholesale price of corn; RNY_t= real national disposable income; POP_t= population; $RWPB_t$= real wholesale bean price; $RWPR_t$= real wholesale price of rice; and $D1_t$= dichotomous variable 1.

The model presented an F= 187.84 (F< 0.0001), which indicates that the independent variables included in it correctly explain the dependent variable. The coefficient of determination indicates that 96.24% of the variation of the dependent variable is explained by the independent variables.

After estimating the parameters, the basic assumptions of the multiple linear regression model were verified. In the first model, the Durbin-Watson statistic was 2.07, with a *p*-value= 0.77, which affirms that there is no autocorrelation in the residuals. White's heteroskedasticity contrast presented a *p*-value= 0.25, which indicates that the residuals are homoscedastic. In the Shapiro-Wilk normality statistic, a *p*-value= 0.2025 was obtained; that is, the residuals come from a normal distribution.

The results of the structural form of the second model are shown below (Table 2). It was observed that the signs of the estimated parameters are those expected based on economic theory. The global significance test was significant, presenting an F= 294.96 (F< 0.0001). The coefficient of determination indicates that 97.57% of the independent variables explain the dependent variable.

Table 2. Estimated parameters for the second linear model of grain corn demand in Mexico, 1970-2020.

	Intercept	$RWPC_t$	RNY_t	POP_t	$RWPW_t$	$D1_t$	$D2_t$	
Parameter	22756225	-2473.208	522.4323	0.0607	781.8638	7181357	5725541	
t-value	3.79	-5.56	2.96	1.16	2.48	3.61	5.77	
Pr> |t|	0.0005	<0.0001	0.005	0.2537	0.0171	0.0008	<0.0001	
F-value								<0.0001
R^2								0.9757
Adjusted R^2								0.9724

Model 2. $RWPC_t$= real wholesale price of corn; RNY_t= real national disposable income; POP_t= population; $RWPW_t$= real wholesale price of wheat; $D1_t$= dichotomous variable 1; $D2_t$= dichotomous variable 2.

Regarding the significance of each parameter (t-test), six of the seven regression coefficients were significant at 95% (p> 0.05), the POP_t variable was not significant, but its t-value was greater than one. The above results show that model two has the best fit compared to models one and three.

In model two, the Durbin-Watson statistic was d= 1.9422, with a p-value= 0.8502, which indicates that there is no autocorrelation. The Breusch-Pagan heteroskedasticity contrast generated a p-value= 0.06, concluding that the residuals do not present heteroskedasticity. In the Shapiro-Wilk normality test, a p-value= 0.3296 was obtained, it is stated that the residuals come from a normal distribution, which denotes high reliability of the data.

Table 3 shows the results of the log-log model. The estimated parameters had the expected signs. The F-value= 277.98 (F< 0.0001) denotes that the model is significant; this indicates that the variables included in the model adequately explain the demand for corn. In the t-test, the regression coefficients were significant at a level of 0.05 ($LRWPC_t$ and $LRNY_t$) and 0.1 ($LRWPS_t$). The coefficient of determination shows that 94.32% of the variation in the dependent variable is described by the independent variables.

Table 3. Estimated parameters for the log-log model of grain corn demand in Mexico, 1970-2020.

	Intercept	$LRWPC_t$	$LRNY_t$	$LRWPS_t$	
Parameter	16.7415	-0.75522	0.50164	0.10789	
t-value	8.86	-5.63	7.23	1.86	
Pr > |t|	<0.0001	<0.0001	<0.0001	0.0695	
F-value					<0.0001
R^2					0.9466
Adjusted R^2					0.9432

Log-log model. $LRWPC_t$= logarithm of the real wholesale price of corn; $LRNY_t$= logarithm of real national disposable income; $LRWPS_t$= logarithm of the real wholesale price of sorghum.

The Durbin-Watson statistic was d= 2.0482 with a p= 0.3414, so it is verified that there is no autocorrelation. White's heteroskedasticity contrast presented a p= 0.0573, which indicates that the model does not show heteroskedasticity problems. In the normality test, the Kolmogorov-Smirnov statistic was used, a D= 0.1216 with a p= 0.0587 was obtained, this value denotes that the residuals fit a normal distribution.

Based on the multiple regression analysis, statistically significant models consistent with demand theory were created, which allowed the generation of one-year predictions (Table 4). It was observed that the percentage difference in absolute terms between the value reported by the official statistics and the estimated one is less than 5%, which shows that the predictive capacity of the three models is acceptable. Models one and two overestimated demand, while model three

Table 4

Comparison between the observed and the estimated values of the demand for corn in Mexico.

Model	Observed value 2021*	Estimated value 2021	Percentage difference
Model 1	43 403 477.82	44 046 898.17	1.48%
Model 2	43 403 477.82	43 770 629.36	0.85%
Model 3	43 403 477.82	41 247 270.27	4.97%

Prediction of the models. *= FIRA (2022).

The magnitude of the estimated parameters was complemented with the calculation of elasticities. Table 5 shows that the elasticities presented the expected sign. The corn price elasticities were -0.753, -0.7994, and -0.7552 for models 1, 2, and 3, respectively. According to García *et al*. (2003), values less than one classify the product as inelastic.

Table 5

Elasticities of corn demand in Mexico 1970-2020.

Independent variable	Model 1 (Linear)	Model 2 (Linear)	Model 3 (Log-log)
$RWPC_t$	-0.753	-0.7994	-0.7552
RNY_t	0.516	0.3007	0.5016
$RWPB_t$	-0.0871		
$RWPR_t$	0.2568		
$RWPW_t$		0.1755	
$RWPS_t$			0.1079
POP_t	0.4001	0.2505	

Based on the coefficients of the estimated models. $RWPC_t$= real wholesale price of corn; RNY_t= real national disposable income; $RWPB_t$= real wholesale price of beans; $RWPR_t$= real wholesale price of rice; $RWPW_t$= real wholesale price of wheat; $RWPS_t$= real wholesale price of sorghum; POP_t= population.

The price elasticity of the third model indicates that, if the wholesale price of corn increased by 10%, the quantity demanded would decrease by 7.55%, *ceteris paribus*. Similar results were estimated by Pérez and Venegas (2017), who reported a price elasticity of -0.799. Reyes *et al*. (2022) found an elasticity of -0.78. Anindita *et al*. (2022) obtained an elasticity of -0.964. When comparing the elasticities of this study with those of other authors, it is stated that the coefficients obtained in this research are within the expected magnitude.

Income elasticities were 0.516, 0.3007 and 0.5016. In the first model, the elasticity calculated was 0.516, which implies that in the face of a 10% increase in national disposable income, the demand for grain corn would increase by 5%, *ceteris paribus*. According to García *et al*. (2003), goods that have a positive income elasticity less than one are classified as necessary normal goods.

These results coincide with those of Bautista *et al*. (2019), who obtained an elasticity of 0.4. The income elasticity estimated by Vargas (2017) was 0.42. The magnitude of income elasticity was consistent with the demand theory; likewise, the above studies agree that grain corn is a necessary normal good. The cross elasticity with respect to the price of beans was -0.0871; this value indicates that in the event of a 10% increase in the wholesale price of beans, the demand for corn would decrease by 0.87%, *ceteris paribus*.

The cross elasticity was less than zero, which classifies beans as a complementary product of corn. A study by Retes *et al*. (2013) found a cross elasticity of the demand for corn tortillas with respect to the price of beans equal to -0.29. Reyes *et al*. (2022) reported a cross-elasticity coefficient of corn with respect to beans equal to -0.23; likewise, Bautista *et al*. (2019) obtained an elasticity of -0.3. underestimated it. The second model presented the best fit and prediction; the difference between the observed and predicted demand was equivalent to 0.36 million tonnes.

The above studies agree on the sign of elasticity. According to SADER (2019), beans and corn are complementary products, which have been an important part of both the Mexican diet and economy since pre-Hispanic times to the present day. The cross elasticity with respect to the price of rice was 0.2568, which indicates that for every 10% increase in the wholesale price of rice, the quantity demanded of corn increases 2.56%, *ceteris paribus*.

The estimated elasticity showed a substitution relationship between corn and rice. The elasticities reported by Retes *et al*. (2013) of corn tortillas with respect to rice were 0.06 and 0.08; Anindita *et al*. (2022) obtained an elasticity of corn with rice equal to 0.0357. The magnitude of the elasticities of other studies is lower than that estimated in this research; however, they all affirm that there is a substitution between these grains.

The cross-price elasticity of the demand for corn with respect to the price of wheat was 0.1755; therefore, these products are classified as substitutes. This finding coincides with that of Retes *et al*. (2013), who reported an elasticity that links the price of corn tortillas with wheat bread equal to 0.18; for their part, Anindita *et al*. (2022) obtained a cross elasticity of corn with wheat equal to 0.0352.

The previous studies agree that there is a substitution relationship between these cereals and in the products derived from them. According to SADER (2019), the country's industrial development will demand corn and wheat in increasing quantities, either to manufacture food or to transform it into various non-food products.

The magnitude of the cross elasticity with respect to the price of sorghum was 0.1079; this elasticity is notoriously lower than that reported by Egwuma *et al*. (2019), whose value was 0.57; likewise, in a study carried out by Carbajal *et al*. (2018), they obtained a cross elasticity of 0.43. With the above, the substitution relationship between corn and sorghum is verified; nonetheless, in this study, it was expected that the magnitude of the elasticity would be greater since, in recent years, Mexico has substituted a large part of its sorghum imports with corn to meet the growing demand for balanced feed by the livestock sector.

The estimated elasticities for the human population were 0.4001 and 0.2505; this variable has a direct effect on grain consumption. These results are close to those obtained by Bautista *et al*. (2019), where the elasticity that relates the quantity demanded of corn with the population was 0.2. The increase in population has increased the demand for corn for human consumption through the consumption of tortillas (Moreno *et al*., 2016).

On the other hand, population growth and urbanization bring with them a growth in the consumption of animal products, which has caused a part of the fodder grains to be destined for the livestock sector (Massieu and Lechuga, 2002). The dichotomous variables D1 and D2 were significant. This was due to the economic impact of the Covid 19 pandemic and Mexico's susceptibility to international agricultural policies.

The effect of China's protectionist policy was a reduction in the international price of corn, which had an impact on increased imports (Tran *et al*., 2015). From 2013 onwards, the dichotomous variable D2 allowed capturing the increase in corn imports, resulting in the substitution of sorghum by corn. According to FAO (2022) data, between 2013 and 2020, imports went from 7.1 to 15.9 million tonnes.

The greatest impact of the pandemic occurred in 2020 and 2021, which was modeled with the dichotomous variable D1. According to data from SNIIM (2022); FAO (2022), this event caused a 48% increase in the price of grain, which resulted in demand not growing and remaining stable at around 43 million tonnes.

The variation in the values of the elasticities of this research, compared to other studies, is due to the use of different time periods. The estimated elasticities were similar to those reported in other studies, all signs were in accordance with what was established by the demand theory. This made it possible to meet the objective of analyzing the determinants of corn demand.

Conclusions

The results obtained from the multiple linear regression models show that the determinants that explain the variation in the quantity demanded of corn in greater proportion are the price of corn, income, and population. The demand for corn responded inversely and inelastically to its price; income had a direct effect, so it is considered a necessary normal good.

Sorghum, wheat, and rice were found to be weak substitute products for corn, while beans behaved as weak complementary. The models and elasticities were congruent and consistent with the theory of demand, and appropriate and statistically significant forecasts were obtained.

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