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The relationship between foreign exchange reserves and the volume of car imports in Algeria for the period: 1990 – 2020

Using the Vector Autoregressive (VAR) model

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Abstract :

This study aims to measure the relationship between foreign exchange reserves and the volume of car imports in Algeria during the period 1990-2020. To achieve the study's objectives, the study data were analyzed using principal component analysis (ACP). The effect of foreign exchange reserves on car import volume was then measured using the autoregressive model (VAR).

The study concluded that there is a statistically significant positive relationship in the short term between foreign exchange reserves and the volume of car imports in Algeria. Additionally, the study recommended the necessity of establishing a real industry to preserve foreign exchange reserves.

Keywords : foreign exchange reserves, car imports, autoregressive model, Algeria.

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INTRODUCTION

Algeria, like other countries in the world, is keen on building foreign exchange reserves as they represent the main source of financing external obligations. It also serves as a safety valve in times of external shocks. Therefore, Algeria has worked in the past years to build significant foreign exchange reserves due to the rise in oil prices.

The accumulation of foreign exchange reserves has a clear positive relationship on stimulating foreign trade, especially in terms of imports. In this context, car imports have witnessed a noticeable increase due to the lifting of restrictions on this activity. According to the National Statistics Office, the national fleet of vehicles reached a total of 5,683,156 vehicles by the end of 2015. However, with several external shocks resulting from the decline in oil prices, this decrease has eroded the foreign exchange reserves. As a result, Algeria has taken several measures to address this erosion, including rationalizing public expenditures and implementing an import allocation system by the Ministry of Commerce. However, in 2017, car activity in Algeria shifted from imports to assembly, as the government aimed to establish a real automobile industry. The decision to stop the importation of semi-assembled cars, which cost the public treasury over $2 billion annually, coincided with the intensification of this crisis. Consequently, the temporary authorities of the country decided in February 2019 to completely abandon this approach, which in turn affected the supply of cars and led to a record increase in prices.

Given this introduction, foreign exchange reserves are one of the most important variables that the state seeks to build to cover any deficit or emergency in the balance of payments. Considering the importance of the vehicles and cars sector in Algeria due to its contributions to the transportation movement, which is the main component of trade movements within and outside the country, this study will highlight the relationship between foreign exchange reserves and the volume of car imports by addressing the following problem:

➢ **What is the relationship between foreign exchange reserves and the volume of car imports in Algeria during the period 1990-2020?**

In order to cover the study's topic, we have formulated the following sub-questions:

- What is meant by foreign exchange reserves, and what are its main determinants?
- What is the reality of car imports in Algeria during the period 1990-2020?
- What is the nature of the relationship between foreign exchange reserves and the volume of car imports in Algeria?

Study Hypotheses:

- There is a long-term equilibrium relationship between foreign exchange reserves and the volume of car imports in Algeria for the period 1990-2020.
- There is a causal relationship between foreign exchange reserves and the volume of car imports in Algeria for the study period 1990-2020.

Importance of the Study:

The importance of this study lies in demonstrating the relationship between foreign exchange reserves and the volume of car imports in Algeria during the period 1990-2020. Considering that the issue of car imports is one of the topics that concerns the Algerian citizens, especially with the recent increase in car prices, and the Algerian government's efforts to find appropriate solutions.

Study Objectives:

- Identify the concepts related to foreign exchange reserves.
- Discuss the impact and importance of foreign exchange reserves regarding the process of importing vehicles in Algeria during the period 1990-2020.

Study Method:

Due to the nature of the subject, we adopted a descriptive-analytical approach in our study of the theoretical aspect. We also relied on factor analysis using Principal Component Analysis (PCA) and the standard method to build a model that explains

the relationship between the study variables, represented by foreign exchange reserves and car imports, using the Eviews 09 software.

Study Structure:

Our research is divided into three main axes:

First Axis: The theoretical and conceptual framework of foreign exchange reserves.

Second Axis: Analysis of the evolution of foreign exchange reserves and car imports in Algeria during the period 1990-2020.

Third Axis: The empirical study of the relationship between foreign exchange reserves and car imports in Algeria during the period 1990-2020.

First Axis: The theoretical and conceptual framework of foreign exchange reserves.

1. Concept of foreign exchange reserves :

There are several definitions of foreign exchange reserves, including:

- **Heller's definition:** They are assets that possess two characteristics: firstly, they are universally accepted by foreign economies as a unit of payment for financial and trade obligations, and secondly, their value as a known unit of account(Zaki, 1994, p. 97).

- **According to John Williamson**, foreign exchange reserves serve as a safety valve that a country keeps and resorts to when necessary to protect it from the effects of external shocks that its economy may face due to its economic relationship with other countries(Williamson, 1988, p. 165).

- **International Monetary Fund (IMF) definition:** They are external assets available to monetary authorities at any time and subject to their control for the direct financing of balance of payments imbalances or for directly or indirectly influencing the volume of payments through intervention in the foreign exchange market to affect the exchange rate or for other purposes(Fund Monetary Internationa, 2009, p. 150).

They are defined as the holdings of gold and foreign currencies by central banks, in addition to Special Drawing Rights (SDRs), which also form part of foreign exchange reserves.

2. Importance of holding foreign exchange reserves:

There are two perspectives through which the motives behind holding foreign exchange reserves can be explained:

✓ **Reserves as a by-product of active intervention in exchange markets:**

The mercantilist approach argues that the increase in reserves is a result of reducing the value of the exchange rate by selling the domestic currency by the central bank. This measure aims to maintain and enhance the competitiveness of exports. Therefore, the accumulation of foreign exchange reserves in this case is considered a secondary outcome of the export promotion policy(Lee, 2005, October, p. 3).

✓ **Self-insurance against shocks:**

An alternative explanation for holding reserves is self-insurance and hedging against shocks. In case of temporary balance of payments deficits, drawing from reserves can help avoid costly adjustments in exchange rates, domestic consumption, and investment. The accumulation of reserves for this purpose is generally referred to as precautionary demand for reserves. From an insurance perspective, countries hold reserves to achieve the following objectives(Rajan, 2006, p. 21).

- Limit exchange rate volatility by intervening in the exchange markets to support exchange rate policy, whether to achieve a stable exchange rate or to maintain the value of the domestic currency. These reserves represent the first line of defense for the value of the domestic currency(Dabrowski, 2015, p. 6).
- Preserve liquidity to avoid situations where access to borrowing or drastic reduction in loans becomes very costly.(Robinson, 2010, p. 12)
- Act as a safety valve for the local economy against balance of payments shocks.
- Provide liquidity to the domestic financial markets and the banking sector.
- Resort to foreign exchange reserves to pay off external debts and their burdens.

- Secure the country's imports of goods and services by facing the expected increase in imports and the growing trade deficit after the liberalization of foreign trade.

1. Reserve exchange components :

according to the International Monetary Fund's Balance of Payments and International Investment Position Manual, consist of the following:(Eldouri, 2006, p. 51)

2.1 Cash Gold: Gold holds significant importance as a strategic reserve that can be relied upon during economic crises, monetary disturbances, and sharp fluctuations in the exchange rates of reserve currencies. Cash gold is a tangible asset representing recognized purchasing power by all economies, as it is the most stable element in international liquidity.(Latrache, 2003, p. 40)

2.2 Foreign currency reserves: These are the country's holdings of currencies from other countries, including foreign banknotes, demand and time deposits in foreign currencies, as well as government bonds.(Maggiori, 2013, p. 01)

2.3 Special Drawing Rights (SDRs): These are book-entry loans used by the International Monetary Fund to provide optional assistance to its members. SDRs are not metallic or paper currency but rather an accounting unit with a legal basis. They serve as a measure of the country's ability to access international liquidity.(Saoud, 2002, p. 236)

3. Indicators measuring reserve adequacy:

To determine the optimal level of foreign exchange reserves, several indicators can describe the state of trade relations between a country and the external sector. These indicators include:

3.1 Import coverage ratio: This indicator shows the ability to finance an economy's imports in case of a shortfall in exports. It examines the import coverage ratio as a measure of the number of months of imports that can be sustained in the absence of foreign currency inflows, such as export revenues, and without any other

foreign currency receipts.(Ogunleye, 2010, p. 06) According to the mostcommon version of the import coverage ratio, reserves should cover 3 to 6 months of imports.

3.2 Monetary aggregates (Reserves-to-Money Supply ratio):

was the first to refer to the reserves-to-monetary base ratio as an indicator of reserve adequacy in the presence of potential capital flight by current residents. It measures the likelihood of a financial crisis. According to monetary aggregates rules, reserves should cover a certain percentage of the monetary base, which is also known as broad money.(Kaminsky, 1999, p. 16)

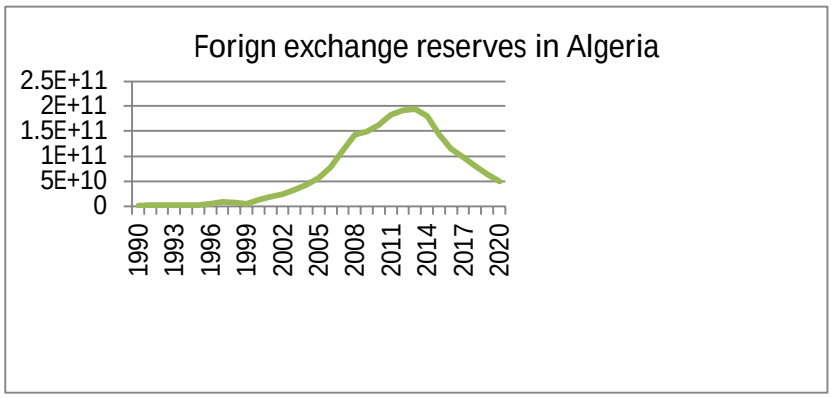
3.3 Guidotti-Greenspan Rule: According to the Guidotti-Greenspan rule, foreign currency reserves should cover short-term external debt. Short-term debt refers to obligations that mature within one year. Previously, balance of payments items were considered the main source of external vulnerability. However, after the 1997 crises in Southeast Asia, the focus shifted to capital account volatility.(Rajan Arvind, 2017)

The second axis: Analysis of the evolution of foreign exchange reserves and the volume of vehicle imports in Algeria during the period 1990-2020.

The evolution of foreign exchange reserves in Algeria depends on hydrocarbon revenues, which have experienced fluctuations in prices, both upward and downward. In the early 1990s, these revenues witnessed a noticeable decline, impacting the level of foreign exchange reserves, reaching very low levels. As a result, the country's imports, including automobile imports, were affected, and their numbers declined due to the decrease in foreign exchange reserves. In the following, we will discuss the current situation of foreign exchange reserves and the volume of vehicle imports in Algeria during the period 1990-2020.

1. The status of foreign exchange reserves in Algeria during the period 1990-2020 :

Fig.1. Evolution of foreign exchange reserves in Algeria during the period 1990-2020



Source: prepared by the researchers based on data from the World Bank

https://data.worldbank.org/country/DZ

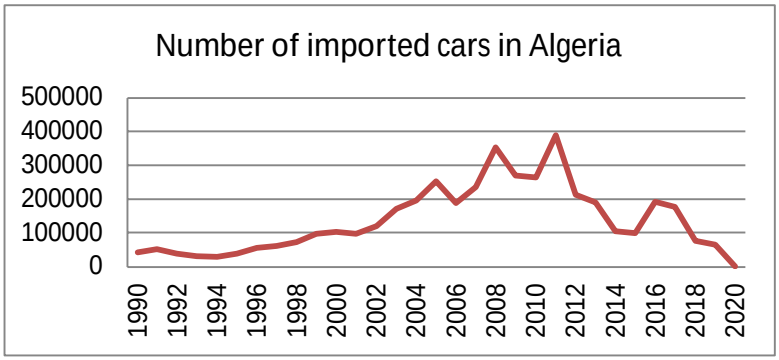
According to the figure above and based on data from the World Bank , hydrocarbon revenues represent the most significant source of foreign exchange reserves accumulation in Algeria. Imports, on the other hand, are the main drain on these reserves. With the beginning of the 1990s and the noticeable decrease in hydrocarbon prices, Algeria's foreign exchange reserves experienced a sharp decline. In 1990, the reserves were around 724,759,955 US dollars, as a result of relying on a single source for hard currency inflows.

This decline continued until the end of the last decade of the previous century, with some slight increases due to higher hydrocarbon prices and interventions from the International Monetary Fund to lend to Algeria. Since the year 2000, Algeria's foreign exchange reserves have witnessed significant improvement, reaching 194 billion dollars by the end of 2013, mainly driven by the rise in hydrocarbon prices. However, Algeria did not fully capitalize on this improvement to boost other productive sectors and diversify its exports beyond the hydrocarbon sector.

With the liberalization of imports, there has been a significant depletion of foreign exchange reserves. By the end of 2019, the reserves stood at around 63 billion US dollars.

The reality of car imports in Algeria during the period 1990-2020 :

Fig.2. Evolution of the number of imported cars in Algeria during the period 1990 – 2020



Source: Prepared by researchers relying on data from the General Directorate of Customs.

Through the above figure and relying on data from the General Directorate of Customs, we note that Algeria has experienced difficult conditions during the last decade of the previous century due to deteriorating security conditions on one hand and a deteriorating economic situation in the country. This forced the country to turn to the International Monetary Fund for borrowing under specific conditions. The import sector, including the import of vehicles, experienced a recession due to the deterioration of the purchasing power of Algerian citizens and the severe shortage of foreign exchange reserves that cover the import process.

However, with the beginning of the new millennium, vehicle imports witnessed a significant improvement, reaching approximately 390,000 imported vehicles in 2011. This can be attributed to the increase in individual income in Algeria and the improvement of citizens' purchasing power due to the rise in fuel revenues. With the

decline in fuel prices, the Algerian government implemented a series of measures to curb the outflow of hard currency, including reducing the volume of imports. This reduction in vehicle imports reached only 600 vehicles in 2020, with assembly factories being an alternative to reduce car imports.

2. Analysis using the Principal Component Analysis (ACP) :

The analysis using the Principal Component Analysis is considered one of the techniques of factor analysis. The concept of ACP dates back to the early twentieth century and was developed by various scientists. It is a statistical and descriptive method that focuses on variables, aiming to study the relationships between variables and summarize a large set of data by identifying the principal components that summarize the measured variables. To perform the analysis and extract the basic components, we calculate the correlation matrix by computing the correlation coefficients between all variables. The correlation matrix contains a number of correlation coefficients.(Dadan , 2012, p. 11)

Therefore, we applied the ACP-norm method to the study variables for the period 1990-2020 using the 2018 xl stat software.

3. Study variables :

Dependent variable: Represented by the number of imported cars and denoted by the symbol INPV.

Independent variable: Represented by foreign exchange reserves and denoted by the symbol RES.

- **Means and standard deviations :**

Table1. Means and standard deviations

standard deviation	average	biggest value	less value	Views	variants
68502810134,008	6968258 2527,658	1947121070 88,462	724759955,044	31	**RES**
99,630,685	137,439, 258	390,140,000	600,000	31	**INPV**

Source: Prepared by the researchers based on xlstat2018.

From the results obtained in Table 01 using the 2018 xlstat software, we observe that the variable representing the number of imported cars (INPV) is more stable compared to the independent variable (RES), as indicated by its lower standard deviation. Therefore, the mean of this variable represents the reality of the series and is responsible for the centralization of the studied community. In contrast, the foreign exchange reserves variable exhibits a higher standard deviation, indicating its instability and responsibility for the dispersion of the studied community.

Table 2. Eigenvalues and proportions represented on the axes

interlocutor	F1	F2
Eigen value	1,706	0,294
Axes representation %	85,287	14,713
aggregate ratios	85,287	100,000

Source: Prepared by the two researchers based on a program xlstat2018

Through the results obtained in the above Table 02 using the xlstat software, we observe that 85.287% of the data is represented by the primary component F1, while 14.713% of the data is represented by the second primary component F2. This means that the representation ratio at the first level (F1+F2) is 100%, which is a good percentage in analysis and study. It indicates that 100% of the initial data table is well represented at the first level, preserving the maximum amount of information for us.

Table 3. The correlation matrix for the study sample

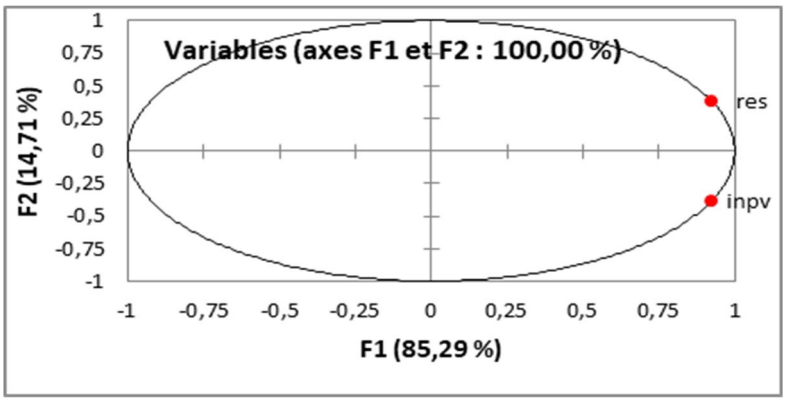
INPV	**RES**	**variants**
0,706	1	**RES**
1	0,706	**INPV**

Source: Prepared by the two researchers based on a program xlstat2018.

Through Table 03, the correlation matrix represents a symmetric matrix that includes the correlations of variables with themselves on the diagonal, which equals 1. The other values represent the coefficients of simple correlations between the variables. We observe a strong positive correlation between the variables (INPV) and (RES), indicating that foreign exchange reserves significantly and positively affect the number of imported cars.

Graphical representation of variables

Fig.3. Graphical representation of the variables



Source: Prepared by the two researchers based on a program xlstat2018

1. Quality: We observe that all variables are far from the center and close to the circumference of the circle, indicating a good representation at the F2-F1 level. Therefore, they are acceptable for analysis and study.

2. Relationship of Variables with Axes: Through the graphical representation, we observe the following:

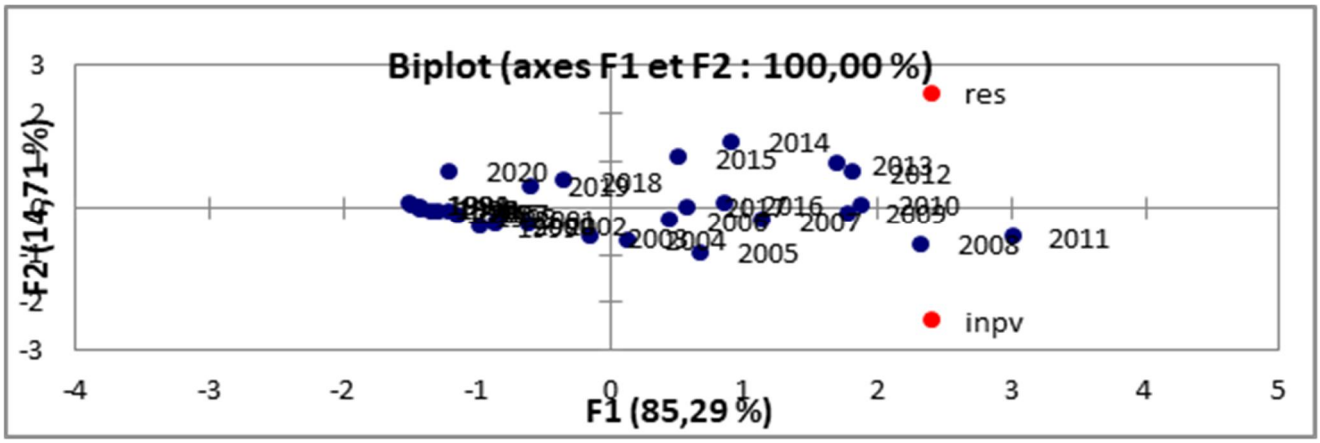
- First Axis: It shows a strong positive correlation with the variable of foreign exchange reserves (RES).

- Second Axis: It shows a strong positive correlation with the variable of the number of imported cars (INPV).

Relationships between Variables: It is noticeable that the distance between the variable of foreign exchange reserves (RES) and the variable of the number of imported cars (INPV) is close, indicating a strong relationship.

Graphical representation of variables and individuals:

Fig.4. Graphic representation of variables and individuals



Source: Prepared by the two researchers based on a program xlstat2018

Through the figure above, which illustrates the relationship between the variables and years of study in Algeria, we observe the following:

- Years from 2010 to 2017: Represented well on the axis (F2) with positive coordinates, strongly and positively correlated with the variables of foreign exchange reserves (RES) and vehicle imports (INPV). This period witnessed a significant increase in oil prices, leading to record-breaking foreign exchange reserves and a rise in the number of imported vehicles to unprecedented levels.
- Years from 1990 to 1999, 2019, and 2020: Also represented well on the axis (F2) with negative coordinates, strongly correlated with foreign exchange reserves (RES) and vehicle import volume (INPV). This period witnessed a decrease in foreign exchange reserves and a decline in the number of imported vehicles.

The third axis: A standardized study of the relationship between foreign exchange reserves and vehicle import volume in Algeria during the period 1990-2020.

1. Data and Methodology :

In order to determine the nature of the impact of changes in foreign exchange reserves on the number of imported vehicles in Algeria, the standardized study included annual data from 1990 to 2020. The dependent variable was the number of imported vehicles in Algeria, while the independent variable was foreign exchange reserves in Algeria. The data on imported vehicles were obtained from the General Directorate of Customs, while the foreign exchange reserves data were obtained from the World Bank. The Eviews 09 program was used for analysis, And the following are these variables:

- **The dependent variable:** it represents the number of imported cars and is denoted by INPV.

- **The independent variable:** it represents foreign exchange reserves and is denoted by RES.

To study the impact of foreign exchange reserves in Algeria on the number of imported cars, we propose the following model:

INPV = B0 + B1RES + t

2. Time series stability study of the variables under study:

The standard study includes introducing the methodology used in the first stage, followed by applying the adopted model in the second stage. Time series describing the study variables often exhibit non-stationary behavior, as most of them change and grow over time. This makes their means and variances unstable and time-dependent.

Therefore, it is necessary to test the stability of time series, treat them, and determine their degree of integration.(Terraza, 2010, p. 07)

To test the stability of time series, we will rely on choosing the Dickey-Fuller (ADF) test or the Phillips- Perron (PP) test.

The Dickey-Fuller test: It is a test for the stability of time series for the dependent variable and the independent variable. To conduct this test, we determine the significance level at a confidence level of 5%.

Table4. ADF test results for the stability of the study variables series

Second Level Second difference			**level one First difference**			**the level Level**			**variants**
without fixed and general direction	**direction coefficient B general and fixed**	**Constant C**	**without fixed and general direction**	**direction coefficient B general and fixed**	**Constant C**	**without fixed and general direction**	**general trend coefficientB and hard**	**Constant C**	
1.95-	3.58-	-2.97	-1.95	-3.58	-2.96	-1.95	3.61-	-2,96	**critical values % at 5**
-4.50	-4.40	-4.43	-1.42	-1.65	-3.95	-1.56	-4.09	-2.18	**TcRES**
0.00	0.00	0.00	.0.13	0.74	0.00	0.1	0.01	0.21	**Pro**
/	/	/	-6.33	6.94-	6.21-	-0.99	1.12-	-1.61	**TC INPV**
/	/	/	0.00	0.00	0.00	0.27	0.90	0.45	**Pro**

Source: Prepared by the two researchers based on a program eviews 09.

Through the results of the Dickey-Fuller test using the Eviews 09 software, the following is revealed:

Examining the appendices 01, 02, 03 for the three models of the independent variable RES)), we observe that the series is not stable at the level. After performing the first difference, it did not stabilize in the three models. However, after performing the second difference, the series became stable. Therefore, it is integrated of the second order I(2).

Similarly, according to the table above and examining appendices 04, 05, the results of the three models for the dependent variable INPV)) show that the series stabilized after the first difference. Hence, it is integrated of the first order I(1).

After confirming the stationary nature of the time series and the absence of a common integration relationship between the study variables due to the lack of stability in the time series of the study variables at the same level, indicating no common integration, we will estimate a Vector Auto Regressive (VAR) model.

In this regard, it can be said that the VAR model is among the models that have gained significant popularity in the literature of economic measurement. The researcher Christopher A. Sims was the first to propose this model. The auto-regressive system is one in which all variables are a function of lagged values and past values of other variables comprising the auto-regressive system, in addition to bounds. To construct this model, we determine the number of time lags.(Belaid, 2022, p. 560)

3. Using Vector Auto Regressive Models:

To use the VAR model, certain conditions must be met before its application, which are as follows:

- Determining the lag order of the model according to criteria such as Akaike Information Criterion (AIC), Schwarz Criterion (SC), and Hannan and Quin Criterion (HQ).

- Verifying the stability of the model using the Inverse Root AR test.

- Performing model adequacy tests.

3.1.Determining the Optimal Lag Length:

It is necessary to determine the number of lag orders (P) to determine the optimal lag period for the measurement equation in the model. This is done based on a set of criteria, the most important of which are Akaike Information Criterion (AIC), Schwarz Criterion, and Hannan-Quinn Criterion.

Fig.5.results optimal delay scores (P)

VAR Lag Order Selection Criteria
Endogenous variables: DDRES DINPV
Exogenous variables: C
Date: 09/06/22 Time: 09:43
Sample: 1990 2020
Included observations: 25

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-11.65102	NA	0.010218	1.092082	1.189592	1.119127
1	-4.430942	12.70734*	0.007915	0.834475	1.127006*	0.915611
2	-0.278562	6.643808	0.007887	0.822285	1.309835	0.957511
3	4.971443	7.560008	0.007279	0.722285	1.404855	0.911601
4	10.28372	6.799711	0.006799*	0.617303*	1.494893	0.860709*

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Source: Prepared by the two researchers based on a program eviews 09.

Through the above figure and the obtained results in the output of Eviews09software, the optimal lag order is determined to be 4 (P), which satisfies the minimum values for the aforementioned criteria.

3.2. Causal Relationship Study:

In this test, we will attempt to study the causal relationship between variables using the GRANGER method. Here, we aim to determine which variable influences the other, or if both variables mutually affect each other simultaneously.

Fig.6. Causal test results (GRANGER)

Pairwise Granger Causality Tests
Date: 09/06/22 Time: 09:50
Sample: 1990 2020
Lags: 4

Null Hypothesis:	Obs	F-Statistic	Prob.
DINPV does not Granger Cause DDRES	25	0.27082	0.8925
DDRES does not Granger Cause DINPV		2.22116	0.1126

Source: Prepared by the two researchers based on a program Eviews 09.

Through the GRANGER test obtained in the above table: the probability corresponding to the null hypothesis (H0), which states that DINPV does not cause DDRES, is 0.89, which is greater than the significance level of 0.05. This indicates the rejection of the alternative hypothesis and the acceptance of the null hypothesis, which acknowledges that DINPV does not cause DDRES.

Furthermore, the probability corresponding to the null hypothesis (H0), which states that DDRES does not cause DINPV, is 0.11, which is greater than the significance level of 0.05. This also leads to the rejection of the alternative hypothesis and the acceptance of the null hypothesis, which acknowledges that DDRES does not cause DINPV. Therefore, there is no causality between the two variables in both directions.

3.3. Estimation of the VAR Model:

Fig.7. Model estimation results (VAR4)

R-squared	0.663498	0.536623
Adj. R-squared	0.495247	0.304934
Sum sq. resids	0.453726	2.105342
S.E. equation	0.168398	0.362745
F-statistic	3.943498	2.316136
Log likelihood	14.64075	-4.543492
Akaike AIC	-0.451260	1.083479
Schwarz SC	-0.012465	1.522275
Mean dependent	0.110450	-0.072523
S.D. dependent	0.237027	0.435099
Determinant resid covariance (dof adj.)		0.003676
Determinant resid covariance		0.001506
Log likelihood		10.28372
Akaike information criterion		0.617303
Schwarz criterion		1.494893

Vector Autoregression Estimates
Date: 09/06/22 Time: 09:53
Sample (adjusted): 1996 2020
Included observations: 25 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	DDRES	DINPV
DDRES(-1)	0.788159 (0.24423) [3.22708]	0.178636 (0.52610) [0.33955]
DDRES(-2)	-0.588193 (0.24901) [-2.36213]	0.816241 (0.53639) [1.52175]
DDRES(-3)	0.630262 (0.24859) [2.53539]	0.402128 (0.53548) [0.75097]
DDRES(-4)	-0.112569 (0.23462) [-0.48022]	0.538849 (0.50540) [1.06619]
DINPV(-1)	0.269581 (0.27850) [0.96797]	-0.389677 (0.59991) [-0.61622]
DINPV(-2)	0.150992 (0.28179) [0.53584]	0.056104 (0.60700) [0.09243]
DINPV(-3)	0.125323 (0.30363) [0.41276]	-0.172091 (0.65404) [-0.26312]
DINPV(-4)	0.037529 (0.28908) [0.12982]	-1.568959 (0.62270) [-2.51963]
C	0.019945 (0.05190) [0.21185]	-0.314577 (0.11179) [-2.82381]

Source: Prepared by the two researchers based on a program Eviews 09.

3.4. Statistical and Economic Evaluation of the Model:

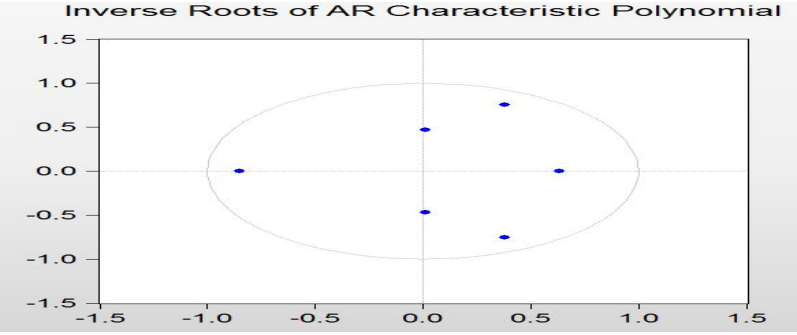
The determination coefficient (R2) is 53%, which is considered a good and significant percentage. This indicates a strong relationship between the dependent variable (INPV = number of imported cars) and the independent variable (RES = foreign exchange reserves). The adjusted determination coefficient is 30%, indicating that the remaining variation is attributed to other variables not included in the model, such as political decisions.

Regarding the individual significance of the model parameters, it is known that in such models with a large number of observations and lagged variables, the degrees of freedom decrease, which weakens the significance of the parameters. However, in this type of model, the main objective is to study the dynamic behavior of variables and analyze shocks. Additionally, the statistical value of the F-test (Fc>Ft) is greater than the critical value (f_c= 3.31 >f_{tab}=2.47), indicating overall statistical significance of the model.

Furthermore, there is a positive trend between the dependent variable (INPV = number of imported cars) and the independent variable (RES - foreign exchange reserves) over the four lag periods (+0.17, +0.81, +0.40, 0.53+). This implies a positive relationship during the study period from 1990 to 2021, which aligns with economic theory. and confirms the formulated hypothesis that an increase in foreign exchange reserves leads to an increase in the number of imported cars in the short term.

- **VAR Model Validity Test (VAR(4)):** To confirm the validity of the proposed model, a series of tests are conducted.
- **VAR(4) Model Stability Test:** To ensure the stability of the model residuals, the multiple roots test is employed. The autoregressive roots are considered stable if all roots are less than one. The figure below demonstrates the results of this test.

Fig.8. Model stability testvar(4)

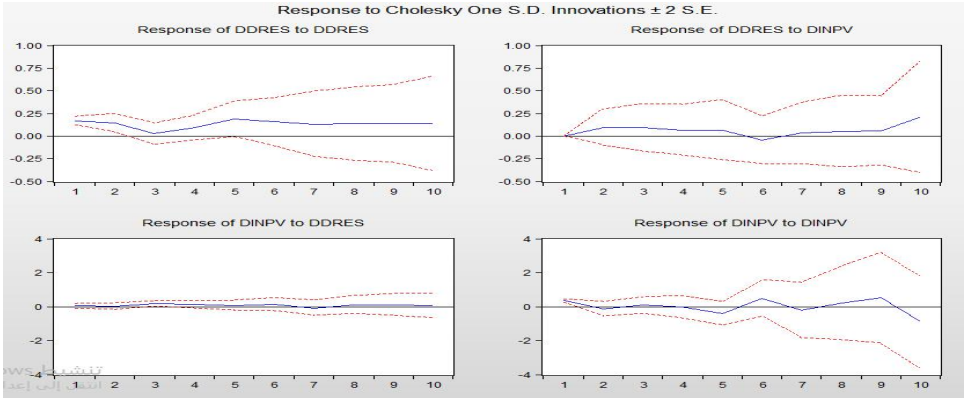


Source: Prepared by the two researchers based on a program Eviews 09.

We observe that all the univariate roots of the VAR(4) model fall within the unit circle, indicating that the model is stable.

- Impulse Response Functions and Shock Analysis: The impulse response analysis allows us to study the impact of a shock on the variables in the model. It enables us to measure the sudden effect of a specific phenomenon on the other variables. In our study, we will analyze the response of DDRES to the shock of DINPV.

Fig.9. Graph of the DINPV response to DDRES shock



Source: Prepared by the two researchers based on a program Eviews 09.

Fig.10. Response data DINPV for DDRES shock

Response of DINPV: Period	DDRES	DINPV
1	0.044139	0.360049
	(0.07228)	(0.05092)
2	0.013765	-0.133102
	(0.09215)	(0.21682)
3	0.160676	0.086744
	(0.08015)	(0.24021)
4	0.124065	-0.005302
	(0.11789)	(0.33264)
5	0.077512	-0.406787
	(0.14268)	(0.34786)
6	0.126306	0.500287
	(0.19715)	(0.52812)
7	-0.081487	-0.218922
	(0.21851)	(0.81607)
8	0.106882	0.220938
	(0.26071)	(1.08860)
9	0.111125	0.514163
	(0.32437)	(1.33522)
10	0.053429	-0.880883
	(0.37139)	(1.36077)

Cholesky Ordering: DDRES DINPV
Standard Errors: Analytic

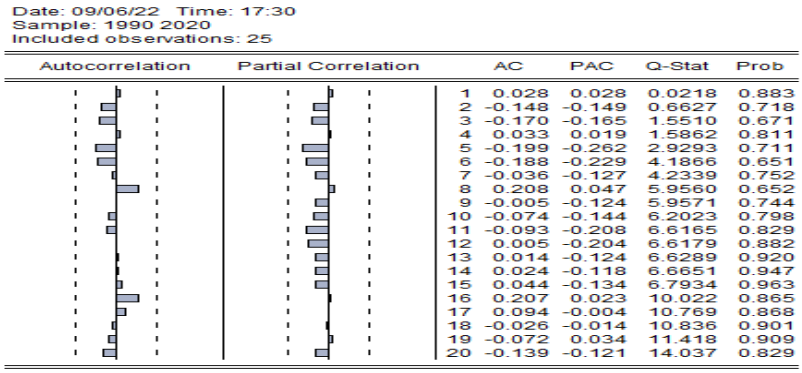
Source: Prepared by the two researchers based on a program eviews 09.

Based on the obtained results, we notice a shock in foreign exchange reserves estimated at 0.044. There was a response in the first period for the number of imported cars estimated at 0.36, and with a decrease in the level of shocks in the third period (0.13), the response level also decreased. However, as the periods progressed and the shocks decreased, the response level in the number of imported cars increased, reaching a value of 0.05 at a shock level estimated at -0.08 in the tenth period. Thus, we can say that any change in foreign exchange reserves in the early periods leads to an increase in the shock and an increase in car imports. However, in

the later periods, specifically the eighth and ninth periods, the impact of the shock was low. In the tenth period, the impact was negative, indicating a negative effect of foreign exchange reserves on car imports, which aligns with real-world observations.

➢ **White noise test :**

Fig.10. Reside autocorrelation function



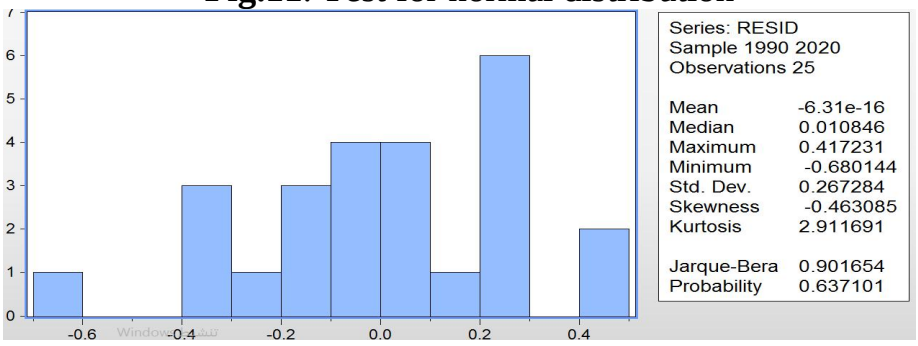
Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.028	0.028	0.0218	0.883
		2	-0.148	-0.149	0.6627	0.718
		3	-0.170	-0.165	1.5510	0.671
		4	0.033	0.019	1.5862	0.811
		5	-0.199	-0.262	2.9293	0.711
		6	-0.188	-0.229	4.1866	0.651
		7	-0.036	-0.127	4.2339	0.752
		8	0.208	0.047	5.9560	0.652
		9	-0.005	-0.124	5.9571	0.744
		10	-0.074	-0.144	6.2023	0.798
		11	-0.093	-0.208	6.6165	0.829
		12	0.005	-0.204	6.6179	0.882
		13	0.014	-0.124	6.6289	0.920
		14	0.024	-0.118	6.6651	0.947
		15	0.044	-0.134	6.7934	0.963
		16	0.207	0.023	10.022	0.865
		17	0.094	-0.004	10.769	0.868
		18	-0.026	-0.014	10.836	0.901
		19	-0.072	0.034	11.418	0.909
		20	-0.139	-0.121	14.037	0.829

Source: Prepared by the two researchers based on a program eviews 09.

Through the above figure, we observe that all the values of the simple and partial autocorrelation coefficients fall within the confidence interval for the remaining coefficients. Additionally, the Box-Lung statistic, with the latest value of Q* = 14.037, is lower than the chi-square statistic of 31.41 at a significance level of 0.05. Hence, we accept H0, which suggests that the residual series represents white noise.

➢ **Normality Test:**

Fig.11. Test for normal distribution



Source: Prepared by the two researchers based on a program Eviews 09.

Based on the above figure of normality distribution coefficients for residuals, which relies on the joint test of symmetry and kurtosis using the Jarque - Bera test, and based on the corresponding probability value of this test, which is 0.63 and greater than the significance level of 0.05, we accept the null hypothesis H0, which suggests that the residuals follow a normal distribution at a significance level of 0.05.

➢ **Autocorrelation test for errors:**

Fig.12. lm-test results

Lags	LM-Stat	Prob
1	12.07162	0.0168
2	9.692730	0.0459
3	6.500258	0.1648
4	0.237815	0.9935
5	4.816075	0.3067
6	8.183976	0.0851
7	0.400298	0.9825
8	1.943698	0.7461
9	2.571926	0.6318
10	1.866113	0.7604
11	2.197894	0.6994
12	1.530918	0.8212
13	5.101629	0.2770
14	3.032842	0.5523
15	6.605326	0.1583

Probs from chi-square with 4 df.

Source: Prepared by the two researchers based on a program eviews 09.

The table indicates the acceptance of the hypothesis of no autocorrelation between the model residuals, as the probability value (pro = 0.15) is greater than the significance level of 0.05.

Discussion of the results:

Through this study, we measured the relationship between foreign exchange reserves and the importation of cars in Algeria during the period 1990-2020. We relied on the descriptive-analytical method for studying the variables and the standard method for determine nature of this relationship. In analyzing the data of the study variables, we utilized one of the techniques of factor analysis, which is Principal Component Analysis (PCA). The results were as follows:

- The analysis proved the existence of a strong positive relationship between the study variables, namely foreign exchange reserves and car imports in Algeria during the mentioned study period.

- The years from 2010 to 2017 were well represented on the (F2) axis with positive coordinates, indicating a strong positive correlation with the foreign exchange reserves variable (RES) and the car imports variable (INPV). This period witnessed a significant increase in oil prices, leading to a rise in foreign cash reserves and an increase in the number of imported cars to record levels.

- The years from 1990 to 1999, 2019, and 2020 were well represented on the (F2) axis with negative coordinates, indicating a strong negative correlation with the foreign exchange reserves variable (RES) and the variable of car import volume (INPV). This period witnessed a decrease in foreign exchange reserves and a decrease in the number of imported cars.

Regarding the standard study, the results revealed the following:

- There is a positive effect at a 5% confidence level of foreign exchange reserves on the number of imported cars. There is a correlation estimated at 53 = R2, indicating a moderate relationship between foreign exchange reserves and the volume of imported cars in Algeria. This is confirmed by the current crisis, indicating that foreign exchange reserves have a relationship with the import volume of cars. Additionally, there are other variables that were not included in the model and were within the margin of error.

- The results also showed, according to the Granger causality test, the absence of causality between foreign exchange reserves and the number of imported cars from both directions.

- The impulse response functions and shock analysis revealed a shock in foreign exchange reserves estimated at 0.044, which resulted in a response in the initial

period of imported car numbers estimated at 0.36, and with a decrease in shock levels in the third period (0.13), the response level decreased. However, as the periods passed and shock levels decreased, the response level in the number of imported cars increased and reached a value of 0.05 at a shock level estimated at -0.08 in the tenth period. Therefore, we can conclude that any change in foreign exchange reserves in the early periods will lead to an increase in the shock and an increase in car imports. However, it is noteworthy that in the later periods, specifically the eighth and ninth periods, the impact of the shock was low, while in the tenth period, the impact was negative, indicating a negative effect of foreign exchange reserves on car imports, which is observed in reality.

The study reached the following conclusions:

- The first hypothesis, which assumes the existence of a long-term equilibrium relationship between foreign exchange reserves and the volume of car imports in Algeria during the period 1990-2020, was refuted. The results demonstrated the presence of a short-term relationship.

- The second hypothesis, which states the existence of a negative relationship between foreign exchange reserves and the volume of car imports in Algeria during the study period 1990-2020, was confirmed by the study's results.

- Based on the study's results for the period 1990-2020, it can be concluded that the increase in foreign exchange reserves led, in the short term according to the var model, to an increase in car imports, albeit to varying degrees according to the study's findings, except for the recent years.

Conclusion:

In our study on the impact of exchange rates on the volume of car imports in Algeria and understanding the causes of the recession in the car market, it can be concluded that the depletion of foreign exchange reserves was the main reason that

led the Algerian government to adopt a policy of "belt tightening" by curbing imports and freezing the import of thousands of goods and products, including cars. This had a negative impact on the car market in Algeria, where the national car market experienced an unprecedented recession due to high demand and declining supply.

Based on this, some recommendations can be proposed:

- Developing a genuine industry to reduce car imports and preserve foreign exchange reserves.

- The necessity of diversifying exports outside the hydrocarbon sector to increase the value of foreign exchange reserves and thus cover imports, especially car imports

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Annexes :

Annexe.1. Deco-Fowler Test Results for the RES Series at Level

Null Hypothesis: RES has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.187291	0.2148
Test critical values:	1% level	-3.679322	
	5% level	-2.967767	
	10% level	-2.622989	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RES)
Method: Least Squares
Date: 09/08/22 Time: 18:09
Sample (adjusted): 1992 2020
Included observations: 29 after adjustments

Null Hypothesis: RES has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 6 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.094258	0.0189
Test critical values:	1% level	-4.394309	
	5% level	-3.612199	
	10% level	-3.243079	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RES)
Method: Least Squares
Date: 09/08/22 Time: 18:06
Sample (adjusted): 1997 2020
Included observations: 24 after adjustments

Null Hypothesis: RES has a unit root
Exogenous: None
Lag Length: 1 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.567010	0.1085
Test critical values:	1% level	-2.647120	
	5% level	-1.952910	
	10% level	-1.610011	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RES)
Method: Least Squares
Date: 09/08/22 Time: 18:12
Sample (adjusted): 1992 2020
Included observations: 29 after adjustments

Annexe.2. Deco-Fowler Test Results for the RES Series at 1st Team

Null Hypothesis: D(RES) has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.427861	0.1398
Test critical values:	1% level	-2.647120	
	5% level	-1.952910	
	10% level	-1.610011	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RES,2)
Method: Least Squares
Date: 09/08/22 Time: 18:16
Sample (adjusted): 1992 2020
Included observations: 29 after adjustments

Null Hypothesis: D(RES) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.651063	0.7468
Test critical values:	1% level	-4.309824	
	5% level	-3.574244	
	10% level	-3.221728	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RES,2)
Method: Least Squares
Date: 09/08/22 Time: 18:13
Sample (adjusted): 1992 2020
Included observations: 29 after adjustments

Null Hypothesis: D(RES) has a unit root
Exogenous: Constant
Lag Length: 7 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.958749	0.0066
Test critical values:	1% level	-3.769597	
	5% level	-3.004861	
	10% level	-2.642242	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RES,2)
Method: Least Squares
Date: 09/08/22 Time: 18:14
Sample (adjusted): 1999 2020
Included observations: 22 after adjustments

Annexe.3. Deco-Fowler test results for the RES series at second difference

Null Hypothesis: D(RES,2) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.404641	0.0083
Test critical values:	1% level	-4.323979	
	5% level	-3.580623	
	10% level	-3.225334	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RES,3)
Method: Least Squares
Date: 09/08/22 Time: 18:16
Sample (adjusted): 1993 2020
Included observations: 28 after adjustments

Null Hypothesis: D(RES,2) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.433284	0.0016
Test critical values:	1% level	-3.689194	
	5% level	-2.971853	
	10% level	-2.625121	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RES,3)
Method: Least Squares
Date: 09/08/22 Time: 18:17
Sample (adjusted): 1993 2020
Included observations: 28 after adjustments

Null Hypothesis: D(RES,2) has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.506466	0.0001
Test critical values:	1% level	-2.650145	
	5% level	-1.953381	
	10% level	-1.609798	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RES,3)
Method: Least Squares
Date: 09/08/22 Time: 18:18
Sample (adjusted): 1993 2020
Included observations: 28 after adjustments

Annexe.4. Deco-Fowler test results for the INPV series at the level

Null Hypothesis: INPV has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.124317	0.9078
Test critical values:	1% level	-4.296729	
	5% level	-3.568379	
	10% level	-3.218382	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(INPV)
Method: Least Squares
Date: 09/08/22 Time: 18:27
Sample (adjusted): 1991 2020
Included observations: 30 after adjustments

Null Hypothesis: INPV has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.999609	0.2777
Test critical values:	1% level	-2.644302	
	5% level	-1.952473	
	10% level	-1.610211	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(INPV)
Method: Least Squares
Date: 09/08/22 Time: 18:30
Sample (adjusted): 1991 2020
Included observations: 30 after adjustments

Null Hypothesis: INPV has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.619513	0.4606
Test critical values:	1% level	-3.670170	
	5% level	-2.963972	
	10% level	-2.621007	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(INPV)
Method: Least Squares
Date: 09/08/22 Time: 18:29
Sample (adjusted): 1991 2020
Included observations: 30 after adjustments

Annexe.5. Deco-Fowler test results for the INPV series at the first difference

Null Hypothesis: D(INPV) has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.332752	0.0000
Test critical values:	1% level	-2.647120	
	5% level	-1.952910	
	10% level	-1.610011	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(INPV,2)
Method: Least Squares
Date: 09/08/22 Time: 18:34
Sample (adjusted): 1992 2020
Included observations: 29 after adjustments

Null Hypothesis: D(INPV) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.218490	0.0000
Test critical values:	1% level	-3.679322	
	5% level	-2.967767	
	10% level	-2.622989	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(INPV,2)
Method: Least Squares
Date: 09/08/22 Time: 18:33
Sample (adjusted): 1992 2020
Included observations: 29 after adjustments