MULTIVARIABLE ANALYSIS OF THE INDUSTRIES THAT MAKE UP GDPAS A RESULT OF THE CRISIS CAUSED BY THE COVID-19 PANDEMIC

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Abstract: This document aims to study the behavior of the industries that make up the Gross Domestic Product (GDP) of Ecuador, in order to demonstrate the incidence that other industries have on Commerce, concerning to the health crisis produced in 2020, which continued in 2021, based on the database published on the official website of the Central Bank of Ecuador (BCE). In order to verify the proposed hypothesis and comply with the objectives established on this document, through the use of the R statistical software, descriptive statistics were carried out to verify the behavior of each one of them over time and, through a linear regression model, identify statistically significant industries; With this information, parametric specifications were applied for k variables; thus, linear regression models, cointegration, autoregressive vectors and k-ways with the STATIS method. Procedure with which it was possible to identify the effects of these variables in moments of crisis and demonstrate that, during the pandemic period, the Commerce industry was affected by the behavior of various industries; and, that other of them present an independent behavior of the regular tendency of the GDP.

Keywords: Gross domestic product; Central bank of Ecuador; Gross Value Added; Autoregressive Vectors; Linear regression; Cointegration; STATIS.

1.Introduction

The current scenario of the Ecuadorian economy presents several difficulties, starting with a high deficit in the current account of the balance of payments, reduction in freely available international reserves, imbalance in fiscal accounts, increase in internal and external public debt , high country risk index hindering access to the capital market, the drop in external competitiveness, among others; and perhaps the most ample excuse for the limited management of the government is the economy recession due to the COVID-19 pandemic.

The situation became more complex, due to various structural circumstances such as low political-administrative credibility, high level of country risk, high level of indebtedness, social problems, including other factors that limited immediate access to more financing (Finanzas, 2020).

Until before the first quarter of 2020, the public administration displayed that it had a very limited margin of maneuver, to be able to diligently deal operationally and technically with the catastrophe that occurred, perhaps a consequence of the fact that our

country has been characterized by maintaining and deepen maneuvers to politicize and deinstitutionalize the Public Administration.

The COVID-19 pandemic, considered the one that has affected the nation the most in recent decades, makes us reflect on the importance of having technically relevant authorities for each position of high authority in the public sphere and, in turn, are truly oriented to the real needs of the population, which today more than ever questions the classic and ineffective political and bureaucratic practices. (ECB, 2021).

The lack of trust in the Public Administration is deepened during the health crisis and, above all, it is characterized by the limited management to face it, which causes the weakening of the bureaucratic apparatus and social acceptance of government management.

It would be expected that the magnitude of the COVID-19 crisis will provide good lessons and allow the present and future of institutions and public service to be redesigned, based on a transparent and sincere political agreement between the various actors.

The manifest lack of capacity of the Public Administration to assertively face the challenges of today's society and, even more so in emergency situations such as the one we are going through due to COVID-19, shows the difficulty in leading processes or stages of crisis; noting that several public institutions and their officials did not act for the benefit of society, but rather, the majority maintained a passive attitude, as was public and notorious from the analysis of different media.

One aspect that today shows singular attention to the development of the Administration and consequently of the country, and which is not being led effectively, is the intensive application of digital technologies; which constitutes a delay in development, by not realizing that we are in the midst of a process of profound technological, economic and social change, and in an accelerated manner due to the COVID-19 crisis; which demands radical transformations to get the country's economy afloat, forcing to innovate the current digital base and create an ecosystem that makes such a purpose viable.

For the exposed; It is pertinent to carry out a detailed analysis of the economy sectors, which for various reasons such as those stated, have been mostly affected by the COVID-19 pandemic; since, the results that are obtained will be able to contribute in a more objective and precise way, the most sensitive groups of society and that require more attention from the public administration.

It should also be noted that not all countries present the same priority or social economic reality, some have medium and high incomes, others low incomes, a situation that leads to making more urgent decisions.

The sectorial composition by industry in the Gross Domestic Product of Ecuador shows a markedly differentiated space between them; which is characteristic of those sectors that can demonstrate vulnerability to crises, mainly due to the sensitivity of the usual activities they carry out, due to the fact that a large part of various productive sectors must be managed in person. (ECB, 2021).

Much of the Ecuadorian economy is characterized mainly by the production of raw materials; that is, it is highly dependent on manufacturing and agriculture, sectors that appear to be the most exposed to the effects of the pandemic. (ECB, 2020).

This research work will demand the application of statistical tools and procedures; Based on the obtained results, it is intended to show that the events that occurred in 2020 are closely related to the reduction in the country's macroeconomic indicators.

Despite the fact that crises occur cyclically, this analysis will focus on comparing the magnitude of the problem in the Ecuadorian economy caused by the pandemic during the years 2020 and 2021, based on historical reports published by the Central Bank of Ecuador. , as part of this statistical analysis; which will facilitate the structuring of a document in which the variations in the results of the national economy are exposed, which allows opening a statistical technical spectrum that protects a better interpretation of reality in the face of the economic crisis in the country.

The results obtained will allow identify which the sector of the economy is most sensitive to crisis scenarios.

According to the Chamber of Industries and Production, the impact of Covid-19 on the Ecuadorian economy has three scenarios, as a consequence of the decrease in demand and the interruption of supply; These analyzes allow to evaluate the losses of more than 69,000 companies; in fact; The First Scenario: the union estimates that, if only the drop in sales in the first half of March 2020 is considered, companies face losses of USD 12,804 million; the Second Scenario: if there is a closure of businesses and therefore the decrease in productivity in the industries, between March 15 and April 15, the decrease in sales would be USD 21,339 million; and, the Third Scenario: the most discouraging scenario will be if the quarantine is not lifted during the entire month of April, the losses would reach USD 32,009 million. (Primicias.ec Portal, 2020).

Among the 20 sectors evaluated by the Chamber of Industries and Production; Commerce registers the worst results; The measures adopted by the National COE, such as mobility restrictions to stop contagion and consumer panic, caused nearly 70% of the businesses in the sector to remain closed, that is, around 7,700 stores without attention since start of quarantine (Primicias.ec Portal, 2020).

During the development of this work, it will be evidenced through the use of statistical tools that the industry most affected in the Ecuadorian economy is Commerce.

2. Materials and Methods

This project will be developed on the basis of the quarterly National Accounts of Ecuador No. 118, published by the Central Bank of Ecuador on its institutional website; From the information of the Quarterly National Accounts Bulletin, the database of the Gross Domestic Product accounts will be used, disaggregated into its components in gross terms by industry, which goes from the first quarter of 2000 to the fourth quarter of 2021, disaggregated by quarterly figures.

The aforementioned data can be found at the following electronic address: https://contenido.bce.fin.ec/home1/estadisticas/cntrimestral/CNTrimestral.jsp

This database contains the results of the sectors of the Ecuadorian economy, through continuous quantitative variables, with a sufficient history that allows responding to the objectives set out in this project and identifying the most sensitive sectors of the macroeconomy, in the face of cyclical situations in the economy. In our country.

The 18 grouped industries, of the macroeconomics, object of the present analysis, plus other elements that make up the GDP, are: Agriculture, Aquaculture and shrimp

fishing, Fishing (except shrimp), Oil and mines, Oil Refining, Manufacturing (except refining oil), Electricity and water supply, Construction, Commerce, Accommodation and food services, Transport, Mail and Communications, Financial services activities, Professional, technical and administrative activities, Education and Social and health services, Public administration, defense ; compulsory social security plans, Domestic service, Other Services; and, additionally, the quarterly inflation rate was incorporated into the analysis.

The analysis of the data will be carried out in the statistical software R, version 4.2.1.

The database that will be used in this document can be found in Annex 1.

TIME SERIES ANALYSIS

To analyze the behavior of the Gross Domestic Product - GDP and how its components were grouped by industry, before and during the COVID-19 pandemic period, time series statistical analyzes will be applied; cointegration models, to establish the linear combination between two or more stationary variables in the long term; vector autoregressive (VAR) models and vector error correction models (VECM) to account for short-term dynamics. Different testing tests will be applied to each model. (Quintana Romero & Mendoza, 2016).

COINTEGRATION

For the econometric analysis, we performed a graphical exploration of the time series in differences. In order to apply the integration model, the series in a difference must be stationary. To verify this, the Augmented Dickey Fuller unit root test (ADF) is applied.

$$Null\ Hypothesis H_0: the\ variable\ x has\ a\ unit\ root$$

$$Alternate\ hypothesis H_1: the\ variable\ \ x\ does\ not\ have\ a\ unit\ root.$$

Unit root processes were generated with the following equations. (Quintana Romero & Mendoza, 2016):

$$Y_t = Y_{t-1} + e_t$$

$$Z_t = Z_{t-1} + V_t,$$

Where $Y_t Y_{t-1} Z_t Z_{t-1} e_t V_t$ are the GDP in quarter t, and t-1, respectively; and Z_t and Z_{t-1} are the value of each variable selected from the GDP industry, y e_t and V_t are error terms.

Once the stationarity assumptions have been verified, two cointegration tests are carried out: the Engle and Grangertest and the Johansen test.

ENGLE AND GRANGER COINTEGRATION TEST

This is one of the tests applied regularly to evaluate the existence of Cointegration; The most general model to estimate, with k minus one variable, in its matrix form is: (Quintana Romero & Mendoza, 2016).

$$Y = XB + U$$

The test is carried out in two steps: (Quintana Romero & Mendoza, 2016).

Perform unit root tests on the regression series to verify that the order of integration is I(1); and, estimate the cointegrating regression.

Expressed this, through the following relationship:

$$Y = X\hat{B} * \widehat{U}$$

If the series are of integration order I(1) and the residuals of the U model are stationary, the variables are cointegrated. (Quintana Romero & Mendoza, 2016).

JOHANSEN'S TEST

For the Johansen test, both the trace statistic and the maximum eigenvalue statistic are used. If both statistics are greater than the critical value of 5 points, we confirm the existence of cointegration.

Johansen's testing process is progressive in its hypothesis testing.

$$Null\ hypothesis H_0: r\ =\ 0\ (there\ is\ no\ cointegration)$$

$$Alternate\ hypothesis H_1: r\ =\ 1$$

If the null hypothesis is rejected, the test proceeds:

$$Null\ hypothesis H_0: r \leq 1\ (there\ is\ a\ cointegration\ relationship)$$

$$Hipótesis\ alternativa\ H_1: r = 2\ (there\ are\ two\ integration\ relations)$$

And so, on up to the number of series.

VECTOR AUTOREGRESSIVE MODEL (VAR) AND VECTOR ERROR CORRECTION MODEL (VECM)

For industries that do not show cointegration, a VAR model is performed in order to explore short-term dynamics.

The VAR (1) model, in its primitive form (Enders, 2010) is shown as follows:

$$y_t = b_{10} - b_{12}z_t + y_{11}y_{t-1} + y_{12}z_{t-1} + \varepsilon_{yt}$$

$$z_t = b_{20} + b_{21}y_t + y_{21}y_{t-1} + y_{22}z_{t-1} + \varepsilon_{zt}$$

Or, in matrix form, it is represented as follows:

$$\begin{pmatrix} 1 & b_{12} \\ b_{21} & 1 \end{pmatrix}\begin{pmatrix} y_t \\ z_t \end{pmatrix} = \begin{pmatrix} b_{10} \\ b_{20} \end{pmatrix} + \begin{pmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{pmatrix}\begin{pmatrix} y_{t-1} \\ z_{t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{pmatrix}$$

Where and are the selected variables of the industry that make up the GDP and the Trade industry, respectively, in quarter t; and the subscript t-1 indicates the quarter t-1. It is equal to:$y_t z_t$

$$\beta x_t = \varphi_0 - \varphi_1 x_{t-1} + \varepsilon_t$$

The vector, groups the endogenous variables, in this analysis, the variables selected from the GDP industry; matrix B represents the coefficients of the contemporaneous effects of the vector; the matrix represents the coefficients of the past effects on y, the vector contains the stochastic effects that alter the variables of the vector; from which, the standard form is obtained: (Quintana Romero & Mendoza, 2016).$x_t x_t \varphi_1 x_t \varepsilon_t x_t$

$$x_t = \partial_0 + \partial_1 x_{t-1} + \varepsilon_t$$

Where:

$$\partial_0 = \beta^{-1}\varphi_0 \qquad \partial_1 = \beta^{-1}\varphi_1 \qquad e_t = \beta^{-1}\varepsilon_t$$

The reference, constitutes a residual component; and, it is assumed that the endogenous variables of VAR(p) satisfy the assumption of stationarity; Therefore, it is possible to visualize through the matrix of the short- and long-term impact multipliers, how stochastic shocks affect the path of the vector of endogenous variables. (Quintana Luis, 2017); which can be appreciated through the following expressions:e_t

$$\begin{pmatrix} y_t \\ z_t \end{pmatrix} = \begin{pmatrix} \bar{y} \\ \bar{x} \end{pmatrix} + \sum_{i=0}^{\infty} \begin{pmatrix} \emptyset_{11}(i) & \emptyset_{12}(i) \\ \emptyset_{21}(i) & \emptyset_{22}(i) \end{pmatrix}\begin{pmatrix} \varepsilon_{yt-i} \\ \varepsilon_{xt-i} \end{pmatrix}$$

Or, generalizing this matrix expression, it remains:

$$x_t = \mu + \sum_{i=0}^{\infty} \emptyset_i \varepsilon_{t-i}$$

Where:

$$\sum_{i=0}^{n} \emptyset_{12}(i) = impactmultiplier.$$

As long as:

$$\sum_{i=0}^{\infty} \emptyset_{jk}^{2}(i) = \text{long} - \text{term or total multiplier.}$$

The VAR model is an important tool for the evaluation of economic policies, since this model shows how each variable affects and is affected by the other variables, this allows analyzing the effects of any variable on another variable. (Quintana Romero & Mendoza, 2016).

By applying this methodology for the estimation of an Autoregressive Vector model, with the use of R statistical software, the behavior of the variables is analyzed; for which, the period between the first quarter of the year 2000 and the fourth quarter of the year 2021 is taken. From this base, a VAR(p) model will be estimated, based on the data obtained from the Web page of the Central Bank of the Ecuador.

The variables under analysis are transformed into a logarithm and subsequently graphed, in order to visually demonstrate whether or not the logarithms present an increasing deterministic trajectory that satisfies the assumption of white noise; which is corroborated by unit root tests. (Quintana Romero & Mendoza, 2016).

To structure the hypothesis test in the VAR methodology, on the Augmented Dickey Fuller unit root (ADF) without constant or trend, proceed as follows:

$$Null\ Hypothesis H_0: the\ variable\ x has\ a\ unit\ root$$

$$Alternative Hypothesis H_1: the variable\ x has\ no\ unit\ route.$$

If the ADF statistical value is positive, it indicates that the logarithm of the variable is not stationary, consequently, the null hypothesis is accepted, that the variable has a unit root. (Quintana Romero & Mendoza, 2016).

To perform the Granger causality tests and determine the causal order between the variables, we use the lmtest library; which, once activated, verifies the direction of causality and lags of one variable over the other and vice versa. (Quintana Romero & Mendoza, 2016).

By using the vars library, the VAR is identified, using information criteria: Akaike (AIC), Hanna-Quin (HQ), Schwarz (SC) and Final Prediction Error (FPE).

It must be kept in mind that, before identifying the VAR, a new object must be created that contains the transformed variables and that these are stationary, which must be transformed as time series. (Quintana Romero & Mendoza, 2016).

To identify the order of the VAR variables, in this study, 4 lags were used according to the aforementioned information criteria (AIC, HQ, SC and FPE); Once the VAR has been identified, the appropriate code is structured in the statistical software R, to obtain the equations that allow the VAR to be modeled.

To confirm whether the estimated VAR satisfies the stability condition, the roots of the characteristic polynomial are obtained; as well as the corresponding statistics to carry out the statistical inference.

After having estimated the VAR statistical model, the Figure of the observed variable versus the estimated one is obtained; as well as the residuals.

Once the behavior of the variables has been evidenced; specification tests are performed; First, we verify the existence or not of serial autocorrelation between the residuals; then, it is verified if the residuals of the estimated VAR are distributed as a normal, based on the results of kurtosis and bias; next, it is verified if the variance of the residuals is homoscedastic or not; Finally, with the Heteroscedasticity test, it is verified that the residuals satisfy the assumption of constant, constant variance, that is, there is no heteroscedasticity (Quintana Romero & Mendoza, 2016).

Regarding the variables that present cointegration, a VECM model is estimated, which is a restricted VAR model that has cointegration restrictions incorporated in the specification in order to incorporate the long-run effect on equilibrium.

PROCEDURE FOR THE ANALYSIS OF THE SHAPE OF THE DISTRIBUTION OF THE INDUSTRIES THAT MAKE UP GDP, FOR K SAMPLES.

In addition to the aforementioned models, a study will be carried out around the multivariate statistical analysis of the data, its representation and interpretation, which result from observing more than one variable on a sample of individuals.

The methods applied for the analysis of multivariate data are applied when working with a set of related variables on a set of individuals; that is, they work with tables of individuals by variables and by conditions (Vicente Galindo, 2013).

The k-way multivariate methods are used for studies with original databases; that is, that adjustments are made directly to the data and the modes are analyzed symmetrically, since, in the end, they result from the distributions that were obtained from the factorial analysis or, through the application of tables or cross-product nuances. (Vicente Galindo, 2013). This paper will focus on the multivariate STATIS methods, since they are the most applied in research.

The Figure representation of data matrices is generalized as follows:

$$X_t = \left(X_{ij}^t\right)$$

Where:

$X_t = tMatrices$

$\left(X_{ij}^t\right) = Information(ij)\ of each matrix at a specific time.$

The statistical information, in multivariate analysis, will be of a multidimensional nature; therefore, geometry, matrix calculus and multivariate distributions play a fundamental role in this project.

A K-way analysis will be applied, using the X-STATIS method, on a set of individuals, measured on the same set of industries in the economy, comprising the same variables, in different periods of time; focusing attention on the positions of individuals.

The aforementioned procedure will consist of carrying out an individual analysis of each data matrix and, later, incorporating into the procedure the structure of the information over time.

In the stages of the STATIS method are; firstly, the calculation of the matrix of vector correlations between matrices; then, the spectral decomposition of the vector correlation matrix will be carried out to proceed with the projection and interpretation of the resulting factorial diagram; With this reference, the consensus matrix is calculated as a weighted average and, finally, the analysis of the observed trajectories. (Gonzalez, 2020).

The consensus matrix only reflects the structure of those matrices highly correlated with the first eigenvector of the matrix of vector correlations. (Gonzalez, 2020).

Multiple factor analysis examines information from a single group of individuals on whom different sets of variables are observed.

The applied methodology of the STATIS method weights all the variables of a matrix that is associated with the commitment, by an initial value that amplifies its original value. (Gonzalez, 2020). It is a question of finding a compromise matrix that, globally, approximates the matrix of crossed products, in order to maximize the criterion, for a determined set of weights. (Gonzalez, 2020).

The information collected in T matrices of order I x J; where I, J, T are the number of respective categories and are observations for all individuals, on all variables, in all experimental conditions or on all occasions. (Galindo, 2013).

3.Results

3.1. Descriptive Analysis

Table 3.1., Presents the summary of the data of the GDP and of each industry of the economy. As can be seen, the GDP during the time analyzed has reached a minimum value of USD 9,134,587 and a maximum of USD 18,083,933. The industries related to oil, construction and commerce in nominal terms present a greater contribution to the Ecuadorian GDP while the industries with less nominal contribution are domestic services and fishing except shrimp.

Table 3.1. Descriptive statistics GDP industries.

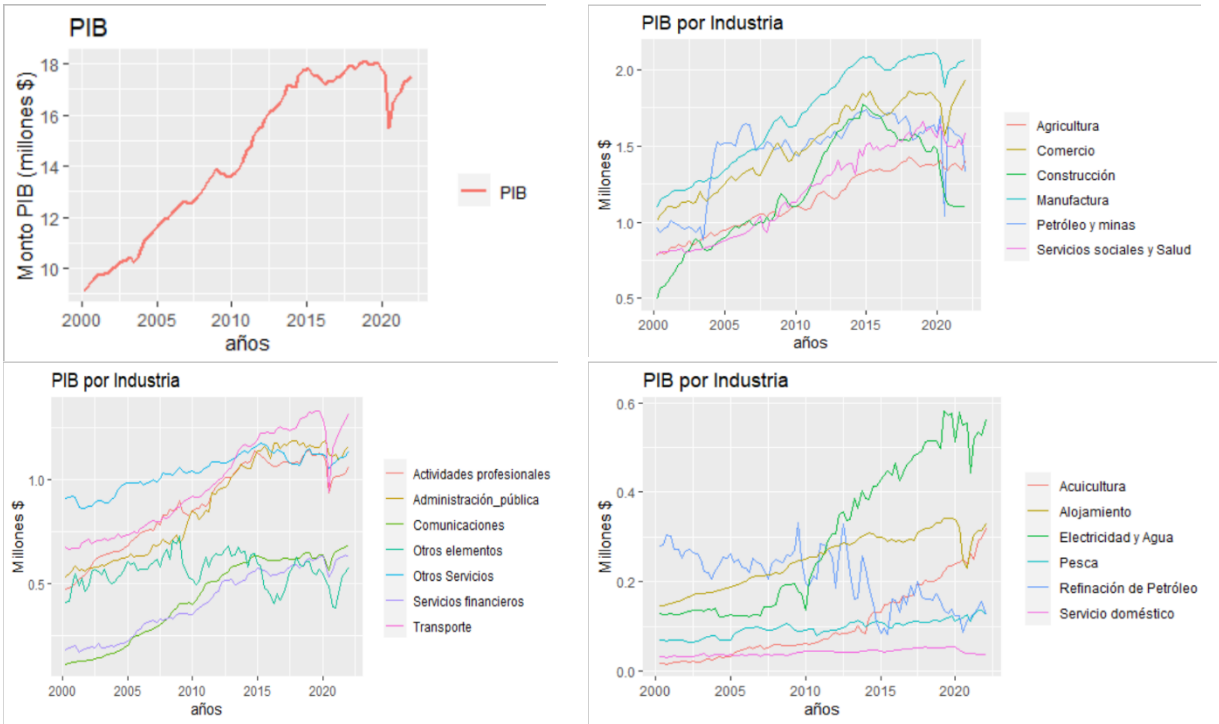
GDP INDUSTRIES.	Min.	1st Qu.	Median	mean	3rd Qu.	Max.
Agriculture	787,431	972,901	1,114,411	1,138,467	1,341,178	1,426,246
Aquaculture and shrimp fishing	16,938	47,934	70,256	105,800	167,593	320,315
Fishing except shrimp	66,252	84,288	97,482	96,727	109,283	137,835
oil and mines	880,806	1,468,923	1,542,232	1,465,331	1,634,864	1,737,371
Petroleum refining	83,624	160,158	222,010	209,276	256,807	332,096
Manufacturing except petroleum refining	1,094,728	1,395,907	1,770,429	1,711,361	2,043,077	2,111,869
Electricity and water supply	121,724	135,753	256,968	300,310	450,519	581,862
Construction	499,868	957,928	1,131,312	1,207,721	1,541,505	1,775,774
Trade	1,013,488	1,291,222	1,523,292	1,514,382	1,767,937	1,931,225
Accommodation and food services	145,793	197,184	255,472	250,197	297,496	342,748
Transport	666,729	750,081	943,629	983,662	1,225,036	1,332,743
Mail and Communications	115,360	251,213	503,254	432,782	619,496	689,628
financial services activities	173,319	271,168	410,310	415,424	562,672	641,345

Technical and administrative professional activities	473,536	726,955	894,931	886,451	1,078,893	1,147,239
Education and social and health services	793,400	905,264	1,243,112	1,205,641	1,499,300	1,662,759
Public administration defense of compulsory social security plans	535,146	635,225	853,968	881,202	1,138,715	1,189,560
Domestic service	31,138	36,822	42,603	42,215	46,530	55,115
Other services	863,720	984,499	1,061,028	1,042,331	1,116,850	1,180,118
OTHER ELEMENTS OF GDP	383,818	512,339	569,364	561,959	609,931	730,917
GDP	9,134,587	11,948,037	14,709,728	14,451,240	17,338,299	18,083,933

Prepared by: The author.

The evolution over time during the period of 2000 and 2021 of the GDP and each of the industries that compose it is shown below in figure 3.1., you can notice a growing trend of the GDP and the industries of the Ecuadorian economy, with very similar falls, particularly in periods of economic and/or political crisis, in the years 2003, 2009, 2015, 2018, 2019 and 2020, except industry, other elements of GDP and oil refining, which by their nature set their own trend. Especially during the 2020 crisis, caused by the COVID 19 pandemic; all industries in the economy are affected, although not in the same proportion.

Figure 3.1. Evolution of GDP and its industries during the period 2000 - 2021.



Prepared by: The author.

3.2. Cointegration

This section seeks to analyze which industries maintain a long-term equilibrium with GDP. This will serve to identify the industries that influence GDP falls in times of crisis, not only in nominal terms but also in their behavior, since they show a common stochastic trend.

Table 3.2 shows the ADF tests to verify stationarity in the first difference of the logarithm of GDP and the industries that comprise it. At 5% significance, the assumption is verified that the GDP series and the industries that compose it are integrated of order

1, that is, stationary after a first difference. Therefore, we can proceed to estimate the cointegration models.

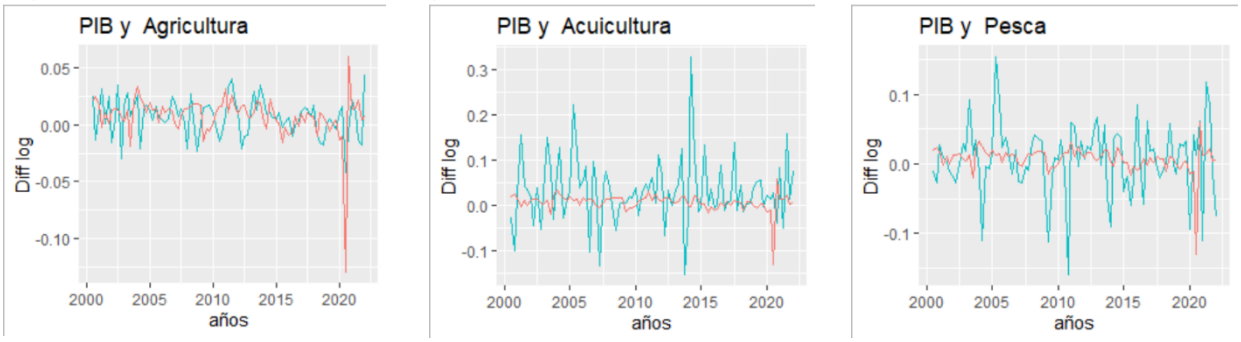
Table 3.2. ADF single root proof in the first difference.

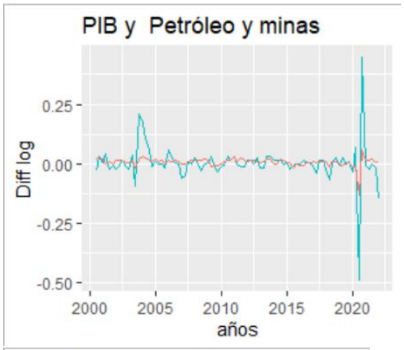
	ADF	P-value
Δlog(GDP)	-8.9183	<0.001
Δlog(Agriculture)	-7.1292	<0.001
Δ log(Aquaculture and shrimp fishing)	-8.7348	<0.001
Δ log(Fisheries except shrimp)	-8.0273	<0.001
Δ log(Oil and mines)	-12,542	<0.001
Δ log(Oil Refining)	-9.3836	<0.001
Δ log(Manufacturing except oil refining)	-7.7293	<0.001
Δ log(Electricity and water supply)	-10,866	<0.001
Δlog(Construction)	-5.4198	<0.001
Δlog(Trade)	-7.2108	<0.001
Δ log(Accommodation and food services)	-7.7382	<0.001
Δlog(Transport)	-10,757	<0.001
Δ log(Mail and communications)	-5.9564	<0.001
Δ log(Financial services activities)	-8.4429	<0.001
Δ log(Technical and administrative professional activities)	-9.3028	<0.001
Δ log(Education and Social and Health Services)	-11,822	<0.001
Δ log(Public Administration defense of mandatory social security plans)	-8,759	<0.001
Δ log(Domestic service)	-9.1225	<0.001
Δ log(Other Services)	-6.6785	<0.001
Δ log(Other elements of GDP)	-8.0811	<0.001

Prepared by: The author.

A preliminary graphical analysis of these series is shown in figure 3.2., where it can be observed that the variables Aquaculture, Fishing, Oil Refining, Electricity and Water and Other elements of GDP maintain a much greater variability throughout the period studied. to GDP. On the contrary, the Agriculture, Manufacturing, Commerce, Accommodation and Transport industries have a variability very similar to that of GDP. Regarding the negative variation of GDP in 2020, the industries that show a similar drop are Manufacturing, Commerce, Financial Services and Domestic Service. It should be noted that the industries that had a drop even more pronounced than total GDP were Transportation, Lodging, Professional Activities, and Oil and Mining. The latter, although it had a strong fall in 2020,

Figure 3.2. First difference of the logarithm of GDP and industries.




PIB y Petróleo y minas
Diff log
0.25
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-0.25
-0.50
2000
2005
2010
2015
2020
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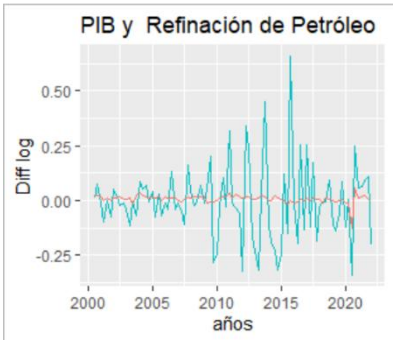
PIB y Refinación de Petróleo
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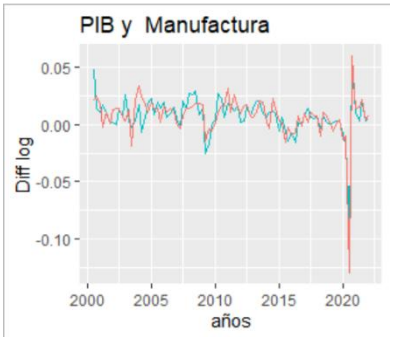
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Diff log
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2005
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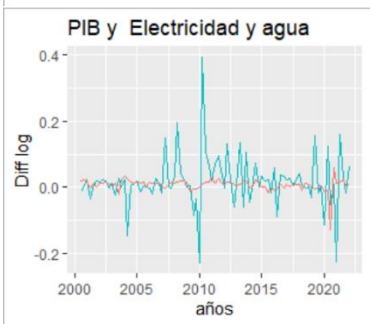
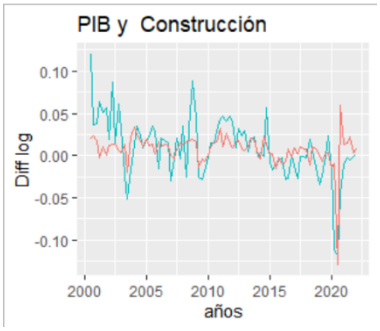
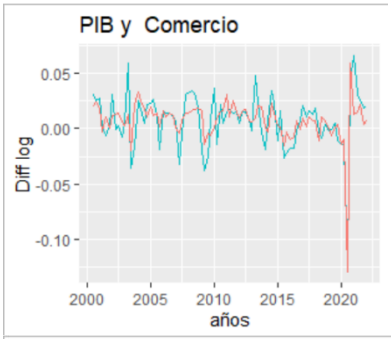
2015
2020
años


PIB y Electricidad y agua
Diff log
0.4
0.2
0.0
-0.2
2000
2005
2010
2015
2020
años


PIB y Construcción
Diff log
0.10
0.05
0.00
-0.05
-0.10
2000
2005
2010
2015
2020
años


PIB y Comercio
Diff log
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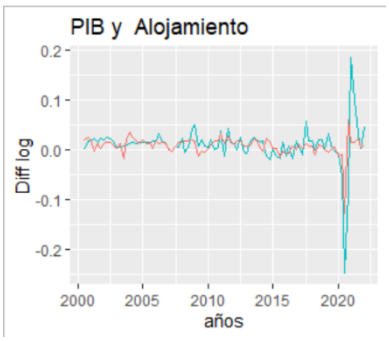
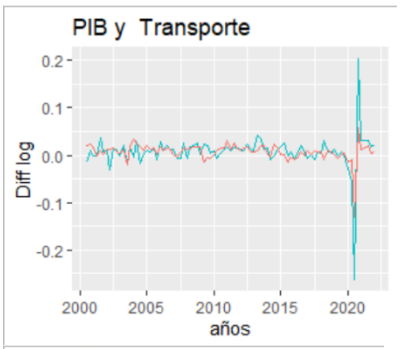
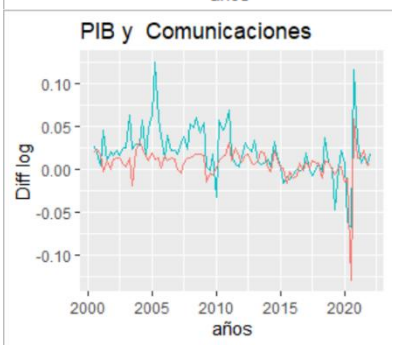
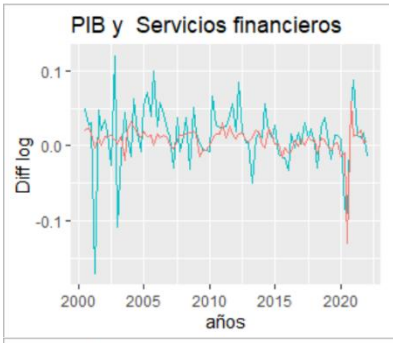
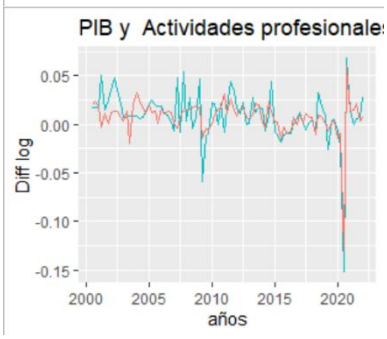
0.00
-0.05
-0.10
2000
2005
2010
2015
2020
años

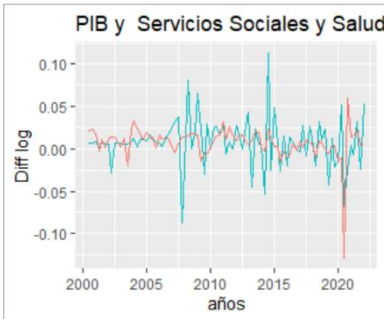

PIB y Alojamiento
Diff log
0.2
0.1
0.0
-0.1
-0.2
2000
2005
2010
2015
2020
años

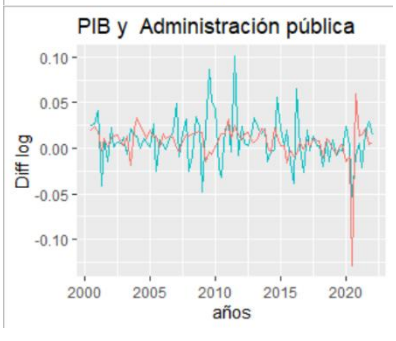

PIB y Transporte
Diff log
0.2
0.1
0.0
-0.1
-0.2
2000
2005
2010
2015
2020
años

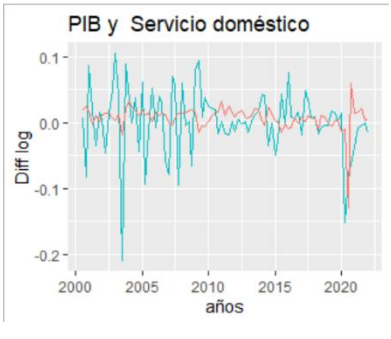

PIB y Comunicaciones
Diff log
0.10
0.05
0.00
-0.05
-0.10
2000
2005
2010
2015
2020
años

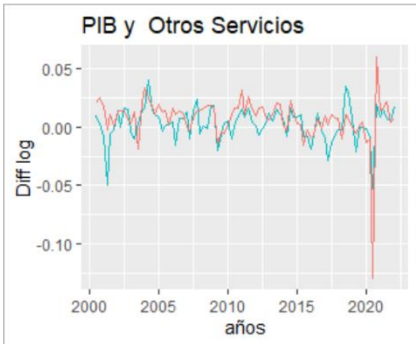

PIB y Servicios financieros
Diff log
0.1
0.0
-0.1
2000
2005
2010
2015
2020
años

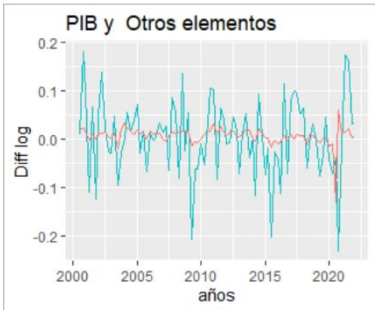

PIB y Actividades profesionales
Diff log
0.05
0.00
-0.05
-0.10
-0.15
2000
2005
2010
2015
2020
años


PIB y Servicios Sociales y Salud
Diff log
0.10
0.05
0.00
-0.05
-0.10
2000
2005
2010
2015
2020
años


PIB y Administración pública
Diff log
0.10
0.05
0.00
-0.05
-0.10
2000
2005
2010
2015
2020
años


PIB y Servicio doméstico
Diff log
0.1
0.0
-0.1
-0.2
2000
2005
2010
2015
2020
años


PIB y Otros Servicios
Diff log
0.05
0.00
-0.05
-0.10
2000
2005
2010
2015
2020
años



Prepared by: The author.

To confirm the industries that show a long-term equilibrium with the total GDP, the cointegration analysis is carried out below.

3.2.1. Engle–Granger test

Using the Engle-Granger methodology, a simple linear regression model is estimated between the two integrated series of order 1 and if the model residuals are stationary, then it is confirmed that there is cointegration between the two-time series. Table 3.3 shows the ADF unit root test for the residuals of each of the 19 models, checking whether the GDP series and each industry are cointegrated.

Table 3.3. ADF unit root test for residuals.

Model residuals: log(GDP) ~	ADF	P-value
log(Agriculture)	-2.6074	0.0958
log(Aquaculture and shrimp fishing)	-1.0745	0.7222
log(Fish except shrimp)	-2.4174	0.1403
log(Oil and mines)	-0.9127	0.7793
log(Oil Refining)	-2.9927	0.0400
log(Manufacturing except petroleum refining)	-2.5602	0.1057
log(Electricity and water supply)	-2.6641	0.0849
log(Build)	0.86072	0.9945
log(Trade)	-3.9461	0.0028
log(Accommodation and food services)	-3.9519	0.0027
log(Transport)	-2.3118	0.1709
log(Mail and Communications)	-1.9443	0.3107
log(Financial Services Activities)	-1.8455	0.3562
log(technical and administrative professional activities)	-2.2074	0.2054
log(Education and social and health services)	-3.1505	0.0269
log(Public Administration defending mandatory social security plans)	-2.7902	0.0643
log(Home Service)	-1.8249	0.3660
log(Other Services)	-3.1465	0.0272
log(Other elements of GDP)	-2.5159	0.1156

Prepared by: The author.

At 5% significance, based on this criterion, the industries that present a common stochastic trend with GDP are Oil Refining, Commerce, Accommodation and food services, Education and Social and health services; and Other Services.

The same analysis with the time series up to the year 2019, reveals that the agriculture (Residues: ADF= -3.4565, value p= 0.012) and Fishing (Residues: ADF= -3.112, value p= 0.031) industries also kept a cointegration ratio with total GDP before the pandemic based on this criterion. However, as seen in figure 1, these industries were not hit as hard in 2020 relative to other industries.

3.2.2. Johansen–Joselius cointegration

To employ the Johansen-Joselius method, the trace statistics and the maximum eigenvalue with a constant are used. Table 3.4., shows the results where it is observed that all the industries with the exception of Oil and mines, Construction and Financial services activities have at least one cointegration relationship with GDP. Additionally, Fishing except shrimp, Trade, Professional Activities, Other Services and Other Elements of GDP have two cointegration relationships.

Table 3.4. Johansen's cointegration test

	Hypothesis	trace		Own value	
		test	Critical Value 5%	test	Critical Value 5%
log (Agriculture)	r<=1	9.08	9.24	9.08	9.24
	r=0	34.41	19.96	25.33	15.67
log (Aquaculture and shrimp fishing)	r<=1	3.67	9.24	3.67	9.24
	r=0	27.18	19.96	23.51	15.67
log (Fishing except shrimp)	r<=1	10.41	9.24	10.41	9.24
	r=0	29.68	19.96	19.26	15.67
log (Oil and mines)	r<=1	5.04	9.24	5.04	9.24
	r=0	15.56	19.96	10.52	15.67
log (Oil Refining)	r<=1	8.87	9.24	8.87	9.24
	r=0	32.64	19.96	23.78	15.67
log (Manufacturing except petroleum refining)	r<=1	9.17	9.24	9.17	9.24
	r=0	24.90	19.96	15.72	15.67
log (Electricity and water supply)	r<=1	8.10	9.24	8.10	9.24
	r=0	27.52	19.96	19.43	15.67
log (Build)	r<=1	5.04	9.24	5.04	9.24
	r=0	17.71	19.96	12.68	15.67
log (Trade)	r<=1	14.89	9.24	14.89	9.24
	r=0	35.41	19.96	20.52	15.67
log (Accommodation and food services)	r<=1	14.46	9.24	14.46	9.24
	r=0	44.00	19.96	29.55	15.67
log (Transport)	r<=1	6.18	9.24	6.18	9.24
	r=0	24.04	19.96	17.87	15.67
log (Mail and communications)	r<=1	3.14	9.24	3.14	9.24
	r=0	30.11	19.96	26.97	15.67
log (Financial Services Activities)	r<=1	9.19	9.24	9.19	9.24
	r=0	24.13	19.96	14.94	15.67
log (technical and administrative professional activities)	r<=1	10.10	9.24	10.10	9.24
	r=0	31.28	19.96	21.18	15.67
log (Education and social and health services)	r<=1	10.30	9.24	10.30	9.24
	r=0	35.02	19.96	24.73	15.67
log (Public Administration defending mandatory social security plans)	r<=1	8.58	9.24	8.58	9.24
	r=0	29.92	19.96	21.33	15.67
log (Home Service)	r<=1	5.30	9.24	5.30	9.24
	r=0	23.07	19.96	17.76	15.67
log (Other Services)	r<=1	11.79	9.24	11.79	9.24
	r=0	33.77	19.96	21.98	15.67
log (Other elements of GDP)	r<=1	11.62	9.24	11.62	9.24
	r=0	37.75	19.96	26.13	15.67

Prepared by: The author.

3.2.3. Error Correction Model for The Trade

As the hypothesis had been structured, particular attention will be given to the Commerce industry and its relationship with GDP. Since these series are correlated, we are interested in modeling the short-term dynamics between these variables. Table No. 3.5., shows the estimated model where it can be seen that trade participates significantly in the short-term dynamics of GDP and also the cointegration vector plays an important role in returning to equilibrium when the series deviates in the short term.

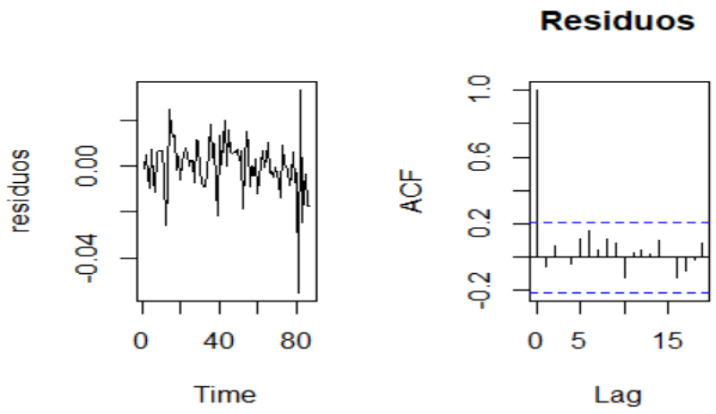
Table 3.5. estimated model

```
Call:
lm(formula = dlog_PIB ~ dlog_comercio + ECT)

Residuals:
      Min        1Q    Median        3Q       Max
-0.055218 -0.006298  0.000094  0.006790  0.033376

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)    0.003084   0.001360   2.268   0.0259 *
dlog_comercio  0.608401   0.053844  11.299   <2e-16 ***
ECT           -0.124943   0.054838  -2.278   0.0252 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.01214 on 84 degrees of freedom
Multiple R-squared:  0.6033,    Adjusted R-squared:  0.5939
F-statistic: 63.88 on 2 and 84 DF,  p-value: < 2.2e-16
```

Prepared by: The author.

An analysis of the residuals indicates that the residuals are indeed white noise (Box-Ljung test, X2= 6.33, p value= 0.70). In addition, graph 3.3. shows the series of residuals and the correlogram where there is no indication of autocorrelation. Therefore, the indicated model is adequate for the relationship of Trade and GDP.

Figure 3.3. Residual series and correlogram



Prepared by: The author.

3.3. VAR models

In order to model the joint short-term dynamics of the industries without cointegration, a VAR model with order 4 in the differences will be used. The model results are presented in table 3.6, where an important effect of the differences is evident. 3 industries in a period of delay, however, the effect of the Construction industry is still important up to four periods of delay.

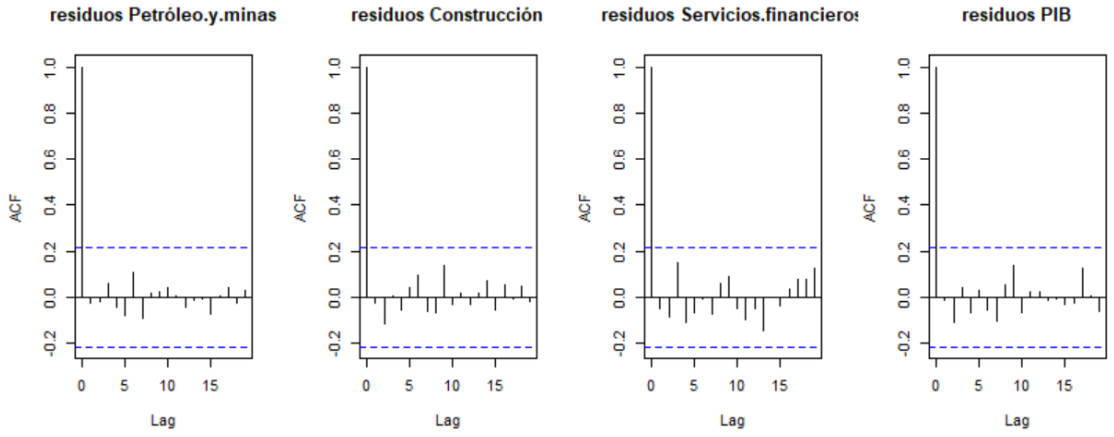
Table 3.6. VAR model with order 4 in the differences.

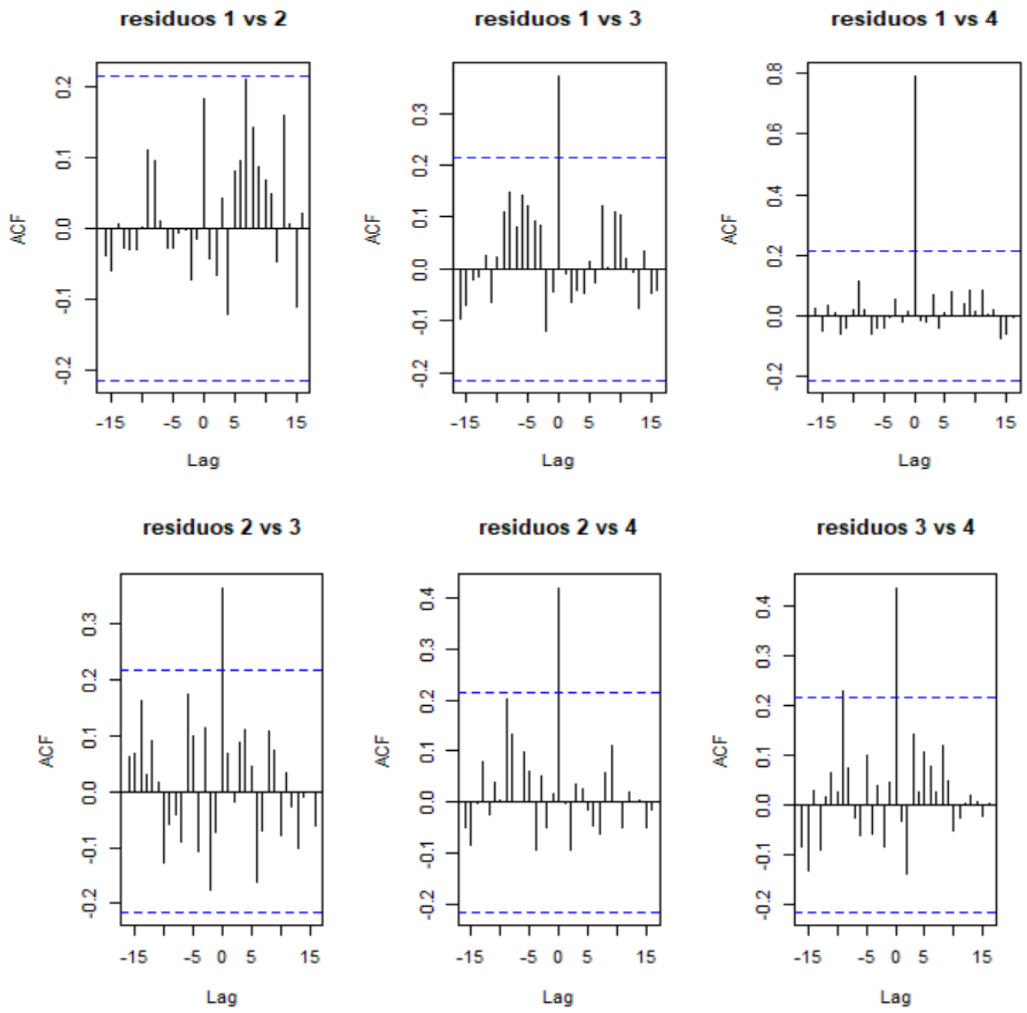
```
Estimation results for equation PIB:
====================================
PIB = Petróleo.y.minas.l1 + Construcción.l1 + Servicios.financieros.l1 + PIB.l1 + Petróle
o.y.minas.l2 + Construcción.l2 + Servicios.financieros.l2 + PIB.l2 + Petróleo.y.minas.l3
 + Construcción.l3 + Servicios.financieros.l3 + PIB.l3 + Petróleo.y.minas.l4 + Construcci
ón.l4 + Servicios.financieros.l4 + PIB.l4

                          Estimate Std. Error t value Pr(>|t|)
Petróleo.y.minas.l1      -0.114316   0.049804  -2.295  0.02485 *
Construcción.l1           0.235318   0.084521   2.784  0.00697 **
Servicios.financieros.l1  0.152344   0.051406   2.964  0.00421 **
PIB.l1                    0.158865   0.233462   0.680  0.49855
Petróleo.y.minas.l2       0.029202   0.051042   0.572  0.56916
Construcción.l2          -0.227978   0.092646  -2.461  0.01645 *
Servicios.financieros.l2  0.026791   0.053558   0.500  0.61855
PIB.l2                    0.035622   0.258582   0.138  0.89084
Petróleo.y.minas.l3      -0.007552   0.054118  -0.140  0.88943
Construcción.l3          -0.306042   0.094832  -3.227  0.00194 **
Servicios.financieros.l3 -0.051163   0.053571  -0.955  0.34299
PIB.l3                    0.437369   0.271529   1.611  0.11193
Petróleo.y.minas.l4      -0.022699   0.045634  -0.497  0.62053
Construcción.l4           0.202326   0.080911   2.501  0.01485 *
Servicios.financieros.l4 -0.092091   0.053767  -1.713  0.09138 .
PIB.l4                    0.209718   0.263454   0.796  0.42882
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


Residual standard error: 0.01665 on 67 degrees of freedom
Multiple R-Squared: 0.4658,     Adjusted R-squared: 0.3382
F-statistic: 3.651 on 16 and 67 DF,  p-value: 9.462e-05
```

Prepared by: The author.

Figure 3.4 shows the simple and crossed correlograms of the residuals. In simple correlograms there is no trace of autocorrelation remaining. However, there are still significant 0-lag cross-correlations of the Oil and Construction industries with GDP and Financial Services.

Figure 3.4. Simple and crossed correlograms of the residuals.



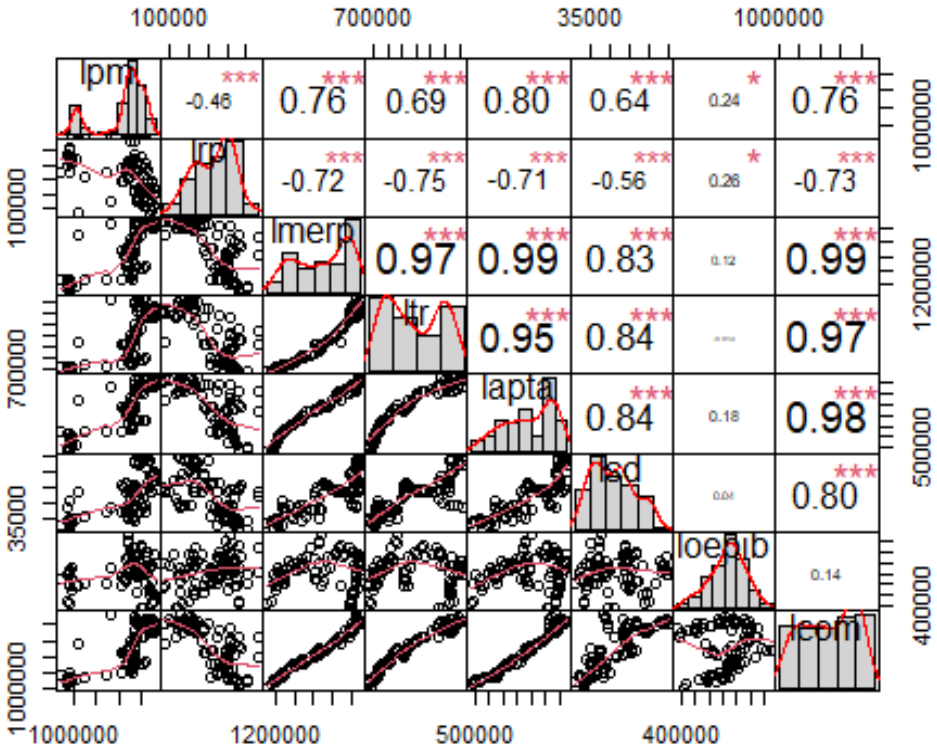


Prepared by: The author.

3.3.1. VAR model for El Comercio

The VAR model seeks to capture the short-term dynamics between Commerce and the industries with which it has a higher correlation. For this, figure 3.5., presents a report of the industries that are highly correlated in a positive and negative way; except industry other elements of GDP. The greatest association is between the industries Manufacturing except oil refining (lmerp), with commerce (lcom) and, with the industry Technical and administrative professional activities (lapta); and, the Commerce industry, highly correlated with Manufacturing except oil refining (lmerp), with Professional technical and administrative activities (lapta) and with Transportation (ltr).

Figure 3.5. Dispersion, histograms and correlations.



Prepared by: The author.

As justified in the corresponding section, the variable object of this study will be the Commerce industry, therefore, the results will be analyzed based on this variable.

Table 3.7. Unit root tests

LEVEL STATISTICS				
VARIABLES	lags	**DFA**(Critical V. 5% = -2.89)	**PH-P**(Critical V. 5%=-2.89)	**KPSS**(Critical V. 5%=0.46)
lmerp	1	-1.78	-1.90	0.80
ltr	1	-0.88	-0.40	0.80
LSD	1	-1.37	-1.75	0.64
loepib	2	-3.13	-3.08	0.17
lcom	1	-0.96	-1.04	0.81
WITH THE FIRST DIFFERENCE				
VARIABLES	lags	**DFA**(Critical V. 5% = -1.95)	**PH-P**(Critical V. 5%= -2.89)	**KPSS**(Critical V. 5%=0.46)
dlmerp	1	-4.55	-8.58	0.34
dltr	1	-6.25	-12.12	0.10
dlsd	6	-2.30	-9.22	0.21
dloepib	1	-5.38	-3.08	0.14
dlcom	1	-5.54	-7.27	0.10

Prepared by: The author.

Based on the unit root tests in Table 3.7., it is concluded that the VAR model analyzed must be modeled in first difference I(1). The Akaike Information Criterion (AIC) suggests a VAR model with two lags; while, the Hannan-Quinn (HQ) criterion with six

lags and the Schwartz (SC) criterion, four lags; Considering the quarterly data, priority is given to the model with six lags, which allows capturing the effect of the fourth quarter.

3.3.2. Fulfillment of econometric assumptions

The multivariate jarque.bera test establishes the null and alternate hypotheses; as follows:

H0: The residuals follow a normal distribution
H1: The residuals do not follow a normal distribution

3.3.2.1. Normality of Residues

Table 3.8. Normality of Residues

Normal	Probability
multivariate JB	2.2e-16
Asymmetry	2.2e-16
kurtosis	2.2e-16

Prepared by: The author.

In table 3.8., it can be observed that the p-value = 2.2e-16, less than 5%; Therefore, it is concluded that the residuals do not follow a normal distribution in a multivariate way, the same happens with Asymmetry and Kurtosis; Therefore, we have normality problems, even if the residuals of the econometric model are extracted, normality is maintained; This happens, mainly due to the magnitude of the COVID-19 crisis, which totally distorts the trend of the series.

3.3.2.2. Serial Correlation

Now H0 is verified: There is no autocorrelation; The following results were obtained:

Table 3.9. Serial Correlation

no autocorrelation	Probability
BG, 4 lags	0.00001912
BG, 3 lags	0.001505
BG, 2 lags	0.003038
BG, 1 lags	0.004557

Prepared by: The author.

Table 3.9., indicates that the p-values are less than 5%, therefore, the null hypothesis is rejected, that is, there is autocorrelation.

3.3.2.3. Homoscedasticity

We verified that there is no multivariate heteroscedasticity.

Table 3.10. homoscedasticity

homoscedasticity	Probability
Not ARCH; 4 lags	0.00002634
Not ARCH; 3 lags	0.002914
Not ARCH; 2 lags	0.112
Not ARCH; 1 lags	0.3572

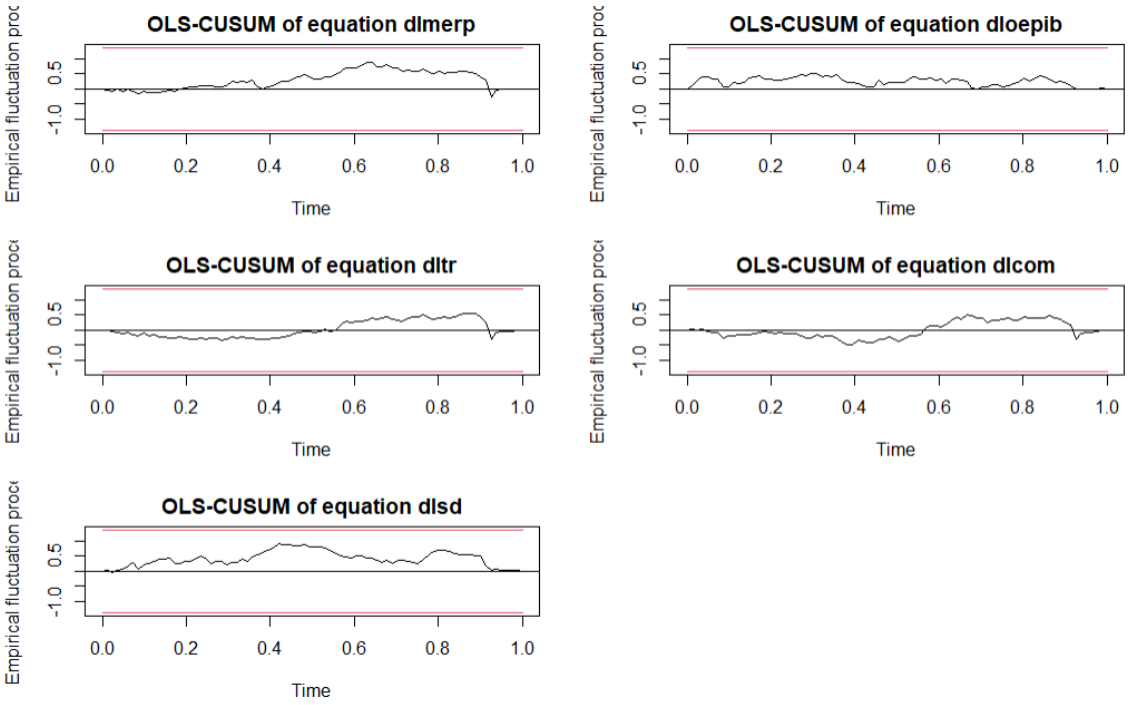
Prepared by: The author.

Table 3.10., indicates that the p-values are greater than 5%, up to the third lag, from which homoscedasticity is generated in the series.

3.3.2.4. Parameter stability

We verify that the parameters, through CUSUM ordinary least squares, are stable over time, that is, that they do not exceed the confidence bands.

Figure 3.6. Parameter stability.



Prepared by: The author.

Figure 3.6., notes that, in all the scenarios presented by the variables, that the trends do not leave the confidence bands, then it is concluded that the series are stable over time.

3.3.2.5. Inverse polynomial roots

Using the following table, we analyze that the polynomial inverse roots are inside the unit circle.

Table 3.11. Inverse polynomial roots

[1]	0.9329431	0.9329431	0.9135748	0.9135748	0.8923852	0.8923852	0.8850369
[8]	0.8850369	0.8511075	0.8511075	0.8303672	0.8303672	0.8128921	0.8128921
[fifteen]	0.7970768	0.7970768	0.7758197	0.7758197	0.7658881	0.7658881	0.7578544
[22]	0.7578544	0.7455552	0.7455552	0.7217649	0.7217649	0.6841594	0.5506665
[29]	0.3816695	0.3816695					

Prepared by: The author.

Table 3.11 shows that all the response roots, in all cases, the probabilities are less than unity; therefore, the values passed in cause Granger between each other.

After having analyzed the econometric assumptions, the VAR model can then be used to perform Granger causality and analyze the impulse response and variance composition function.

3.3.3. Granger causality

Table 3.12. Granger causality

Granger	Probability
dlmerp	0.04161
dltr	0.3721
dlsd	0.3242
dloepib	0.8905
dlcom	0.4741

Prepared by: The author.

Table 3.12., allows us to notice that the Commerce variable is not explained or does not generate Granger over the others; with a p-value = 0.4741; that is, the null hypothesis is accepted, that the Commerce industry causes Granger over the others (dlmerp, dltr, dlsd, dloepib).

3.3.3.1. unrestricted variance decomposition

The variance decomposition analysis function explains it by 8 quarters into the future; as noted in the following table:

Table 3.13. Unrestricted variance decomposition.

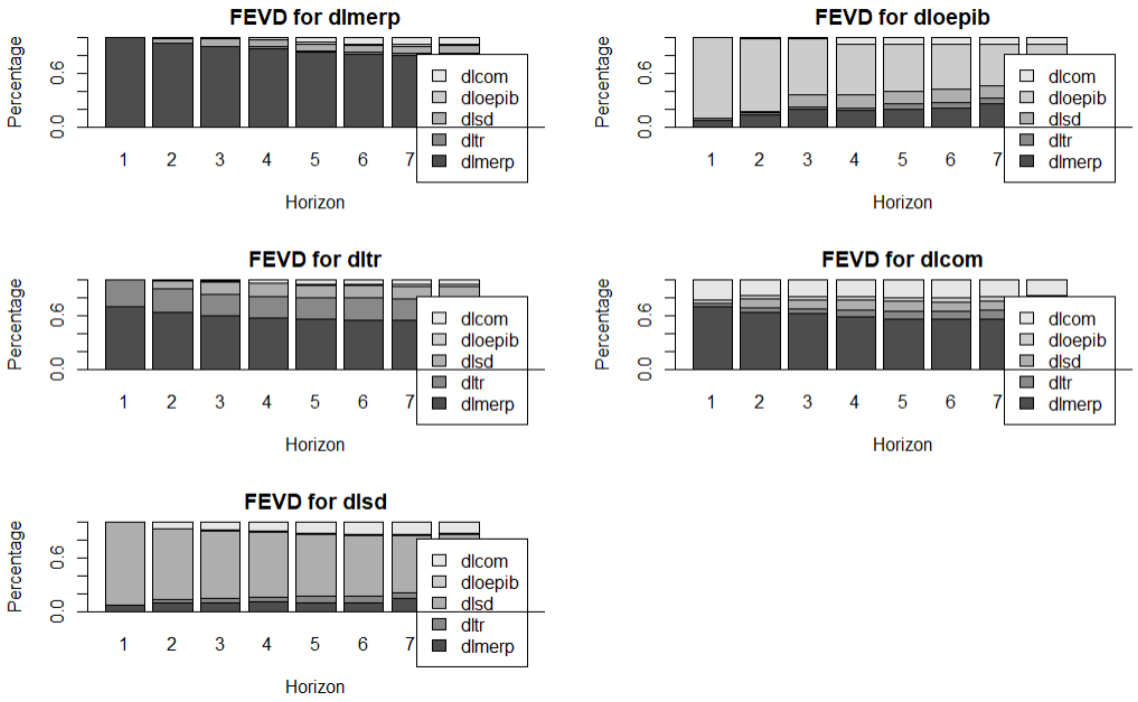
	dlmerp	dltr	dlsd	dloepib	dlcom
[1,]	0.6958482	0.03893260	0.01107639	0.03813246	0.2160104
[2,]	0.6415524	0.04576086	0.10357066	0.03301761	0.1760984
[3,]	0.6293265	0.05015587	0.10174794	0.03548782	0.1832818
[4,]	0.5925517	0.07607201	0.11320158	0.03493585	0.1832388
[5,]	0.5610470	0.08572619	0.11227363	0.04867008	0.1922831
[6,]	0.5591345	0.08989716	0.10795801	0.04657435	0.1964360
[7,]	0.5607142	0.10086193	0.10188833	0.05018411	0.1863514
[8,]	0.5724871	0.11075378	0.09855976	0.04706759	0.1711317

Prepared by: The author.

Table 3.13 indicates that the variance decomposition analysis function is mainly explained by its own innovations and by those of the other variables.

These results can be expressed by a Figure, as represented below:

Figure 3.7. Decomposition of variance of the Trade variable.



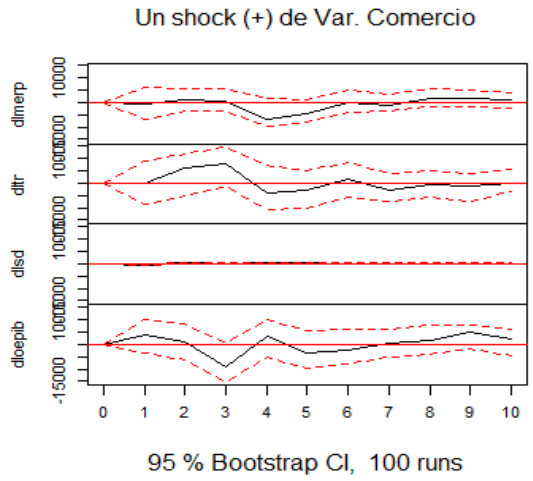
Prepared by: The author.

In figure 3.7., the variance decomposition analysis of the Commerce variable, it is explained that to a greater extent it is explained by the variation of the Manufacturing variable except oil refining, around 60% on average, followed by Domestic service. , on average with 10% and, on average, with 18%, for the same variable as such.

3.3.3.2. Impulse response functions

This function allows to identify how the shock of a variable affects the other variables.

Figure 3.8. Shock of the Trade variable.



Prepared by: The author.

In figure 3.8., the variables are manifested with a positive impact and statistically equal to zero, except for the variable Other elements of GDP (dlloepib).

3.3.4. Vector Error Correction Model

The component selects the industries that present signs of cointegration relationships with GDP, with both cointegration tests (Oil Refining, Commerce, Accommodation and food services, Education and Social and Health Services, and Other Services); and we proceed to use the vector error correction model. The order of the VAR model selected using the BIC criterion is 2. Based on the Johansen test, there are 3 cointegration relationships (H0: r<=2, test: 58.63, critical value 5pts: 45.23; H0: r<=3 trace : 29.33 critical value 5pts: 31.52).

The estimated coefficients of the model and the estimated vectors of cointegration are presented in Table 3.14.

Table 3.14. Estimated coefficients of the model and the estimated vectors of cointegration

Coefficients:						
	Petroleum Refining.d	**trade.d**	**Accommodation.d**	**Social Services and Health.d**	**Other Services.d**	**GDP.d**
ect1	-0.1555827	0.0106699	0.0538762	0.0202623	-0.0008404	0.0223017
ect2	-1.4334491	-0.1236126	0.3178924	0.3930279	0.1189708	0.0960059
ect3	-0.0129812	-0.0999596	-0.4300332	0.0535193	-0.0044695	-0.0650962
constant	7.2233640	-1.3223176	-3.3186679	-0.1773627	0.4908425	-1.4462657
Oil_Refining.dl1	-0.0499150	-0.0365789	-0.0568519	-0.0291550	-0.0148854	-0.0303340
Trade.dl1	-0.5303117	0.1466762	-0.3275608	-0.1929424	-0.1394553	-0.0435518
Accommodation.dl1	0.5579207	0.0094460	0.2487955	0.0059320	-0.0110989	0.0115940
Social_Services_and_Health.dl1	-0.1925106	-0.2295401	-0.5118389	-0.4072078	-0.0992079	-0.2124817
Other_Services.dl1	-0.5108964	0.0908116	0.2473802	-0.1764280	0.4000998	0.1884220
GDP.dl1	0.5114836	0.2021508	1.0845114	0.4645073	0.0554618	0.0044987

$beta			
	ect1	**ect2**	**ect3**
Oil_Refining.l1	1,0000000	0.0000000	0.0000000
trade.l1	0.0000000	1,0000000	0.0000000
Accommodation.l1	0.0000000	0.0000000	1,0000000
Social_Services_and_Health.l1	3.1798630	-0.4220082	-0.2501388
Other_Services.l1	10.7766800	-0.8851452	0.8104999
GDP.l1	-7.6892700	0.0234559	-1.2483710

Prepared by: The author.

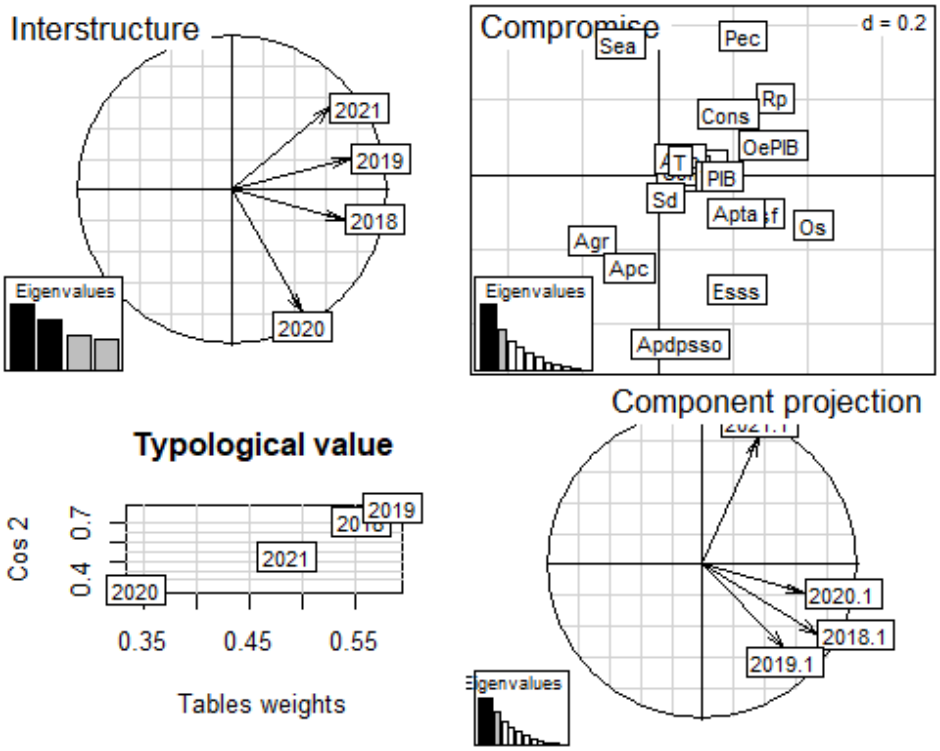
The model supports both short- and long-term dynamics of these industries similar to that of GDP.

3.4. K-WAYS model

The application of the STATIS method, in the present work, will allow explaining the behavior of the GDP industries during the last four years; measured in this way, over the same quarters, in the same set of variables, for different years.

First, the data is standardized by variables; that is, it is centered and normalized by column, across the entire matrix; then, the normalized matrix is centered in each k-table and normalized, dividing the data in the matrix by the column standard deviation of the total table, so that each k-table has mean 0 and total variance =1 , through the difference of the logarithms of the variables; All this process is carried out automatically with the use of the appropriate codes in the R statistical software; Thus, the following Figures result:

Figure 3.9. Representation of k-way variables



Prepared by: The author.

Figure 3.9., Interstructure, indicates the tables that have similar structures; in this case, differentiated for the years 2018, 2019, 2020 and 2021; since, we compare the previous years and the one in which the COVID-19 crisis occurred.

The horizontal axis is axis one and the vertical axis two, which are the ones that accumulate the greatest amount of variance of the variables; axis one, collects the greatest amount of information and, in turn, allows the identification of the financial behavior of the variables through two groups, one made up of the years 2018, 2019 and 2021, and another group structured solely by the year 2020, evidencing behaviors similar depending on the smaller angles formed between the vectors; therefore, they are expected to have high vector correlation coefficients between these clusters.

The vectors made up of the years 2021 and 2020, due to their opposite direction or around 90 degrees, their degree of correlation is expected to be weak.

The image of the commitment matrix (commitment) is a linear combination of each k-table that is related according to the weighted weights of the groups of industries that make up the GDP and indicates the average structure of the score assigned in each year where, it is evident that through a decomposition of singular values of the variables,

most of them are grouped very closely with similar scores, except Public Administration, Education and social and health services, Aquaculture and shrimp fishing and, Agriculture; and, with opposite scores, another group made up of Fishing except shrimp and Electricity and water supply.

The image of the weights (Typological value) allows the identification of the weights on the horizontal axis and, on these, it can be seen that the years 2018 and 2019 are the ones that contribute the most to build the commitment, while the year 2020, contributes with little information; The vertical axis represents the cosine square, which indicates the commitment matrix best represented, in this case the same years referred to.

The image (Component projection) represents a kind of rotation of the Interstructure Figure; note a change in the association of groups, with a better selection among them, this is how the first quarters of the years 2018, 2019 and 2020 are grouped, close to axis one, and the year 2021 to axis two; however, for the analysis the Interstructure Figure is more applied.

The interstructure matrix presents the vector correlation coefficients, detailed below:

Table 3.15. interstructure matrix

	2018	**2019**	**2020**	**2021**
2018	1,0000000	0.3340887	0.22753764	0.21417716
2019	0.3340887	1,0000000	0.14585321	0.33329862
2020	0.2275376	0.1458532	1,0000000	0.04328022
2021	0.2141772	0.3332986	0.04328022	1,0000000

Prepared by: The author.

Table 3.15., Presents moderate correlation coefficients and refers to a similar structure between the financial reality of the years analyzed, except for the year 2020, as already noted in the figure of interstructures.

Matrix of square cosines:

0.7102923	0.7804555	0.3467978	0.5200476

Prepared by: The author.

The high values of the cosine square explain that the commitment matrix better represents the financial results of the k-tables that correspond to the years analyzed.

Matrix of weights for the k-tables:

0.4974781	0.3413586	0.2392538	0.4922206	0.5800572

Prepared by: The author.

Regarding the weights that represent the last four years analyzed, they indicate that the highest values provide more information to build the commitment.

Matrix of eigenvalues for the inter-structure:

1.6832177	1.0275463	0.9133655	0.7722765	0.6035940

Prepared by: The author.

The eigenvalues of the interstructure allow calculating the variance of each component; then, based on the accumulated variance, the number of components that explain its percentage is established.

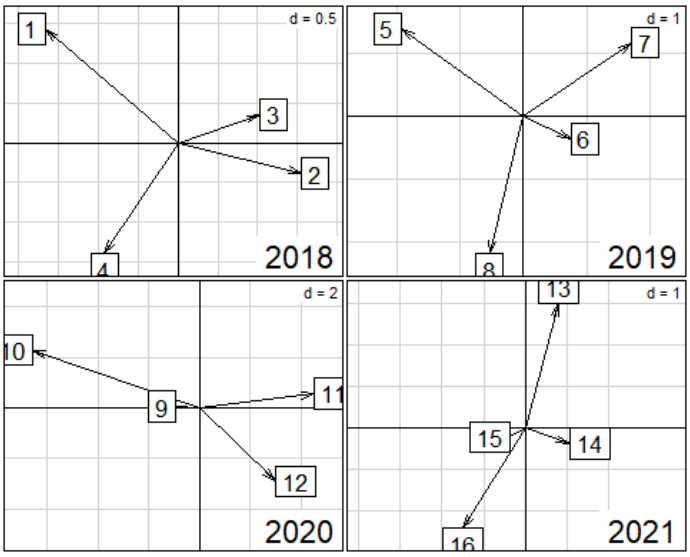
Table 3.16. Matrix of eigenvalues for the commitment.

0.835206727	0.790019516	0.408657890	0.288131144	0.221998882	0.174852657
0.128741879	0.076383803	0.056102328	0.034435783	0.021447079	0.005884697

Prepared by: The author.

The matrix of table 3.16., identifies which are the eigenvalues of the commitment, based on the decomposition of singular values to obtain the eigenvalues and eigenvectors; The components that have been used to represent the figure of the commitment matrix result from the eigenvalues, by accumulating the variance in two components.

Figure 3.10. STATIS



Prepared by: The author.

Figure 3.10., represents the financial information of the last four years of analysis, on the commitment plane; and, it explains the qualification that each year gives to the industries that make up the GDP; Thus, it can be seen that, in the year 2020, the object of this analysis, each quarter shows an independent behavior between them, with a low value in the first quarter and a very high value in the second quarter, opposite to the values of quarters three and three. four.

The first quarter of 2020 is around the average of the data, the second quarter is below the average with the greatest contribution to axis one in a negative way, the third quarter is above the average and also contributes to axis one, but in smaller magnitude positively; and, the fourth quarter focuses on the two axes; the corresponding analysis is performed for each year.

4.Discussion

Based on the hypothesis proposed in this paper, whether the health crisis caused by COVID-19 caused a greater crisis in the Commerce industry and consequently, the decline in the Gross Domestic Product of the Ecuadorian economy; It can be inferred that the assumption is fulfilled on the occasion of the following discussion:

- The analysis of the data will be carried out in the statistical software R, version 4.2.1.
- This document was developed on the basis of data from the quarterly National Accounts of Ecuador No. 118, published by the Central Bank of Ecuador on its institutional website; Based on the information from the Quarterly National Accounts Bulletin, the Gross Domestic Product accounts database was used, disaggregating its components in gross terms by industry, ranging from the first quarter of 2000 to the fourth quarter of 2021 and, by quarterly figures. The aforementioned data can be found at the following electronic address:https://contenido.bce.fin.ec/home1/estadisticas/cntrimestral/CNTrimestral.jsp
- The industries related to oil, social services, construction and commerce in nominal terms presented the greatest contribution to national production, while the industries with the least nominal contribution are domestic services and fishing.
- The variables Aquaculture, Fishing, Oil Refining, Electricity and Water and Other elements of the GDP, evidenced throughout the period studied a much greater variability than the GDP; on the contrary, the industries of Agriculture, Manufacturing, Commerce, Accommodation and Transportation, a variability very similar to that of GDP.
- The industries that had a more pronounced fall than the GDP were Transportation, Lodging, Professional Activities and Oil and Mines; Although the latter had a sharp drop in 2020, it also showed a significant recovery in 2021.
- The Agriculture and Fishing industries were not so hit during 2020 in the midst of the pandemic, in contrast to the other industries that make up GDP.
- All industries except Oil and mining, Construction, and Financial services activities have at least one cointegration relationship with GDP.
- Commerce is a very important industry in the short-term economic dynamics of GDP; thus, the cointegration vector plays a significant role in returning to equilibrium when the series deviates in the short term.
- The variance decomposition analysis of the Commerce variable indicates that, to a greater extent, this is explained by the variation in the Manufacturing industry, except oil refining, around 60% on average.
- By applying the STATIS method, it is confirmed that the GDP industries presented similar structures and behaviors in recent years except for the year 2020.
- Through a decomposition of the singular values of the variables, it is noted that the industries are grouped very closely with similar scores for most of them, except for Public Administration, Education and social and health services, Aquaculture and shrimp fishing, and, Agriculture; and, with opposite scores, another group made up of Fishing except shrimp and Electricity and water supply.
- The year 2020 provides little information to build the commitment matrix of the variables, which confirms the assumption that the crisis that occurred this year affected national production.
- In general, the distribution of the Commerce industry and GDP, both from the graphic analysis and from the results of the tests implemented, during the year 2020, presented important changes in the trend of the Commerce industry, GDP and the others. industries; Although they present a sustained shift to the right, in 2020 there is evidence of a change in density concentration, from higher levels to much lower levels in the analyzed road industries.
- Although several parametric tests based on the Cointegration, Vector Autoregressive and K-Ways models have been applied, they are not the only tests developed to prove the homogeneity between the distributions; therefore, in subsequent works, other tests supported by different methodologies can be examined.

- From the review of the literature, specifically for our country, no studies were found with the present approach for the analysis of the incidence of COVID-19 on GDP; Therefore, it constitutes an informative contribution on the economic reality of the country in the face of the crisis caused by the pandemic.
- It is important to monitor the evolution of the trend of the industries of Commerce, Manufacturing, Transportation, Domestic service, Oil refining and Professional activities; since, they present greater interference in the behavior of the Commerce industry and consequently in the GDP.
- Complementarily, it is evident that the oil industry presents an isolated behavior from the other industries that make up the GDP; which does not necessarily follow the similar trend, despite the cyclical crisis scenarios in the economy.

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