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ARTÍCULO CIENTÍFICO

ECUADORIAN FLOWER EXPORTS AND THEIR SEASONALITY: AN ECONOMETRIC ANALYSIS USING GARCH MODELING

EXPORTACIONES DE FLORES ECUATORIANAS Y SU ESTACIONALIDAD: UN ANÁLISIS ECONOMÉTRICO UTILIZANDO MODELOS GARCH

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Resumen / Abstract

Exports of natural flowers as macroeconomic variables present repetitive behaviors or patterns; the objective of this research is to obtain a GARCH econometric model of the seasonal behavior of Ecuadorian flowers in the international market. The applied methodology was descriptive with a mixed approach and quantitative approach to a total of 259 monthly data from January 2000 to July 2022. For this study, the Box- Jenkins or seasonal ARIMA time series methodology known as SARIMA (Seasonal Autoregressive Integrated Moving Average Model) was used with the Eviews 9 program. The results showed that the application of a GARCH model to a seasonal model was adequate to forecast five out-of-sample data after generating a first difference to the original model because it was not stationary, the peak export months are February, March, and May, respectively; the first because there is a significant boom every year as a result of the fact that in this month the day of love and friendship is celebrated and orders worldwide multiply, and the third for Mother's Day.

Key Words: econometrics, Ecuador, exports, natural flowers, seasonality, SARIMA model, GARCH model.

Las exportaciones de flores naturales como variable macroeconómica presentan comportamientos o patrones repetitivos, el objetivo de esta investigación es obtener un modelo econométrico GARCH del comportamiento estacional de las flores ecuatorianas en el mercado internacional. La metodología aplicada fue descriptiva con enfoque mixto y énfasis cuantitativo a un total de 259 datos mensuales desde enero del año 2000 hasta julio del año 2022. Para este estudio se utilizó la metodología de series de tiempo Box – Jenkins o ARIMA estacional conocida como SARIMA (Seasonal Autoregressive Integrated Moving Average Model) mediante el programa Eviews 9. Los resultados demostraron que la aplicación de un modelo GARCH a uno estacional fue adecuado para pronosticar cinco datos fuera de la muestra luego de generar una primera diferencia al modelo original por no ser estacionario y donde se aprecia que los meses donde alcanza la cima de exportaciones son de febrero, marzo y mayo respectivamente; siendo el primero porque existe un auge importante cada año producto de que en este mes se celebra el día del amor y la amistad y los pedidos a nivel mundial se multiplican y el tercero por el día de la madre.

Palabras clave: trabajo estándar; metodología 5S; productividad.

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Introduction

At the beginning of the 19th century, David Ricardo (1950/1993) **specified** the participation of economies in the international context and the benefits through their specialization in those goods that present comparative advantages, which in the Ecuadorian context is beneficial due to the **geographic location** for flower production (Moreno et al., 2016); therefore, an economy with a favorable trade balance helps economic growth (Zack & Dalle, 2015, as cited in Aguilar et al., 2020). Consequently, it is important to analyze exports, because according to Gladys Mireya Valero Córdoba et al. (2016), they represent the capacity of an economy to produce goods that will cross national borders to satisfy the needs of international economies and are related to what José Elías Durán Lima and Mariano Álvarez (2008) **consider** exports are the sales of goods and services by residents of one economy to others from another economy and that **they are** equivalent to the production not consumed in the country.

Ecuador, in particular, has great natural resources such as bananas, cocoa, shrimp, flowers, etc., and some of them have experienced important booms[1] throughout the country's agroeconomic history (Cedillo Villavicencio et al., 2021). **However,** these goods are seasonal and respond to certain characteristics of the national and international market for their commercialization.

To model and forecast the behavior of a variable such as exports, there are several methodologies**, each one being more rigorous than the other and crucial for econometric analysis**. In this particular case, the one based on the historical behavior of the export **variable was chosen**, its level of volatility and its period of seasonality, using Generalized AutoRegressive Conditional Heteroscedasticity (GARCH), which is part of the family of ARCH models that use maximum likelihood **estimation of parameters** (Espinosa Acuña & Vaca González, 2017).

The seasonality condition allows identifying certain patterns that are repetitive for some variables such as exports (X) of natural flowers, **toy sales,** seasonal illnesses due to climate changes, etc. The flowers of Ecuador are among the best in the world. Their characteristics are mainly: thick stems and large extension, large buds and bright colors. In addition, the great distinguishing feature of the Ecuadorian rose is its long vase life after cutting (Subgerencia de Análisis e Información, 2017). Among the varieties are: Gypsophila, carnation, roses, lilies, and others. According to **the National Institute of Statistics and Census, according to** the International Standard Industrial Classification, flowers fall under code A0119.03 "**Growing of flowers"** ¿, including the production of cut flowers and flower buds (Instituto Nacional de Estadísticas y Censos [INEC], 2012). This classification is used by the Central Bank of Ecuador to prepare the statistics used in this research (Banco Central del Ecuador [BCE], n.d.).

According to the National Finance Corporation, in 2017 there were 204 companies whose economic activity was the cultivation of flowers, located mostly in Pichincha with 77%. In 2018, of the 208 companies, 74% **were** also located in this same province. In 2019, of the 181 companies registered with the Superintendence of Companies, 74% **remained** in Pichincha, and according to 2020, of the 237 companies, 73% **continued** their economic activity in Pichincha, followed by Cotopaxi as the most representative (Subgerencia de Análisis e Información, 2017). The industrialization process of this sector demands important sources of economic resources and, as we have seen, there is a high concentration of companies in the highlands due to the high **(Henao et al., 2022)** of companies in the highlands due to climatic conditions and irrigation water (Mena Vásconez et al., 2017). Table 1 shows the classification of the companies dedicated to this activity.

In Table 2, in the last four years, the highest number of employees **was** recorded in **year** 2018 with 33,494 people **employed** in the flower sector, **followed by 29,867 in 2017, 28,775 in 2020, and 25,177 in 2019.**

With respect to production and harvested area, **their** evolution over the last five years can be seen in Illustration 1, taking into account that the rose is the **most sold species** in the local and international market.

Flowers are a non-traditional export product for Ecuador[2], whose figures for the last 13 years, including the current year 2022, are shown in Illustration 2, which highlights that in 2021 they grew by 12%

1. The case of cocoa had two great booms in the periods of 1763 - 1840 and 1870 - 1920 respectively. In the case of banana, its greatest production occurred in the 50s - 60s, and the oil boom in the 70s that contributed important income to the economy.

2. Flowers are the third non-traditional export product from Ecuador, after mining products and canned fish. According to the BCE (2023), to March 2023, 83 million dollars, equivalent to 14 thousand metric tons of natural flowers, were exported.

Table 1
Classification of companies by size in Ecuador

	Number of companies			
Size of the company	**2017**	**2018**	**2019**	**2020**
Large	54	0	32	35
Medium	83	69	53	80
Small	39	35	43	55
Micro	28	59	53	65
ND	0	45	0	2
Total	**204**	**208**	**181**	**237**

Source: Subgerencia de Análisis e Información (2018), Subgerencia de Análisis de Productos y Servicios (2019, 2020, 2021).
Prepared by: Authors

Table 2
Classification of companies by number of employees

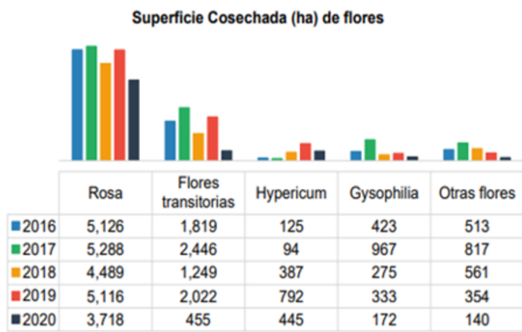
	Number of employees			
Size of the compaῆy	**2017**	**2018**	**2019**	**2020**
Large	22750	0	18039	18851
Medium	6435	7646	5689	8074
Small	549	954	1147	1502
Micro	133	349	302	348
ND	0	24545	0	0
TOTAL	**29.867**	**33.494**	**25.177**	**28.775**

Source: Subgerencia de Análisis e Información (2018), Subgerencia de Análisis de Productos y Servicios (2019, 2020, 2021) .

Illustration 1

Flower Crop Production

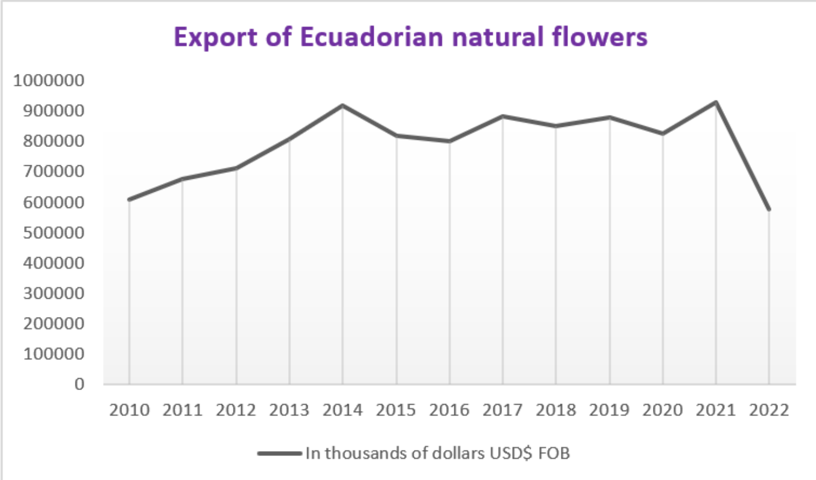
Harvested Area of Flowers



Source: Subgerencia de Análisis e Información (2018), Subgerencia de Análisis de Productos y Servicios (2019, 2020, 2021)

Illustration 2
Export of Ecuadorian natural flowers

YEARS	In thousands of dollars USD$ FOB
2010	607.765,1
2011	675.678,6
2012	713.502,1
2013	808.134,7
2014	918.242,0
2015	819.939,1
2016	802.461,3
2017	881.461,6
2018	851.930,8
2019	879.778,9
2020	827.142,1
2021	927.276,1
2022	576.337,0



Source: BCE: annual statistics. Prepared by: Authors

compared to 2020, when flower exports fell to $827,142.1 as a result of the decrease in demand for many exportable products due to the effects of the COVID-19 pandemic [3].

The main destinations of Ecuadorian exports in 2021 were: United States with 37%, Russia with 14%, Holland with 10%, Ukraine and Italy with 3%, Canada with 4% and the rest of the world with 29%, (Subgerencia de Análisis de Productos y Servicios, 2021) therefore, the trade balance for this product is favorable, including the year 2020, which was $827 thousand dollars FOB due to the limited import of flowers from the world. With respect to imports (M) to the year 2019 there was a highly significant value in its historical evolution, reaching $255,036.85 FOB imports, being the countries of Colombia with 99% and China with 1% respectively the countries of origin to the years 2020 and 2021. The financing received by this sector comes in 93% from Private Banks and 7% from the Public; the latter, through the National Finance Corporation mostly in the province of Pichincha with 56%, followed by Cotopaxi, Imbabura, Carchi and Cañar with 16%, 14%, 8% and 6% respectively between 2018 and 2021 (Subgerencia de Análisis de Productos y Servicios, 2021).

Finally, the article is structured as follows: a section **with an introduction on** the importance of the analysis of the Ecuadorian export sector, the next section contains the GARCH methodology applied to the historical series extracted from the Central Bank of Ecuador. Also; in the results section the calculated seasonal model and the stationarity tests are shown, in the discussion section some studies related to the floriculture sector and finally the section on conclusions and recommendations for future research related to the prediction of economic variables.

Justification

It is important for students, teachers and the scientific community to analyze the behavior of a seasonal economic variable such as exports of Ecuadorian natural flowers, since it allows us to study, analyze and understand its cyclical component related to international demand, especially in the months of February and May of each year while in the rest of the months exports fluctuate, an essential condition of the GARCH volatility models, which at a macroeconomic level allow the construction of scenarios based on public policies

3. The world economy was affected by the COVID-19 pandemic, in particular in Ecuador a 6-month lockdown was decreed on March 19, 2020, which produced unemployment and a reduction in most macroeconomic indicators such as exports, particularly natural flowers.

of incentives or benefits for economic sectors that boost the economy between them the agricultural one.

The practical application of this type of models is reflected in several disciplines; for example, Olga Formigoni Carvalho Walter et al. (2013) analyzed the influence of prices on motorcycle sales using a SARIMA forecast model (1,0,1) $(2,1,0)_{12}$. On the other hand, Juan Tudela Mamani et al. (2022) studied the demand for tourists to Peru, through a seasonal ARIMA model, with characteristics (1,1,1) $(0,1,1)_{12}$ that captured the cyclical essence of tourism for decision making as well as that Thushara et al. (2019) who agreed that tourism in Sri Lanka has grown, generating foreign exchange and employment, the prediction of which was possible through the use of a SARIMA model (3,1,3) $(2,1,2)_{12}$. For their part, Wanderson de Paula Pinto et al. (2015), in their study on the flow of the Doce River and its seasonal behavior, obtained a SARIMA model (1,1,1) $(1,1,2)_{12}$ for the management of the Municipality of Colatina in the prevention of possible natural disasters. Regarding the application in the agricultural sector of Submedio the Valley of São Francisco River in Brazil, on the export of mango, the price of this fruit could be related through a SARIMA model (4,1,1) $(0, 1,3)_{2}$ of biannual seasonality for the determination of public policies related to subsidies to producers (Lima et al., 2013). Concerning the environment, Claudionor Ribeiro da Silva et al. (2018), carried out a study on the recovery forecasts of Caatinga and vegetation areas in the Serra das Capivaras National Park in the state of Piauí - Brazil for the conservation of the biome and determined a SARIMA model (1,2,2) $(0,1,2)_{12}$ for making decisions aimed at protecting natural areas.

In this sense, there are international studies **analyzing** the statistical behavior of this variable. However, the econometric background in Ecuador related to the use of the GARCH methodology is limited and not necessarily oriented to the flower sector, which **highlights** the importance of this research.

Objective

To build an econometric model of the seasonal behavior of Ecuadorian natural flower exports to the international market using the GARCH methodology **to predict economic scenarios that can inform public and private decision-making related to foreign policy.**

Methodology

The research was descriptive and used a mixed approach, where the quantitative analysis was based on the Box - Jenkins (1970) methodology better known as ARIMA (Pérez Cargua, 2017) by studying a seasonal factor that allowed understanding this effect in the longitudinal monthly historical series, corresponding to 259 observations from January 2001 to July 2022, obtained from the (BCE, n.d.) in statistical-documentary form through the econometric program Eviews 9. The application of this methodology began with the specification, verification, prediction, and use of the model **Altamirano, 2021**, which started with the **review** of the original model through the application of stationarity tests to ensure that the series **was** stable and **allowed capturing** the seasonal component for prediction. When this condition **was not met, a first-difference transformation was applied** to the series of natural flower exports to subsequently obtain a robust SARIMA model of monthly frequency (f=12) **which served as the basis for** the GARCH[4] model (1,1) (Javed et al., 2022) model, which was subjected to validation tests for use in forecasting five data points between August and December 2022.

Results

By generalizing the ARMA (p,q) model **by incorporating a difference to make the process stationary** it becomes ARIMA (p,d,q) **to** eliminate the unit root. It is important to consider that the three components of this model are: autoregressive, integration by difference, and moving averages (Fernández Jiménez, 2008;

4. The family of models based on the capture of its historical memory, begin to develop from an ARIMA, SARIMA until use more complex models such as ARCH, GARCH, LGARCH, EGARCH, VGARCH, etc.

Gujarati & Porter, 2010; León Anaya, 2017). The ARIMA equation is as follows:

$$Y'_t = \alpha_1 Y'_{t-1} + \alpha_2 Y'_{t-2} + \dots + \alpha_p Y'_{t-p} - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-q} + U_t \quad (1)$$

By **adding seasonality conditions to** the ARIMA model, two important extensions are derived, which are: SAR and SMA, **which relate to** seasonal autoregressive and moving average processes that together make up the SARIMA model (P,D,Q), where D is the integration process or seasonal difference (Rosales Alvarez et al., 2010). This model allows the variable Yt to correlate with its seasonal lags (Franses et al., 2014).

The seasonal autoregressive variant of the SAR (p,d,q) (P,D,Q)f equation:

$$\Delta_{12} Yt'_t = \alpha_1 Y'_{t-1} + \dots + \alpha_p Y'_{t-p} + \alpha 2 Y_{t-12} + \dots + \alpha_p Y_{t-f} + U_t \quad (2)$$

The seasonal moving average variant of the SMA (p,d,q) (P,D,Q)f equation:

$$\Delta_{12} Yt = -\theta_1 \varepsilon_{t-1} - \dots - \theta_q \varepsilon_{t-q} - \theta_2 \varepsilon_{t-12} - \dots - \theta_q \varepsilon_{t-f} + U_t \quad (3)$$

The SAR and SAM combination in SARMA would be:

$$\Delta_{12} Yt = \alpha_1 Y_{t-1} + \dots + \alpha_p Y_{t-p} + \alpha 2 Y_{t-12} + \dots + \alpha_p Y_{t-f} - \theta_1 \varepsilon_{t-1} - \dots - \theta_q \varepsilon_{t-q} - \theta_2 \varepsilon_{t-12} - \dots - \theta_q \varepsilon_{t-f} + U_t \quad (4)$$

The SARIMA combination (p,d,q) (P,D,Q)f:

$$\Delta_{12} Yt = \alpha_1 Y'_{t-1} + \dots + \alpha_p Y'_{t-p} + \alpha 2 Y_{t-12} + \dots + \alpha_p Y'_{t-f} - \theta_1 \varepsilon_{t-1} - \dots - \theta_q \varepsilon_{t-q} - \theta_2 \varepsilon_{t-12} - \dots - \theta_q \varepsilon_{t-f} + U_t \quad (5)$$

The Garch (p,q) model is mathematically defined as follows (El Jebari & Hakmaoui, 2019) as follows:

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i u_{t-i}^2 + \sum_{i=1}^{p} \beta_i h_{t-i} \quad (6)$$

The GARCH model (generalized autoregressive conditional heteroscedastic conditional model) uses the variance and its lags (u_{t-i}^2) where β is the volatility factor and α the shocks that affect the model and it is required that:

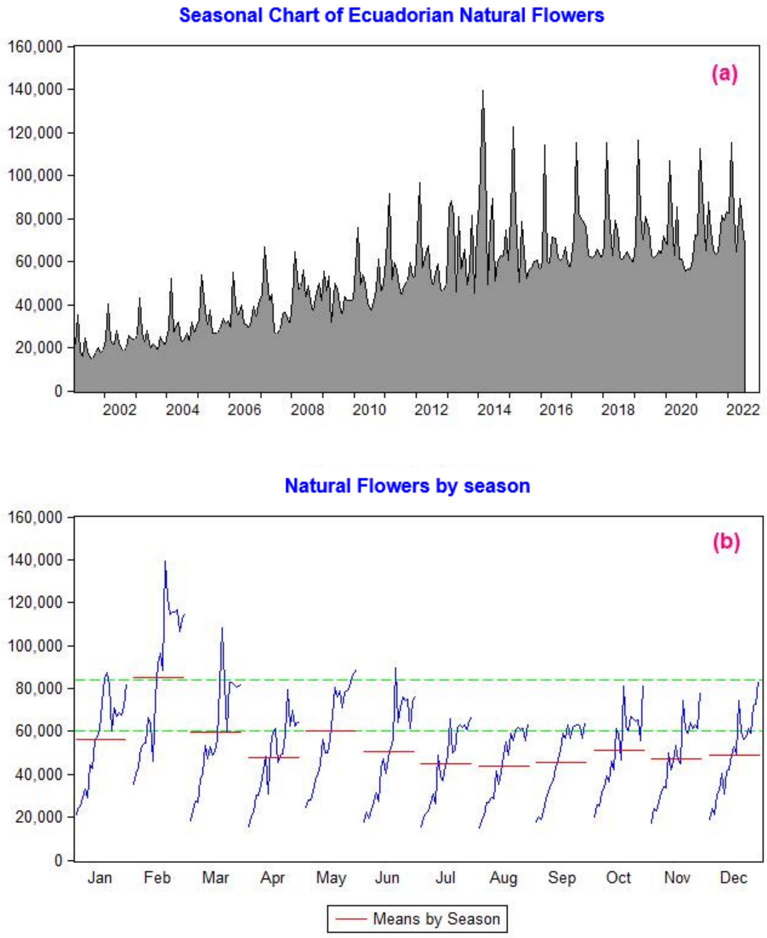
$$\sum(\alpha + \beta) < 1 \text{ to be stationary} \text{ and in the model } C>0 \quad (7)$$

When analyzing the original series in Illustration 3 (a), it is possible to observe values that exceed the **average values** and **indicate** seasonal characteristics that are repeated **each period of** the historical series under study.

By obtaining a graph in Eviews that breaks down the seasonality of the export series, it is possible to **observe** monthly periods that experience high FOB values, such as February, March, and May **throughout** the entire statistical series; and, in the case of Ecuador, it **corresponds** to events such as **Valentine's Day** as well as Mother's Day, **when** sales experience their highest economic growth internationally, and that according to Reinoso (2016, as cited in Cedillo Villavicencio et al., 2021), there are periods of high demand at high prices as well as low demand for the product, generating low export values to the Ecuadorian economy as is shown in Illustration 3 (b).

The ARIMA methodology begins with the specification, i.e. the evaluation of the natural flower export series and the contrasts that were applied: Dickey Fuller Augmented (DFA), Phillips Perron (PP), Kiatkowski, Phillips, Schmidt and Shin (KPSS) and Elliott Rotheberg and Stock (ERS) (Altamirano, 2021).The results are presented in Table 3**.**

Illustration 3
Seasonal Chart of Ecuadorian Flowers



Prepared by: Authors

Table 3
Contrasts to determine the stationarity of the flower export series[5]

CONT.	HYPOTHESIS	EXPECTED	DECISION RULE	VALUE	DECISION
ADF	Ho: Unit Root	Reject **Ho**	p < 0.05 t-stat = - 3,456950	p= 0.6910 t-stat = -1,162345	No Rejection Ho
PP	Ho: Unit Root	Reject **Ho**	p < 0.05 t-stat = -3,455585	p= 0.0000 t-stat = -6,433712	Rejection Ho
KPSS	Ho: Stationarity	**NO** reject **Ho**	Vcal = 2,139727	Vcr = 0.739000 al 99% de confianza	Rejection Ho
ERS	Ho: Unit Root	Reject **Ho**	Vcal = 160,0209	Vcr = 1,933600 al 99% de confianza	Rejection Ho

Source: Altamirano (2021) . Prepared by: Authors

5. The KPSS and ERS contrasts are of high power and allow to distinguish a stationary series and the absence of unit roots, while the ADF and PP tests are of low power.

As can be seen, the series is not stationary; therefore, it requires a transformation process through a first difference **to allow** the mean to be zero, E(wt)=0, and the variance **approximately constant**, Var(wt)=σ^2, a process known as white noise (Hamilton, 1994; Morales Oñate, n.d.). We therefore proceed to evaluate the criteria again in Table 4.

With these data, we proceed to determine the appropriate model **and verify it** according to the Box-Jenkins methodology, as shown in Table 5.

As can be seen, 11 models were obtained, **and we proceeded to verify** the one whose coefficients are significant, as in the case of models 1, 5, 6, 7, and 10, whose probability (p < 0.05**. Through** the application of the validation criteria Akaike (AIC), Schwarz (BIC)**,** and Hannan-Quinn (HQ), the one with the smallest coefficient was chosen as technically adequate (Sánchez Verdezoto, 2021), as can be seen in the records of Table 6.

According to the evaluation shown in Table 6, the model that technically **fits best** is model 10. **While,**

Table 4
Contrasts to determine the stationarity of the Differentiated Flower Export Series

CONT.	HYPOTHESIS	EXPECTED	DECISION RULE	VALUE	DECISION
ADF	Ho: Unit Root H1: No Unit Root	Reject Ho	p < 0.05 t-stat = - 6,495554	p= 0.0000 t-stat = -3,456950	Rejection Ho
PP	Ho: Unit Root H1: No Unit Root	Reject Ho	p < 0.05 t-stat = -3,455685	p= 0.0000 t-stat = -25,49209	Rejection Ho
KPSS	Ho: Stationarity H1: No Stationarity	NO reject Ho	Vcal = 0,014261	Vcr = 0.739000 al 99% de confianza	No Rejection Ho
ERS	Ho: Unit Root H1: No Unit Root	Reject Ho	Vcal = 395,0402	Vcr = 1,933200 al 99% de confianza	Rejection Ho

Source: Altamirano (2021). Prepared by: Authors

Table 5
Significance of the coefficients of the proposed models

	ar(1)	ar(2)	ar(7)	ar(10)	ar(11)	ma(1)	ma(2)	ma(10)	sar(12)	sma(12)
Model 1	**0.0001**					**0.0000**				
Model 2	0.4890	0.8216				0.2679	0.1204			
Model 3	0.8191	0.3011	0.0082			**0.0053**				
Model 4	0.7925	**0.0000**		**0.0000**		**0.0000**	**0.0214**	**0.0000**		
Model 5	**0.0000**	**0.0000**			**0.0000**	**0.0000**	**0.0066**			
Model 6	**0.0032**					**0.0000**				**0.0000**
Model 7		**0.0000**					**0.0000**		**0.0000**	**0.0000**
Model 8	**0.0000**	0.1200				**0.0000**	**0.0000**		**0.0000**	**0.0000**
Model 9	0.1326					0.5051	0.2283		**0.0000**	
Model 10		**0.0001**				**0.0000**			**0.0000**	**0.0000**
Model 11		**0.0001**		**0.0445**		**0.0000**		0.1509	**0.0000**	**0.0000**

Note: Coefficients in color are significant to 95%
Prepared by: Authors

Table 6
Validation Criteria for the models

	AIC	BIC	HQ
Model 1	21,89941	21,9545	21,92156
Model 5	21,95029	22,04669	21,98905
Model 6	21,48571	21,55457	21,5134
Model 7	21,45623	21,53886	21,48946
Model 10	20,91128	20,99391	20,94451
Least criteria	**20,91128**	**20,99391**	**20,94451**

Prepared by: Authors

under the parsimony criterion, the first models could be considered, they would not capture the essence of the seasonality that is intended to be demonstrated in this research.

Model 10: d_ord_export c ar(2) ma(1) sar(12) sma(12)

The model was subjected to unit root analysis, in order to rule out the possibility that the model is unpredictable and can be reliable, as shown in Illustration 4 (a).

In this sense, the model does not contain unit roots and **the analysis of** the residuals through the Durbin-Watson Criterion **allows for the analysis of their independence**, as shown in Illustration 4 (b) (Altamirano, 2021). The Durbin-Watson criterion **is used to determine the independence** of the residuals (Talero Sarmiento et al., 2019):

$$DW = \frac{\sum_{t=2}^{T}(e_t - e_{t-1})^2}{\sum_{t=1}^{T} e_t^2} \quad (8)$$

The DW coefficient **of 1.925606** allows us to accept the null hypothesis of independence of the residuals (Altamirano Pérez et al., 2022). With respect to the analysis of the squared residuals **we observe that** the model suffers from heteroscedasticity, since the probability values are less than 0.05, **and the null hypothesis of** homoscedasticity is rejected (see Illustration 5 (a)).

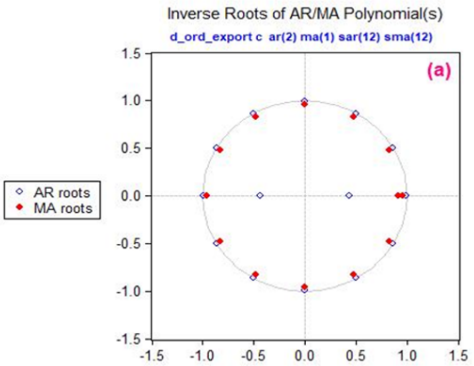
The probability value is less than 0.05 (p<0.05) and **indicates a volatile model**, which is complemented by the heteroskedasticity test in Illustration 5 (b) **with a p-value of 0.0000, which** determines variance problems.

To correct the variance, it has been proposed that the model be structured under the ARCH family of heteroskedastic models developed **in 1982** [6] and its variant or extension GARCH (generalized autoregressive conditional heteroskedastic **model**) (El Jebari & Hakmaoui, 2019), proposed by Bollerslev (1986). **This model abandons** the traditional assumption of normality for the presence of time-varying variance (Javed et al., 2022) to correct these problems that affect the predictive process and **is** based on maximum likelihood criteria. The results of the GARCH model are shown in Illustration 6.

By analyzing the unit root processes, residuals and squared residuals to detect autocorrelation and heteroscedasticity, the problem has been corrected obtaining an acceptable coefficient of determination of 76%.

6. Engle (1982) considers that "these are mean zero, serially uncorrelated processes with nonconstant variances conditional on the past, but constant unconditional variances. For such processes, the recent past gives information about the one-period forecast variance" (p. 987).

Illustration 4



(b)

Dependent Variable: D_ORD_EXPORT
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 09/28/22 Time: 14:04
Sample: 2001M02 2022M07
Included observations: 258
Convergence achieved after 94 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	224.8443	593.8277	0.378636	0.7053
AR(2)	0.188633	0.046819	4.029003	0.0001
SAR(12)	0.965571	0.020736	46.56412	0.0000
MA(1)	-0.912943	0.020761	-43.97328	0.0000
SMA(12)	-0.597849	0.062593	-9.551363	0.0000
SIGMASQ	62868237	3396128.	18.51174	0.0000

R-squared	0.771962	Mean dependent var	178.6063
Adjusted R-squared	0.767437	S.D. dependent var	16636.24
S.E. of regression	8022.786	Akaike info criterion	20.91128
Sum squared resid	1.62E+10	Schwarz criterion	20.99391
Log likelihood	-2691.555	Hannan-Quinn criter.	20.94451
F-statistic	170.6158	Durbin-Watson stat	1.925606
Prob(F-statistic)	0.000000		

Prepared by: Authors

Illustration 5

(a)

Date: 10/02/22 Time: 13:41
Sample: 2001M01 2022M07
Included observations: 258

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.375	0.375	36.643	0.000
		2	0.389	0.289	76.255	0.000
		3	0.220	0.010	88.937	0.000
		4	0.383	0.267	127.66	0.000
		5	0.195	-0.038	137.71	0.000
		6	0.166	-0.066	145.01	0.000
		7	0.090	-0.011	147.19	0.000
		8	0.127	-0.003	151.54	0.000
		9	0.151	0.102	157.70	0.000
		10	0.144	0.059	163.32	0.000
		11	0.161	0.077	170.40	0.000
		12	0.180	0.080	179.28	0.000

(b)

Heteroskedasticity Test: ARCH

F-statistic	41.67686	Prob. F(1,255)	0.0000
Obs*R-squared	36.10310	Prob. Chi-Square(1)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 10/02/22 Time: 13:45
Sample (adjusted): 2001M03 2022M07
Included observations: 257 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	39324540	9937566.	3.957160	0.0001
RESID^2(-1)	0.374882	0.058069	6.455762	0.0000

R-squared	0.140479	Mean dependent var	62978471
Adjusted R-squared	0.137108	S.D. dependent var	1.59E+08
S.E. of regression	1.48E+08	Akaike info criterion	40.47226
Sum squared resid	5.59E+18	Schwarz criterion	40.49987
Log likelihood	-5198.685	Hannan-Quinn criter.	40.48336
F-statistic	41.67686	Durbin-Watson stat	2.216742
Prob(F-statistic)	0.000000		

Prepared by: Authors

Illustration 6

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	242.1386	4.44E+08	5.45E-07	1.0000
AR(2)	0.162323	0.075457	2.151214	0.0315
SAR(12)	1.000000	8.31E-06	120298.2	0.0000
MA(1)	-0.834397	0.039276	-21.24427	0.0000
SMA(12)	-0.390082	0.043335	-9.001633	0.0000
Variance Equation				
C	1420756.	438569.8	3.239522	0.0012
RESID(-1)^2	0.132535	0.030278	4.377237	0.0000
GARCH(-1)	0.839759	0.028407	29.56220	0.0000

R-squared	0.761671	Mean dependent var	178.6063
Adjusted R-squared	0.757903	S.D. dependent var	16636.24
S.E. of regression	8185.591	Akaike info criterion	20.37745
Sum squared resid	1.70E+10	Schwarz criterion	20.48762
Log likelihood	-2620.691	Hannan-Quinn criter.	20.42175
Durbin-Watson stat	2.124502		

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Illustration 7

Correlogram of Standardized Residuals (a)

Date: 10/03/22 Time: 11:06
Sample: 2001M01 2022M07
Included observations: 258
Q-statistic probabilities adjusted for 4 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.066	0.066	1.1453	
		2	0.036	0.032	1.4918	
		3	-0.025	-0.030	1.6601	
		4	0.026	0.029	1.8381	
		5	-0.064	-0.066	2.9151	0.088
		6	-0.031	-0.025	3.1719	0.205
		7	-0.040	-0.031	3.5985	0.308
		8	-0.002	-0.000	3.5999	0.463
		9	-0.070	-0.066	4.9239	0.425
		10	-0.128	-0.126	9.3677	0.154
		11	-0.011	0.007	9.4020	0.225
		12	-0.149	-0.155	15.419	0.051

Correlogram of Standardized Residuals Squared (b)

Date: 10/03/22 Time: 11:08
Sample: 2001M01 2022M07
Included observations: 258

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.013	-0.013	0.0409	0.840
		2	0.020	0.020	0.1450	0.930
		3	-0.020	-0.020	0.2551	0.968
		4	0.020	0.019	0.3570	0.986
		5	0.044	0.045	0.8659	0.973
		6	0.015	0.014	0.9222	0.988
		7	-0.028	-0.029	1.1369	0.992
		8	-0.042	-0.043	1.6204	0.991
		9	0.016	0.015	1.6929	0.995
		10	0.026	0.025	1.8783	0.997
		11	-0.019	-0.021	1.9781	0.999
		12	0.194	0.198	12.220	0.428

Prepared by: Authors

The probability p-values in Illustration 7 (a)**, exceed** the condition of 0.05, **therefore,** there is independence of the residuals. In Illustration 7 (b)**, the p-values similarly exceed 0.05, which certifies** the stability of the model, and **especially when** it is complemented with the Heteroscedasticity Test, which **produced the values shown** in Illustration 8, **These values exceed the 0.05 threshold.**

The next stage **correlates** with the prediction according to the proposed ARIMA methodology. **Therefore, we proceed to determine** the predictability criteria in Illustration 9 (a) **for model 10**.

The criteria that **determine the model's reliability are analyzed**; its mean absolute percentage error (MAPE) is 10%, which means that it can be used **within a moderate range** for forecasting, considering the high volatility that can occur in the international market due to different circumstances that affect **exports of various** Ecuadorian products, as has happened with the pandemic and the current Russian invasion of Ukraine. Illustration 9 (b) shows the results obtained from the technical proposal of using the GARCH model **with** the SARIMA model as a fundamental basis **for** the original data.

The predictions for the next five months, from August to December 2022 **using this model** are shown in Illustration 10 (a) in graphical form.

The projection equation that allows the modelling of this macroeconomic series of exports is detailed below:

D(FLORES_NATURALES) = 242.138613003 + [AR(2)=0.16232307357,SAR(12)=0.999999852079,MA(1)=-0.834397244354,SMA(12)=-0.390081700646,UNCOND,ESTSMPL="2001M02 2022M07"]
GARCH = 1420756.94618 + 0.132534530067*RESID(-1)^2 + 0.839759440725*GARCH(-1)

The model corresponds to a SARIMA (2,1,1) $(1,0,1)_{12}$, where the coefficient ar(1) remains muted in

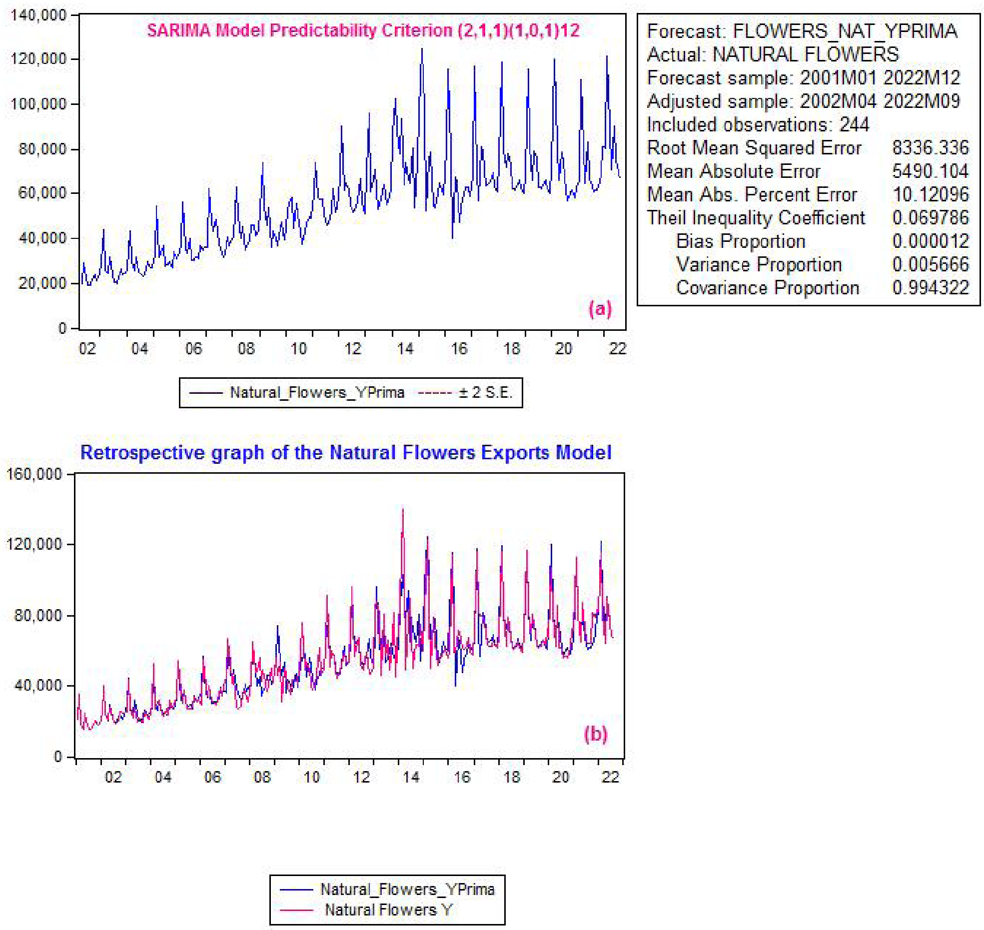
Illustration 8

Heteroskedasticity Test: ARCH

F-statistic	0.040075	Prob. F(1,255)	0.8415
Obs*R-squared	0.040383	Prob. Chi-Square(1)	0.8407

Prepared by: Authors

Illustration 9



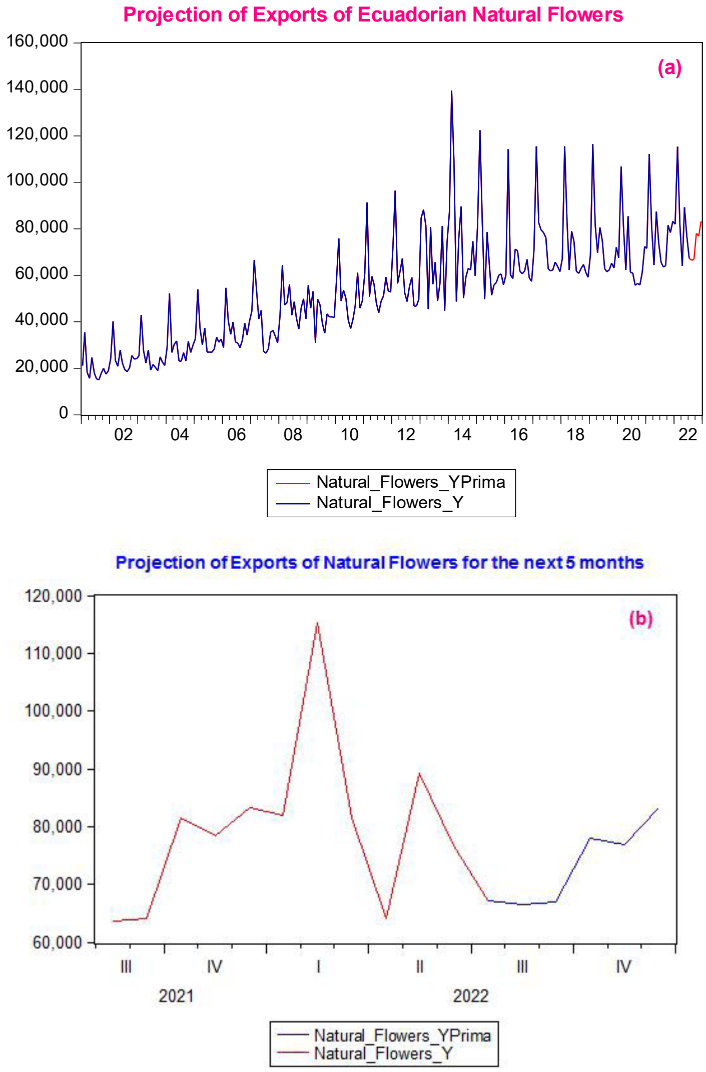
Prepared by: Authors

the model. The projected values for the five out-of-sample data are broken down graphically and numerically in Illustration 10 (b)**, These projections allow for** good growth expectations that will help sustain the national economy by **providing** resources **to support decision-making** related to the use of foreign currency in the General State Budget (PGE).

Discussion

The application of the SARIMA model is **broad**, in this case **applied to** the prediction of exports of Ecuadorian natural flowers, where the SARIMA model (2,1,1) $(1,0,1)_{12}$ indicates that with a moderate MAPE of 10% **meets** the conditions **of** stationarity and **can** be used to predict the last months of the year 2022. On the other hand, in **the investigation of** Carlos Andrés Salazar Bernal (2020) about the relationship of non-traditional exports of Ecuadorian flowers with respect to the economic growth, it is proposed a direct correlation model using ordinary least squares (OLS), obtaining a coefficient of determination of 0.93 to complement his study. Likewise, Josselin Gabriela Heredia Landeta (2023) **conducts** an analysis **of** the comparative advantage that Ecuadorian flowers **had** in the international market **in** the year 2021**This analysis is presented** through

Illustration 10
Graph of the Projection of Ecuadorian Exports



Prepared by: Authors

Table 7

Projected Month	Value
August - 2022.	66.502,08
September - 2022.	66.851,85
October - 2022.	77.999,14
November - 2022.	76.960,28
December - 2022.	83.262,15

multiple linear regression, obtaining a significant correlation of 77.3%; however, **this analysis shows** that flower production is inversely related to competitiveness. **Regarding,** Mayorga Abril et al. (2022) **concur** with the previous authors and **propose** four types of econometric models **using** ordinary least squares (OLS) to measure the competitiveness of Ecuadorian flowers **compared to** Colombian ones; **exported to**) the United States, concluding that in the period 2005 - 2020, **Ecuador's competitiveness decreased by 56.9%**, despite the growth **in figures reported by** the Central Bank of Ecuador and the statistics projected in this investigation.

Álvaro Román Bayona García y Lady Liliana Morales Choez (2019) **considered** two types of models for the analysis of **exports of** canned fish and flowers: a linear probability model (MPL) and a Probit-Logit model, and **identified variables that affect these exports, including** the size of the company, modernization, foreign investment, seniority, and properties; **allowing the identification of public** incentive policies that **benefit** these sectors.

Conclusions

There is evidence that Ecuadorian flower exports are subject to important seasonal influences that affect the economy. This implies that there are periods with **higher and lower** demand for flowers, related to holidays and special events in importing countries. This non-traditional product could be modeled using the Box-Jenkins methodology, obtaining a SARIMA model (2,1,1) $(1,0,1)_{12}$, which, after its evaluation, was suitable for building a GARCH model using **maximum likelihood techniques** that allowed **capturing** the volatile and cyclical characteristics of the monthly time series.

The contribution of GARCH models to governments is essential because they **can directly predict and better manage risks** associated with these variables and foreign policy strategies, which **directly impacts economic** policy decision-making that must consider the influence of external factors such as weather, price fluctuations **as well as** policies and trade agreements with other countries.

Finally, the use of the GARCH methodology in time series analysis has proven to be an effective tool in **government economic policy and in making decisions about** incentive policies associated with seasonal variables of SARIMA models because it can accurately identify and model the volatility of economic data and help governments make more efficient decisions.

Recommendations

The use of this methodology allowed the construction of models that were evaluated until the optimal one was obtained. Nevertheless, it is recommended for future research that the historical series **be** expanded and updated with **more data** so that the average absolute error percentage **decreases** and a model with a higher degree of robustness **can be** obtained.

Additionally, it is recommended that economic variables such as inflation, commodity prices, **and** imports, among others that contain high fluctuations, **be** understood and technically analyzed by the government's economic team, especially during periods of high demand, **when** the government could implement **expansionary** policies to control, facilitate, and promote flower exports, such as reducing red tape, improving logistics infrastructure, and incentivizing farmers to invest. In contrast, during periods of low demand, the government **could** take measures to counteract the effects of the crisis on the economy, diversifying productive investment towards other **agro-export** sectors and promoting, for instance, tourism as a factor of economic growth.

Limitations

The proposed methodology could be stronger **if** complemented with prediction techniques such as neural networks, multiple regression models, VAR models, among others that **enrich** the theoretical-practical scaffolding of applied econometrics.

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