ASSOCIATION BETWEEN THE INCREASE IN THE PRICE OF PANELA AND ETHANOL PRODUCTION FROM 2000 TO 2017 IN VALLE DEL CAUCA

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ABSTRACT

This study determines the degree of association between the increase in the price of panela and ethanol production, from 2000 to 2017, in the department of Valle del Cauca. The material used in the research was divided into two segments. The first segment, a bibliographic one, used databases such as Google Scholar, ScienceDirect, and Scopus. The second segment used statistical data with databases such as the consumer price index provided by DANE and the ethanol production level provided by Asocaña. The method used in the research focused on the error correction model. The most relevant result obtained in the model is that for every 1% increase in ethanol production, the price of panela increases by 0.231025%. Finally, the most relevant conclusion is that there is a rivalry for sugarcane due to the increase in ethanol production, which is generating an increase in the final price of panela, because it is a food commodity.

Keywords: Biofuel, Ethanol, Panela, Sugar, Food Security

INTRODUCTION

Historically, biofuels date back to the late nineteenth century, pioneered by the German engineer Nikolaus Otto who integrated ethanol as fuel in one of his engines. Later, Henry Ford, in 1908, installed an engine that ran on a mixture of ethanol and gasoline in his very well-known Model T. The biggest boom of ethanol developed during the Second World War, when there was little access to oil, and ethanol was used as an alternative.

The impact of ethanol on the increase of food prices is relatively new. Authors such as Rosegrant (2008); Gorter, Drabik & Just (2013); Gorter, et al., (2013) have shown the relationship between the increase of land use for ethanol production and its impact on global food prices. Therefore, this study aims to determine the degree of association between the increase in the price of panela and ethanol production, from 2000 to 2017, in the department of Valle del Cauca. The specific goals to reach the general purpose are, first, to identify the characteristics of ethanol production in Valle del Cauca during 2000–2017, second, to identify the characteristics of panela price behavior in Valle del Cauca for 2000–2017, and finally, to determine the degree of association between the behavior of ethanol and panela prices.

The article comprises four sections presented below: The first one presents the theoretical framework, a bibliographic review of the background of international and national research on the topic of biofuels, ethanol, and food security, as well as the economic theory linked to the research topic. The second section presents the econometric methodology of the Error Correction Model (ECM), the third one compiles the results in relation to the goals set in the research work, and lastly, the fourth section outlines the final conclusions of the article.

Citation Information: Calderón, D.F.V., Melenje, E.L.S., & Pérez, J.F.B. (2021). Association between the increase in the price of panela and ethanol production from 2000 to 2017 in Valle del Cauca. *Journal of Management Information and Decision Sciences, 24*(S6), 1-9.

THEORETICAL FRAMEWORK

The study of biofuels, especially ethanol and their association with food prices, has had little relevance in Colombia because the country's production is relatively new compared to that in other countries, such as the United States and Brazil, which are the world's leading producers. International studies conducted by De La Torre Ugarte, et al., (2000); Lazear (2008); Razo, et al., (2007); Zhang, et al., (2010) on the increase in food prices and the link between the increase in the price of panela and ethanol production have shown that ethanol is causing a shift in crops that were historically used for human consumption toward their current use in ethanol production. This generates an increase in food prices for consumers, especially food related to the cultivation of sugarcane and its derivatives. The study conducted by Giraldo, Arango & Martínez (2014) in Colombia has reached the same conclusion regarding the increase in food prices, especially those related to sugarcane.

Regarding the increase in food prices, it is important to analyze the most widely consumed food in poor households in Colombia, such as panela, not only because of its sweetening properties but also because of its high caloric level (Mascietti, 2014). Colombia is the second largest panela producer in the world only after India, which is in the first place. Moreover, Colombia is the world's leading consumer (Orjuela, Huertas, Figueroa, Kalenatic & Kadena, 2011).

Table 1
PER CAPITA CONSUMPTION (KG/YEAR) IN THE SOCIOECONOMIC STRATA AND THEIR PREFERENCES BETWEEN PANELA VERSUS SUGAR FOR THE YEAR 1990

Socioeconomic Stratum	Panela	Sugar
Low	20,92	18,44
Medium	17,30	21,40
High	13,64	34,91
Weighted Average	18,22	21,69

Source: Rodriguez, et al., (2004)

Therefore, households with unsatisfied basic needs consume more panela compared to households with a lower level of unsatisfied basic needs, which prefer to consume refined sugar, as shown in Table 2.

Table 2
PER CAPITA CONSUMPTION OF PANELA *VS*. SUBSTITUTES SUCH AS HONEY AND SUGAR

Households	Panela	Honey	Sugar
With UBN	46	46,72	8,17
Without UBN	36,36	9,80	14,36
Weighted Average	43	32,21	10,61
Note: UBN=unsatisfied basic needs			

Source: Rodriguez, et al., (2004)

Ethanol is a biofuel obtained from organic raw material. It is considered a renewable fuel due to the use of crops as raw material, ranging from sugars, corn, or beets to any organic product that contains large quantities of sugars. In Colombia, ethanol is produced with first-generation technology, the national development plan 2006–2010 established the guidelines of the key development sector for ethanol production, while Resolution 180687 of 2003 provided that the production must be carried out with biomass as the sole product and it must be with sugarcane, thus completely setting aside the oil industry and prioritizing sugar mills.

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Sugarcane is an agro-industrial crop; hence, the raw material for both panela and ethanol. The growing increase in the demand for ethanol because of Law 693 of 2001 and Resolution 90932 of 2013 provides for the increase of ethanol blending with gasoline at 10%. Therefore, this increase has caused the demand for raw material to rival food crops (Orjuela, et al., 2011); consequently, there is an increase in food prices and food security is threatened, as established in the study by von Braun & Torero (2009).

The association of price increase as a feature of the interrelation between the fuel market such as ethanol with food product market such as panela can be seen in relation to the general equilibrium theory of Leon Walras. The increase in the price of panela is the result of increased demand for sugarcane due to the growth of ethanol production, thus generating a shortage of raw material and a new effective demander, such as sugar mills in the market (Granger, 1981), resulting in an increase in the price of panela for consumers.

METHODOLOGY

The methodology used to approach the described problem, between the association of the increase in panela prices and ethanol production for the department of Valle del Cauca, relied on the ECM, which has been integrated in different empirical research studies, thus contributing to the statistical analysis proposed by Granger (1981); Engle, et al., (1982) in the time series analysis.

The equilibrium relationship presented in the model is based on cointegration, which is reproduced in a statistical model against the equilibrium relationship (Robert, Engle & Granger, 1987), thus establishing the concept of cointegration by integrating it into the ECM. The model has a wide scope and allows to relate two different points between the analysis of time data: the first one, a statistical approach to time series of the Box–Jenkins method type, which does not consider long-term information but solves the spurious regression problem, and the second one, which considers the econometric approach that presents a model based on economic theory.

Y_t is a scalar variable, which follows a first-order autoregressive process as stated by Obando (2003) in his article:

$$Y_t = \alpha Y_{t-1} + \varepsilon_t \quad t = 1,2 \ldots ..\mathrm{T}$$

Where:
α: First-order autoregressive coefficient
ε_t: Perturbation term assumed to follow a stochastic process.
T: Number of observations
Y_0: Initial process condition
By subtracting both terms of the equation, the following is obtained:

$$\Delta Y_t = \delta Y_{t-1} + \varepsilon_t$$

Where:
$\delta = \alpha - 1 \; and \; \Delta$: The forward difference operator
Therefore:
$\delta = 0$: Has no unit root and is integrated of order I (0).
$\alpha = 1$: Has a unit root and is integrated of I (1).
In the presence of unit root with effect of $\alpha = 1$ in (1) we subtract Y_{t-1} from both sides and obtain:

$$\Delta Y_t = \varepsilon_t$$

Granger (1981) states that the formalization of this concept of order in the integration of a series I (1) is preceded in the presence of the unit root, (1) is expressed as:

$$Y_t = Y_0 + \sum \varepsilon_i$$

Where:

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Y_0: Initial value of the series has mean Y_0 and variance t_{σ^2}.
$\sum \varepsilon_i$: Permanent effect on the level of the series, since they accumulate, therefore, it is called integrated.
In general, equivalence between the concepts of cointegration and ECM, insofar as they cointegrate, implies an ECM referring to the Granger representation theorem. In this regard, consider the two-scalar series Y_t and Z_t both I (1) autoregressive distributed lag (ADL) model.

$$Y_t = \alpha Y_{t-1} + \beta_0 Z_t + \beta_1 Z_{t-1} + \varepsilon_t$$

Subtracting $Y_{t-1}$from both sides and adding and subtracting $\beta_1 Z_{t-1}$ from the right-hand side we obtain the ECM of the ADL:

$$\Delta Y_t = \beta_0 + \Delta Z_t + (\alpha - 1)[Y - KZ]_{t-1}$$

Where the coefficients are:
β_0: Impact coefficient, which measures the short-term effects of a change in Z_t.
K: Measures the long-term effect of change in Z_t on Y_t.
$[Y - KZ]_{t-1}$: Cointegration factor.
$(\alpha - 1)$: Reflects the impact of Y_t.

According to the methodology described above, an empirical model is proposed to determine the association between the increase in panela prices and ethanol production for Valle del Cauca, based on the statistical data provided by DANE, which subtracts the panela price from the database used to calculate the consumer price index and ethanol production, downloaded from the statistical database of Asocaña's website, by selecting the variables described in Table 3.

Table 3
DESCRIPTION OF INDEPENDENT VARIABLES

Variable		Type of Variable	Measurement Scale
	Dependent Variable		
Y_t	Panela Price Logarithm	Numeric	Colombian Pesos
	Independent Variables		
β_2	Ethanol Production Logarithm	Numeric	Liters
β_3	Sugar Import Logarithm	Numeric	Tons
β_4	Sugar Export Logarithm	Numeric	Tons

Source: prepared by the authors.

Finally, the econometric model proposed to empirically explain the degree of association between panela prices and ethanol production is as follows:

$$log\ (panela\ price)\ = \beta_1 + \beta_2 + + \beta_4 +\ u_t$$

The descriptive statistics of the econometric model variables for ECM are presented in Table 4.

Table 4
DESCRIPTIVE STATISTICS OF THE VARIABLES IMMERSED IN THE ERROR CORRECTION MODEL

Descriptive Statistics	Panela Prices	Ethanol Production	Sugar Import	Sugar Export
Mean	1320933	28649.15	14491.12	61643.83
Median	1.260.540	28798.50	12548.29	58023.24
Maximum Value	2.124.430	45533.20	71786.40	177756.5
Minimum Value	7.860.800	1692680	3501011	5090977
Standard Deviation	2.863.228	7.495.499	10022.54	29527.24
Observations	144	144	144	144

Source: prepared by the authors with data from DANE and Asocaña.

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Furthermore, the search to characterize ethanol production and panela prices formation was carried out through a bibliographic review of several databases such as ScienceDirect, Scopus, Oxford, and academic search engine Google Scholar.

RESULTS

Regarding ethanol production in Valle del Cauca from 2000 to 2017, results show that the department is the main domestic ethanol producer according to Procaña (2018), as it represents 29% of the departmental GDP in the industrial sector and 31% in the agricultural sector. The agro-industrial crop is distributed along the banks of the Cauca River; it includes the departments of Cauca, Valle del Cauca, and Risaralda in 47 municipalities of the aforementioned departments. The socioeconomic sector generates 188,000 tons, the amounts of cultivated hectares are 232,070 of which 75% are owned by suppliers (approximately 2,750 hectares) and the remaining 25% (58,018) hectares belong to 12 mills.

The economic dynamics in the department of Valle del Cauca imposed by the large landowner's model transformed the peasant dynamics since its inception in 1860 to develop consumer goods imports driven by sugarcane (Rincón & Machado, 2014). In relation to the structural organizational system resulting from the large landowner's model, a model worthy of an agro-industrial cluster was produced, comprising great socioeconomic efficiency, which provided the necessary conditions to start sugarcane-based ethanol production (Chaux, 2000).

In 2015, ethanol production worldwide was 85% concentrated in the United States and Brazil, while at the national level, 93% of production was for personal consumption, and the remaining 7% was exported. This was as per the legal requirement of the 8% gasoline blend. An amendment to the resolution required a 10% gasoline blend; hence, demand is now 82% covered by the annual domestic production of 260–300 million liters (Asocaña, 2015).

Low international oil prices have presented high volatility, which leads to a decrease in ethanol prices; consequently, ethanol producers undergo losses, something similar to what happened in 2008, which elucidates the high vulnerability of the Colombian ethanol production sector that primarily affects the departmental economy of Valle del Cauca (Cerquera, Marín & Polania, 2018).

As regards the panela price behavior in Valle del Cauca for 2000–2017, Mojica-Pimiento & Paredes-Vega (2004) state that this region follows the same trend as does the domestic panela market. The price is subject to a cyclical behavior during sugarcane harvest and is exposed to consumer decision factors. Conditions such as its presentation, quality, weight, and color cause prices to vary every month depending on the conditions of the international market in relation to the price of sugar, which is a substitute for panela. Higher prices lead to an increase in the production, thereby causing an increase in the final price of panela due to the scarcity of raw material.

Prices follow behaviors, according to the research of Rangel (1997); accordingly, the panela consumer begins to denominate panela as a traditional consumption good, thus changing expectations in the market through the integration of pulverized panela with a high level refining. As such, panela follows the behavior of a normal good exposed to supply and demand based on prices, while consumers are to some degree indifferent to price (47.7%) due to their consumption habits.

Regarding the degree of association between the behavior of the prices of ethanol and panela according to the model validity, the presence or absence of unit root in the proposed variables was verified, using the Dickey–Fuller and Phillips–Perron tests. The variables of alcohol production, sugar import, and sugar export do not present a unit root and are of integrated order I (0); meanwhile, the variable price of panela has a unit root and is of integrated order I (1).

After performing the unit root tests, we modeled the variables using ECM, the presence of a unit root in the explanatory variables is dismissed and it is only present in the dependent variable of

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the panela price, thus obtaining the results shown in table 5. We dismissed the variables that did not have a spurious correlation in the proposed ECM. For this purpose, we performed the Phillips–Perron and Augmented Dickey–Fuller tests on the residuals. We obtained the following results: for Dickey–Fuller, the prob value is 0.0491 with 5% stringency, while Phillips–Perron test yields a p-value of 0.0000 also with 5% stringency; therefore, the proposed model is cointegrated, is not a spurious model, and presents a causal relationship between the variables.

The Durbin–Watson statistic can be applied with a higher stringency and as a complement to the previous result, to determine if there is cointegration for the cointegrating regression, whose critical values at different levels of significance are shown in Table 5. As a result, Durbin–Watson statistic (0.400411 for this case) is greater than the critical values tabulated at 5%, and the cointegration relationship can be accepted.

Table 5
CRITICAL DATA FOR THE DURBIN–WATSON TEST

Significance Level	Critical Value
1%	0.511
5%	0.386
10%	0.322

Source: prepared by the authors.

Lastly, the final cointegration model used to determine the underlying ECM integrates the error of the residuals with a previous period; finally, it is determined as a log-log model. All variables are statistically significant in explaining the model; R^2 also explains 77% of the variations in the model.

Table 6
FINAL MODEL OF COINTEGRATION OF THE DEPENDENT VARIABLE PRICE OF SUGARCANE

Variable	Coefficient	Std. Error	t-Statistic	Prob
Intercept	5.203911	0.303833	17.12754	0.0000
Logarithm Alcohol Production in Liters	0.231025	0.024519	9.422132	0.0000
Sugar Import Logarithm	0.030443	0.009740	3.125465	0.0022
Sugar Export Logarithm	−0.062142	0.018776	−3.309714	0.0012
Residual	0.855418	0.052712	16.22817	0.0000

Source: prepared by the authors.

Interpretation of the variables (Table 6):

- Log alcohol production in liters: for every 1% increase in the production of alcohol in liters, the price of panela will increase by approximately 0.231025%, the sign is expected and so is the result according to the national and international research on the subject.
- Log sugar imports in tons: for every 1% increase in sugar imports, the price of panela will increase around 0.030443%, the positive sign is expected in relation to the theory, and the significance parameter is high. The raw material such as sugar cane is directed to the production of refined sugar due to the increase in demand that is not satisfying the deficient domestic production; the increase in the price of panela is not very high.
- Log total sugar exports in tons: for every 1% increase in sugar exports, the price of panela will decrease by approximately 0.062142%, the sign is expected around the economic theory and the significance parameter is high. The decrease in the price of panela may be occurring due to processes that violate the Law 40 of 1990, article 5. As shown by Barrios and

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Quimbayo (2016), taking advantage of the low cost of sugar price, unscrupulous people melt sugar to illegally manufacture panela, disguising it as legitimate panela and thus aggravating the problem of sugar smuggling.

- The coefficient associated to the resid variable (residuals lagged one period) is of great importance, as it shows the speed of convergence to the long-term equilibrium of the cointegrated model. In this case, it is positive (0.855418), that is, the dependent variable (panela price) was in the previous period (t-1) below its equilibrium value, which will begin to increase in the following period until the equilibrium value is restored. The magnitude of this coefficient (0.855418) shows that stabilization will be relatively fast.

DISCUSSION

The research results show that the increase in the price of panela (by 0.231025%) can be associated with the increase in ethanol production; therefore, the food market is related to the market of fuels deriving from agriculture. Thus, it is possible to interrelate this with the economic theory of general equilibrium, put forward by Granger (1981) for these two markets.

CONCLUSION

Regarding the ethanol production in Valle del Cauca during 2000–2017, the whole production is concentrated in the large mills, almost entirely in the department of Valle del Cauca. Moreover, the ethanol market was created by the national government to favor the mills that have a great departmental and national influence.

In terms of panela price behavior in Valle del Cauca for 2000–2017, panela prices behave in a normal way with a strong influence in the consumers' preferences in relation to culture as well as preferences to higher-quality panela and innovations such as granulated panela. Additionally, the panela price is exposed to cyclical behavior and is strongly related to the sugar market as it is a substitute product.

In conclusion, regarding the general goal related to the specific goal of determining the degree of association between the behavior of the price of ethanol and panela, we can say there is a degree of association between ethanol production and the increase in panela prices. Thus, panela prices increased by 0.231025% for each liter of ethanol produced. This shows a rivalry between the crop dedicated to human consumption and that dedicated to energy consumption.

Mainly, the imbalance generated by the effective demand of ethanol-producing plants for sugarcane and their willingness to pay more for this raw material than the natural price, generates a change in the general market equilibrium, preventing panela producers from being able to pay the full market price, causing shortages, and therefore, an increase in the selling price of panela.

In conclusion, there may be possible collateral damages that ethanol may cause in the increase of food prices, putting food security at risk in Valle del Cauca and consequently, in Colombia due to the price increases and thus creating a purchasing incapacity for the most economically vulnerable population.

ACKNOWLEDGMENT

This research has been funded by the General Research Office of Universidad Santiago de Cali under call No. 01-2021.

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Citation Information: Calderón, D.F.V., Melenje, E.L.S., & Pérez, J.F.B. (2021). Association between the increase in the price of panela and ethanol production from 2000 to 2017 in Valle del Cauca. *Journal of Management Information and Decision Sciences, 24*(S6), 1-9.

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