FORECAST FOR BRANCH ONION PRODUCTION FROM A VAR MODEL

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Abstract
This work aims to develop a VAR forecasting model for branch onion production with data from the municipality of Aquitania-Boyacá, using multivariate time series methods. The methodology has included the materialization of study phases according to the Box Jenkins method and the application of a series of Phillips and Perron statistical stationarity tests, augmented Dickey-Fuller unit root (ADF), Jarque-Bera normality tests, Phillips Ouliaris test, Granger causality test, among others. The results allow establishing a forecast model under normality, which can support the decision making of technical institutions in the sector. Finally, the conclusions allow establishing the need for this type of models that result in research for the improvement of the agricultural sector in the face of the production and harvested area.
Key Words - *Branch onion, production, harvested area, VAR model*

1. INTRODUCTION

The emergence of a number of global developments over the past few decades, such as globalization, integrated value chains, rapid technological and institutional innovations, environmental constraints and rising prices of agricultural goods, has brought agriculture back onto the global agenda, while providing a renewed role in the development of countries (Perfetti, Balcázar, Hernández, & Leibovich, 2013).

In this way, changes in volatility affect prices, production, and inventories in two main ways. First, volatility directly affects the marginal value of storage, commonly called marginal return of convenience, i.e., the flow of profits from an extra unit of inventory in the hands of producers and/or consumers. When prices (and therefore production and demand) are more volatile, consumers and producers have a greater demand for inventories, which are necessary to smooth production and deliveries and reduce marketing costs. (Pindyck, 2004).

Commodity prices have long been a source of considerable interest among academic researchers and have been a major cause of concern for policymakers and a harsh reality in the lives of the poor in countries that rely predominantly on primary production and exports (Razzaque, Osafa-Kwaako, & Grynberg, 2007).

Thus, the *Commodities* They are markets characterized by having existed throughout the history of humanity, over time, their scope has grown introducing in addition to agricultural products, those related to metals and energy, their trade began with organized barter in the cities with the use of means of payment other than money, to the futures market, with the intervention of clearing houses, generating solvency in transactions and lower risks (Geman, 2005).

In this way, these goods come mainly from agricultural activities, on the contrary, others maintain transformation processes, being derived from an underlying agricultural product such as soybean meal and oil (Baker, Filbeck, & Harris, 2018). Therefore, most of them *Commodities* Agricultural crops are associated with food, being fundamental for the social and economic development of the population, thus, from a historical component, food crops and the products that arise from them have given rise to the initial mechanisms of monetary exchange in the market.

Thus, the trade that was initially carried out between commodities was mainly dominated by *Commodities* However, until recently these exchanges were mainly between producers and consumers, to cover the risk in prices (Bain, 2013).

In this way, it is found that agricultural prices are versatile due to aspects of variability in production and consumption, economists differentiate between predictable and unpredictable variability, due to the shocks of production and consumption that is transmitted to prices. In the case of the former, as a result of the area planted and the yield, it depends on the greater impact on agriculture from climatic shocks, while consumption, due to changes in income, substitutes and consumer tastes (Gilbert & Morgan, 2011).

Also the prices of the *Commodities* Agricultural companies, they quickly anticipate changes in supply and demand, in order to Schnepf (2006) differ from other goods as a result of the seasonality that occurs in production, the environment and the functions of demand and supply inelastic against price. In the case of seasonality, agronomic conditions related to climate and soil significantly influence the viability of a crop, in this way farmers base their decisions on the possibilities of future yields, product and input prices, probably on the rates derived from government programs for alternate production activities. in the same way, international markets in terms of producer prices and trade changes from an international perspective. Likewise, the growing demand for agricultural products for industrial processing causes the price inelasticity of the demand for agricultural products (Piot-Lepetit & M'Barek, 2011). For Nguyen and Prokopczuk (2018b, p. 1) "Agricultural commodity prices can react strongly to adverse weather conditions, political announcements, surprises in inventory announcements."

Thus, the International Institute for Environment and Development (IIED) (2005), based on the discussions held at the World Bank, established the characteristics of the *Commodities*, (a) higher volatility in the prices of *Commodities* subject to prices associated with industrial goods, (b) frequent shocks of some *Commodities* c) persistent price shocks, d) maximum impact of the price shock is achieved after four years, e) persistence of long-term shocks, which can last up to 20 years, to return to the starting point, f) since the energy crisis of 1973, the volatility of commodity prices persists, (g) existence of the positive relationship between growth and *Shocks* h) increase in poverty resulting from negative shocks due to declining incomes and growth, i) positive price shocks are cushioned by producers, while the boom in the *Commodity* it is not as favorable, as the occurrence of a loss.

Economies with a lower level of development produce raw materials that are consumed almost immediately after a limited transformation process, however with economic progress there are also advances in production processes, in turn decreasing the participation in GDP (Radetzki, 2008). Thus, agricultural participation has great relevance in the Colombian economy, being a sector that generates employment and income for the economically active population, however, affected among others by economic, political, social and environmental factors (Fonseca-Cifuentes, León-Castro, & Blanco-Mesa, 2021).

These structural constraints have not made it possible for the rural sector to be dynamic, related to: (a) the absence of formalization and regularization of property rights and economic, social and ecological difficulties due to the conflict; b) increase in the gaps between urban and rural areas, due to the lack of social mobility and human development; c) weaknesses in the generation of income in a sustainable manner and access to productive assets; (d) limited provision of goods and services necessary for the promotion of agricultural competitiveness; e) absence of institutions that generate

strengthening of the management of rural and agricultural development (Presidency of the Republic, 2015).
This situation leads to the realization of a study that allows the prognosis for the production of the *Commodity* On the understanding that this municipality makes the most significant contribution to the total national production, employing most of the inhabitants of the municipality and generating 70% of the income of the economy, approximately with a sowing of 3,800 hectares per year and a harvest of 100,750 tons. occupying the first place at the level of the Department of Boyacá together with potato production (Aquitaine Municipal Mayor's Office, 2020).
In this way, it is worth noting that the agricultural vocation of the municipality of Aquitaine, whose production is focused on the primary sector of the economy, mainly generates employment for the rural population, so the study becomes a determining factor that promotes a model incorporating elements that materialize in planning processes. control and decision-making.
Thus, the document is structured as follows: methodology with the description of the data, methods and statistical tests; Results From the assumptions, selection and prognosis of the proposed model, the conclusions and bibliographic references of the article finally appear.

2. METHODOLOGY

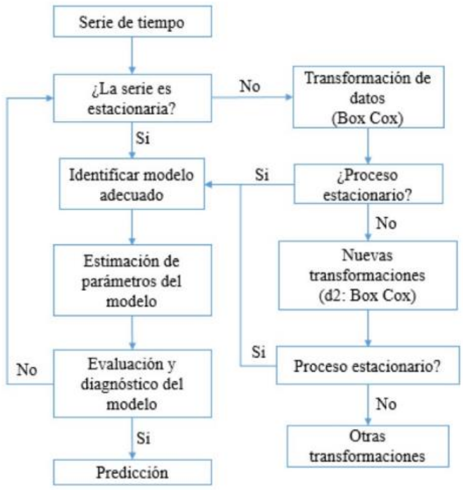
Data
The information for the study comes from the cultivation of onions from the municipality of Aquitania-Boyacá, based on the Agricultural Evaluations (EVA) and the Statistical Yearbook of the Agricultural Sector (Agronet, n.d.), according to the harvested area and production, with records between 2006B and 2022B, data processed by the R Studio software version 4.3.1., through which six variables were considered categorized according to table 1.

Board 1. Study variables according to agricultural evaluation by consensus

Variable Type	Variable Name	Description
Qualitative	Cultivation	Type of transitory, annual and/or permanent crop.
Qualitative	Period	A (first semester) and B (second semester).
Quantitative	Planted area (Ha)	Area in hectares (Ha) destined for crop germination.
Quantitative	Harvested area (Ha)	Extension from which production is obtained in hectares (Ha).
Quantitative	Production (t)	Volume obtained in tons (t) of harvested area
Quantitative	Yield (t/Ha)	Tonnes (t) obtained per hectare of crop (Ha)

Own elaboration based on (Agronet, n.d.)
Statistical methods and tests
The model was developed according to the Box Jenkins methodology (see figure 1), materialized from four stages, a) identification of the model, b) estimation of the parameters, c) diagnosis of the model based on residuals and, d) generation of predictions.

Figure 1. Box Jenkins Methodology



(Uribe, Fajardo, & Romero, 2017)

Thus, for the analysis, the following hypotheses have been initially considered for the determination of the assumptions of the model,

Ho = The time series is considered non-stationary because it maintains unit root *P – value >0.05*

H1 = The time series is considered stationary *P – value <0.05*

From these, the Phillips and Perron stationarity tests and unit root are subsequently performed Augmented Dickey-Fuller (ADF). The stationarity test of Phillips and Perron (1988) It establishes that the analysis of time series based on the verification of the null hypothesis, verifies the existence of evidence to affirm whether the series complies with a random walk (unit root). It assumes that the Yi generation process follows a higher order of autocorrelation supported by the test equation, causing Y_{T-1} is endogenous in nature, making non-parametric corrections in the test statistic, invalidating the Dickey-Fuller test (Meneses-Cerón & Pérez-Pacheco, 2020). The unit root test, by means of the Augmented Dickey-Fuller (ADF), establishes whether the null hypothesis generates unit root through three versions, excluding the intercept, with suppression of the trend or with one of the two, however, it is advisable to determine it using the tendency to correct this effect if it exists. (Montero, 2013). Therefore, the unit root is a case of non-stationarity, where the time series has a persistent stochastic tendency over time.

Once the results are available, the causality test has been established based on the following hypotheses:

Ho = The type of production is NOT causal in the Granger sense (it serves to predict) the harvested area (Ha) of the semi-annual onion *onion P – value >0.05*

H1 = The type of production IF is causal in the Granger sense (it serves to predict) the harvested area (ha) of the semi-annual onion *onion P – value <0.05*

The Granger causality test, a statistical hypothesis test in order to establish whether the time series is useful for the prediction of another, allows answering questions such as, do changes in Y1 cause changes in Y2? Can Y1's past improve Y2's future prediction? (bidirectional causality), does knowledge of the future of Y1 help in improving the prediction of Y2? (instantaneous causality)

Then, for the selection of the model and based on the Phillips Ouliaris test, the following hypotheses have been included, in order to identify whether the time series allows cointegrations.

Ho = The time series does NOT allow cointegration of the variables *P – value >0.05*

H1 = The SI time series allows cointegration of the variables *P – value <0.05*

3. Results And Discussion

3.1. Assumptions of the model

Based on the stationarity test presented in Table 2, the hypotheses are validated,

Board 2. Stationarity and unit root test results

Test	Phillips-Perron	Dickey-Fuller
Function	your.pp	your.df
Statistical criteria	P-Value	P-Value
Production	0,758	9,029e-06
Harvested area	0,01711	0,006218

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According to the criteria of the statistical tests of stationarity (Phillips-Perron) and unit root (Dickey-Fuller), for the variables production and harvested area the results are less than 0.05, so the alternate hypothesis is accepted with 95 % confidence since the data follow a stationary behavior, likewise, the null hypothesis is accepted with 95% since the data does not follow a stationary behavior because it generates results above 0.05.

3.2. Model selection

Then, based on the theory of cointegration, it is established that, although the original series are non-stationary, there may be linear combinations of equilibrium between them that maintain the stationary character (these long-term relationships are called cointegration relations). In VEC models, an attempt is made to establish a single framework with the integration of stationary long-term relationships (brought together through cointegration relationships) together with the short-term dynamic dependencies achieved through VAR models (Novales, 2017).

In this way, the generation of the model has considered a) identification of the number of lags, b) Phillips Ouliaris test, c) identification of the number of cointegration relationships.

Identification of the number of lags

The number of suggested lags and their selection criteria are shown in Table 3.

Board 3. Suggested lags identified

Indicator	Lags	Criterion
AIC	1	2.753201e+01
HQ	1	2.761928e+01
SC	1	2.781748e+01
FPE	1	9.072289e+11

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The model has considered the information criterion Hannan-Quinn (HQ), a measure of goodness of fit of the statistical model, used in the selection of a model against a finite set of models. In this way, the measure introduces a penalty term for the number of parameters, so that, given two estimated models, the model with the lowest value in HQ is preferred, which implies a smaller number of explanatory variables, better fit, or both. It can be used in the comparison of the estimated models when the numerical values of the dependent variable are identical so that all estimates are compared (Pollock, 1999). In this way, the order of the VEC always corresponds to one, less than the VAR (Novales, 2017), therefore, and according to the results for the development of the model, it begins with 1.

Phillips Ouliaris test

Then, the calculation of the Phillips-Perron Z(alpha) statistic is established for a unit root in the residuals of the cointegration regression. The unit root is estimated from a regression of the first variable (column) of *x* on the other variables of *x* without constant and with a linear tendency. To estimate variance, the Newey-West estimator is used. If the shorts is TRUE, the truncation delay parameter is set to trunc(n/100); otherwise, trunc(n/30) is used. The values of *p* are interpolated from Table Ia and Ib,Phillips & Ouliaris (1990, p. 189). If the calculated statistic is outside the critical value table, a warning message is generated. Once the results are available *P-Value* = 0.07275 the null hypothesis is accepted, that is, the time series does not allow cointegration of the variables.

Identification of the number of cointegration relationships

In this stage, the number of independent or long-term cointegration relationships between the variables is established. This number is called the cointegration range. In general, if you have *n* Non-stationary series The cointegration range can range from *0, 1, ..., n - 1* (Novales, 2017). The authors estimated a VEC through which a deterministic trend has been included in the cointegration relationship. Thus, in the first and second null hypotheses *r=0* and r>=1, since the test statistic 4.78 and 3.84 do not exceed all critical values, the first and second hypotheses cannot be rejected. Therefore, the cointegration is r=0 and r<=1 under maximum eigenvalue statistics (see table 4).

Board 4. Test de Phillips Ouliaris

r	Test 1	1%	5%	10%
<= 1	3,84	12,97	9,24	7,52
= 0	4,78	20,20	15,67	13,75

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3.3. Model evaluation and validation

For the validation process of the model, normality tests, serial autocorrelation tests, impulse response test, FEVD variance decomposition, Phillips-Ouliaris cointegration test and homoscedasticity test have been performed.

Normality Test

This test has considered the criteria of the Jarque-Bera test, asymmetry (measurement of the lesser or greater symmetry of the distribution between two measurements) and kurtosis (measurement of the greater or lesser concentration of data around the mean), allowing the irregularity of the distribution to be determined. For which the following hypotheses have been considered:

Ho = The residuals of the model are normally distributed *P – value >0.05* is not rejected.

H1= The residuals of the model are NOT normally distributed *P – value <0.05*. The null hypothesis is not accepted and the alternative hypothesis is accepted.

According to the results of the normality test in Table 5, the alternative hypothesis is accepted, the residuals of the model are NOT normally distributed. In particular, for a simulated white noise series, the 5%of the autocorrelations are significantly different from zero at the level of significance of the 5%, which is displayed as dotted lines in the correlogram (Metcalfe and Cowpertwait, 2009).

Board 5. Normality Test Results

Test	Normality
Statistical criteria	P-Value
JB-Test (multivariate))	0,01775
Skewness only (multivariate)	0,01054
Kurtosis only (multivariate)	0,2415

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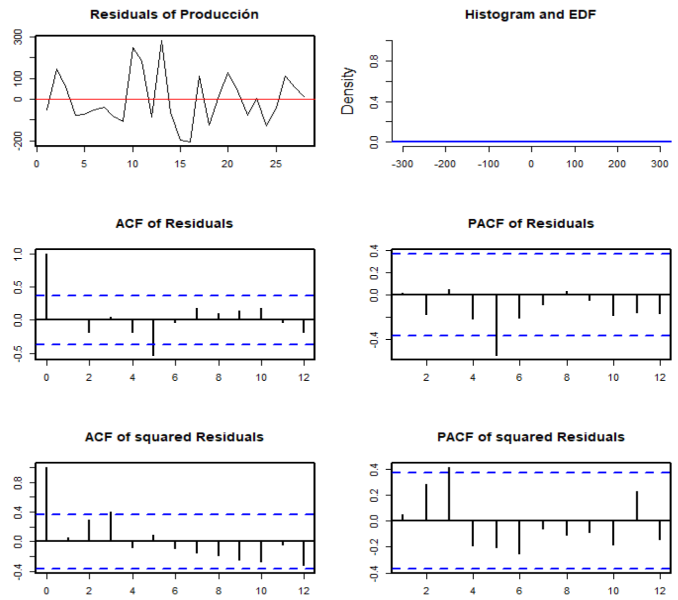
In addition to the quantitative tests, graphs were made to visualize the distribution. Figure 1 identifies the independence of the residuals (i.e., they are not uncorrelated). Therefore, if the *p-value* obtained is small, it indicates that there is no randomness, on the other hand, the higher the *p-value*, the more evidence there is that the residuals are white noise. For a model to be valid, the different analyses on the residuals obtained in the estimation must be noise.

Graphic 1. Model Residuals



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Serial autocorrelation tests

Mean and variance play an important role in the study of statistical distributions as they include two key distributional properties: central location and dispersion. Similarly, with keys in the study of time series models, second-order properties, which include mean, variance, and serial correlation (Metcalfe & Cowpertwait, 2009).

Therefore, the decision criterion is specified, in the sense of rejecting the null hypothesis, if the value of the probability is less than the level of significance (Morán Chiquito, 2014), in this way it is established,

Ho = The residuals of the model are NOT correlated $P - value > 0.05$ is not rejected.

H1 = The residuals of the SI model are correlated $P - value < 0.05$ the null hypothesis is not accepted and the alternative hypothesis is accepted.

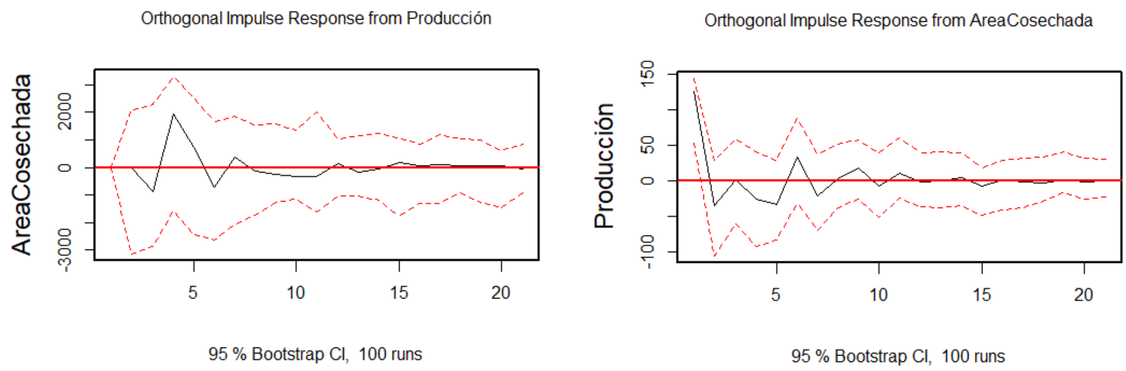
Thus, the *p-value* results are less than 0.05, which indicates that the residuals of the model are correlated, therefore, the alternative hypothesis is accepted, the residuals are not correlated, as can be seen in graph 1.

Impulse test response

This test is a useful instrument to evaluate the congruence and dynamic sensitivity of the variables specified in the model, for this reason, it is efficient to evaluate and propose economic policies. Generalized Impulse-Response Functions (FGIR) allow us to establish the dynamic response of a given system variable to shocks (or unanticipated changes) in some other variable (Morán Chiquito, 2014). Thus, the impulse response analysis is based on the representation of the global moving average of the VAR(p) process. It is used to investigate the dynamic interactions between endogenous variables (Pfaff, 2008).

Therefore, the test was applied to all the variables, showing that they respond to the stimuli generated by the other variables, a situation that can be seen in graphs 2 and 3.

Graphic 2. Impulse Test Response Production and Harvested Area



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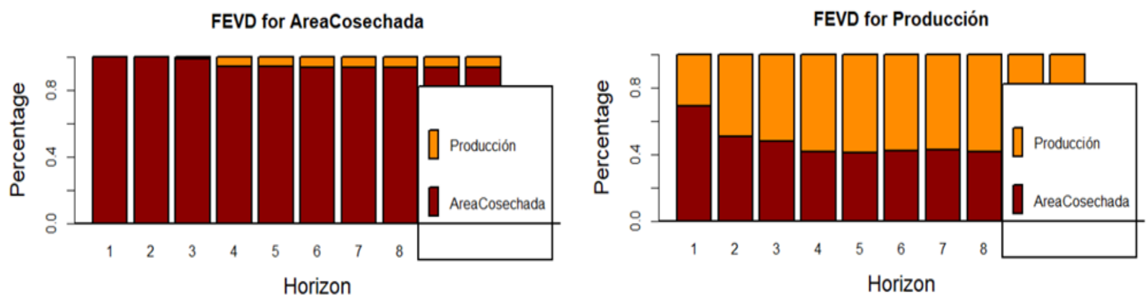
FEVD Variance Decomposition

The decomposition of variance indicates the amount of information that each variable contributes to the others

variables in autoregression. It determines how much of the variance of the forecast error of each of the variables can be explained by exogenous shocks to the other variables. Similarly, variance decompositions establish to what extent (or by what percentage) one variable is influenced by innovations in another variable (Cuevas Ahumada, 2008).

In graph 3, variance is decomposed, which in general terms results in the degree of incidence of variance in the different variables. In the case of the total sum of production during the time periods, the variability is typical of the same variable, while, over the period of time, the incidence of the harvested area variable is quantitatively observed.

Graphic 3. FEVD Variance Decomposition



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Phillips-Ouliaris Cointegration Test

In the null hypothesis of non-cointegration, a slow rate of convergence of test statistics is found (Reimers, 1992), in this way,

Ho = The series are NOT cointegrated *P – value >0.05* is not rejected.

H1 = The SI series are cointegrated; there is evidence to support that the series are cointegrated, i.e. that there is a long-term trend *P – value <0.05* the null hypothesis is not accepted and the alternative hypothesis is accepted.

The results allow us to establish a value of *p-value* = 0.07275, so there is no evidence for the rejection of the null hypothesis of the cointegrated series, i.e., they maintain a long-term trend.

Homoscedasticity Test

The assumption of homogeneity of variances, also known as homoscedasticity, considers that variance is constant (does not vary) at different levels of a factor, i.e., between different groups (Horngren, Datar, & Rajan, 2012), the results showed values of *p-value* = 0,00558

Granger causation test

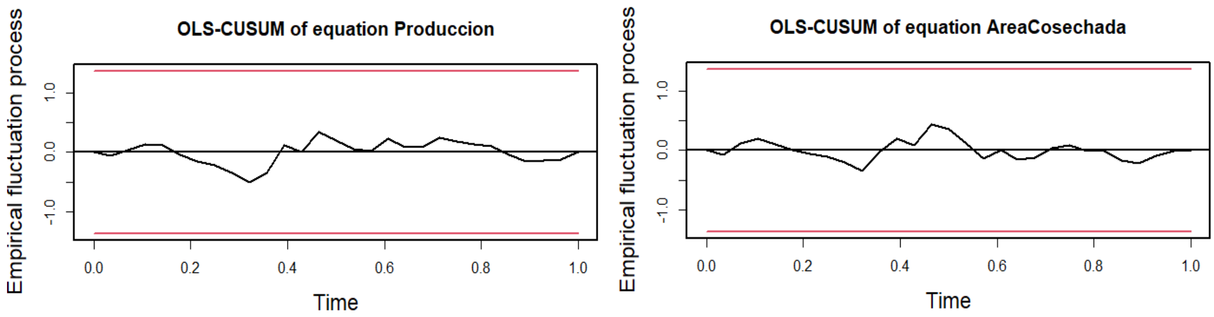
Granger's concept of causality has been widely used to study the dynamic relationships between economic time series. This probabilistic concept is defined in terms of predictability and explores the direction of the flow of time to achieve a causal ordering of dependent variables in multivariate time series (Eichler, 2012). It is then established that,

Ho = The time series x does not cause the time series and *P − value* >*0.05* is not rejected.

H1 = The time series x Granger-causes the time series *P − value* <*0.05*

The results allow us to establish a value of *p-value* = 0.0006032, likewise the semi-annual growth of the production causes Granger, the semi-annual growth of the harvested area, at least in the estimation period of the study. As shown in Figure 4, there does not seem to be a break in the respective confidence intervals.

Graphic 4. Structural Breakdown of Waste



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Finally, in table 6, the forecast of the VAR model is made for three subsequent years, with a confidence level of 95%, the estimate of the harvested area and production for the two semesters of each year is found, in this way a key tool for agriculture is obtained that also enables investments in the agricultural sector essential for the reduction of hunger and poverty. improving aspects of food security, job creation and resilience to disasters (United Nations, 2018).

Board 6. Harvest area and production forecast

Projection Period (Year/Semester)	Harvested area (ha)	Production (t)
1A	1.283	59.707
1B	1.297	61.309
2A	1.202	59.050
2B	1.193	59.149
3A	1.274	62.754
3B	1.272	60.756

This study

In this way, the possibility of generating a forecast model of *Commodities*, for the case study Cebolla de rama, results in mechanisms for the assurance of harvests and their successful harvesting, even more so with the considerations associated with climate change, systematically impacting socioeconomic aspects at the regional and national levels (Fonseca-Cifuentes & Esquivel-Medrano, 2018).

The application of forecast models for time series is of great importance to predict the production in tons of the vine onion and to be able to identify the variables that can contribute to improving the harvested area, thus seeking to direct efforts for future municipal agricultural evaluations. The model developed will allow the Rural Agricultural Planning Unit-UPRA, to forecast the harvested area and the production of the vine onion or reed in a better way, according to the prediction in semesters.

4. CONCLUSIONS

The document aims to make the forecast for the production of *Commodity* branch onion from a VAR model, with related information from the municipality of Aquitaine, for which, in the first instance, conceptual aspects related to these assets were contemplated from authors such as Geman (2005), Baker et al. (2018), Bain (2013), Gilbert & Morgan (2011) among others.

To this end, the model has considered information from the cultivation of onions from the aforementioned municipality from the Agricultural Evaluations-EVA and the Statistical Yearbook of the sector, likewise, the Box Jenkins methodology has been developed (Uribe et al., 2017) through a compendium of statistical tests that included Phillips and Perron stationarity tests, unit root Augmented Dickey-Fuller (ADF), Jarque-Bera normality tests, Phillips Ouliaris test, Granger causality test.

In order to achieve a relevant and accurate forecast model, the pretreatment of the data is required, it should be noted that for this study, the information has been obtained from the Municipal Agricultural Evaluation of the Agricultural Sector Information Network, to later carry out filters by department, municipality, crop and period.

The model considers a historical of the planted area (ha), harvested area (ha), production (t) and yield (t/ha) for the future forecast, however, this can be affected by external factors related to the climate or phytosanitary problems, likewise the model can be useful, among other technical institutions, to the Rural Agricultural Planning Unit-UPRA and the municipal agricultural evaluations in articulation with the unified national rural information system agricultural (SNUIRA).

Finally, the absence of research in this area of knowledge in the particular case of Colombia has led to focusing only the discussion of the shortcomings of this sector on technical aspects, which do not result in strategic decisions and do not tend to generate value from the financial sphere, although "the prices of agricultural products can react strongly to adverse climatic conditions, political ads, surprises in inventory ads" (Nguyen & Prokopczuk, 2018a, p. 1).

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