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The relationship between the consumer price index and macroeconomic policy variables in North African countries (2001-2020)

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Abstract--This research paper deals with the relationship between the consumer price index and the macroeconomic policy variables (LG, M2 and EXCH), in the North African countries (Algeria, Tunisia, Egypt and Morocco), in the period (2001-2020). The study relied on the Panel Vecm model in order to show this relationship in the long and short run. This study was found that there is at least one cointegration relationship, through tests of (Pedroni, Kao and Johanssen), the stability of the variables in the first differences, and the rate of return to equilibrium was determined, which was estimated at 3.5% per year, which showed the extent of the weakness of the economies of the selected countries in fixing the various imbalances that occurred.

Keywords--Government spending, Monetary expansion, The consumer price index, Cointegration, Stability.

Introduction

Inflationary pressures have become of great importance in various countries, especially developing countries, including North African countries (Algeria, Tunisia, Egypt and Morocco), as these countries have adopted economic reforms

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with the aim of moving to a market economy and abandoning the directed economy, in order to adapt to the emerging changes on the global scene. A significant rise in prices emerged in the nineties, which had negative effects on both consumers and producers, leading to a deterioration in the economic situation of these countries.

These countries (North African countries) have followed intensive development strategies aimed at raising the standard of living of individuals and achieving economic stability. Among the most prominent strategies adopted are the expansion of consumer spending and investment spending, which later led to the creation of a deficit in the general budget of these countries for successive years, in addition to implementing an expansionary, unsystematic monetary issuance strategy, which led to inflationary pressures in the economies of these countries as a result of the increase in the consumer price index through increased consumer demand. In addition, the inflationary pressures occurring in North African countries also led to a reciprocal effect between them and exchange rates, as some studies have proven the existence of a relationship between the exchange rate policy represented by the exchange rate and indicators of monetary stability such as inflation.

Accordingly, through our research, we seek to find a relationship between the consumer price index and macroeconomic policy variables (government spending, monetary expansion and exchange rate) in North African countries (Algeria, Tunisia, Egypt and Morocco) during the period 2001-2020. This research studied the following problem : **What is the relationship between the consumer price index and macroeconomic policy variables in North African countries in the period 2001-2020?**

2. Determining the temporal and spatial framework of the study

2.1 The temporal framework:

We chose the time period (2001-2020), because we wanted to study the relationship between financial and monetary variables in the consumer price index in a more recent period with close changes related to global macroeconomic events (oil crisis, Corona virus, financial crisis ...), and internal events in the countries under study (Arab Spring, political changes, borrowing and debt policy), and what affected inflation rates to varying degrees, as they reached very high levels, especially in recent years in these countries, which relied on different policies to confront these changes through development programs with huge financial amounts through circumstantial and structural policies to confront the existing imbalances.

2.2 Spatial framework:

With regard to the spatial framework, we can say that despite the differences in the economies under study, there are several common factors, which is what made us choose the spatial framework under study, which is the countries of North Africa (Algeria, Tunisia, Morocco, Egypt), and the common factors can be highlighted in the following points:

- They are all countries located in North Africa, and therefore located in an active area for economic exchange and open to foreign markets, especially European and Asian ones, as they are the closest to them.
- They all have geographical characteristics that help in trade exchange, such as the Suez Canal, the Mediterranean Sea, and the Atlantic Ocean.
- They are all considered to be large consumer countries, and therefore an active market for imported products, especially food and intermediate products that enter into production processes.
- As for stability, they are all countries that have been exposed to economic and political shocks to varying degrees, and they also adopt an open market system in their economy, albeit to certain degrees, and they depend on support policies for widely consumed materials, albeit to varying degrees, in addition to having parallel markets, especially for the exchange and foreign currency markets, which represent a large monetary mass outside the control and management of the state.
- It can be said that its production system is characterised by a lack of flexibility and the inability to meet the needs of the consumer market, so most of them tend to import materials from abroad to fill the shortage and achieve what is required by various needs.

3. Study variables

The research deals with studying the impact of a set of variables on inflation resulting from the prices paid by consumers annually for the countries of North Africa (Algeria, Tunisia, Morocco, Egypt) during the period 2001-2020. We took Three independent variables (government spending, official exchange rate and money supply as a percentage of gross domestic product). Each variable, its abbreviated symbol and its data sources were summarized and presented as shown in Table No 1. The inflation rate resulting from the prices paid by consumers annually, which comes as a percentage, was relied upon as a dependent variable for several reasons :

- The difference in food commodities and services from one country to another.
- The difference in the base year to which the comparison is made.
- The difference in the objectives of its calculation.
- The method of data collection, the target group of the census process.
- The percentage of the population.
- Consumer behavior in countries.
- Monetary and financial reserves and the domestic product and the diversity of its sources.

Therefore, the inflation rate resulting from the prices paid by consumers annually provides us with the percentage of increase and decrease each year in the inflation rates resulting from the prices of widely consumed goods accurately without being affected by the difference in food commodities from one country to another or the target group, and thus facilitates the process of integration, comparison and measurement with the changes that occur in this rate in these countries with ease, and also facilitates the process of studying the relationship between it and the overall variables that express the most important monetary and financial macroeconomic policies as independent variables (monetary mass, exchange rates and government spending) and because it is a comprehensive

indicator that expresses overall changes in the countries under study, which is what we are trying to know by studying the relationship between the study variables.

The various symbols used to indicate the variables in the study can be summarized in the following table:

Table 1. Symbols of the variables used in the study

Variable	Symbol	Source
The inflation rate resulting from the prices paid by consumers annually	INF	World Bank data
Money supply as a percentage of GDP	M2	World Bank data
Official exchange rate	EXCH	World Bank data
Government spending (after entering LOG)	LG	World Bank data
<p>INF : Inflation as measured by the consumer price index reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly.</p> <p>M2 : Money and quasi money (M2) as % of gdp: comprise the sum of currency outside banks, demand deposits other than those of the central government, and the time, savings, and foreign currency deposits of resident sectors other than the central government.</p> <p>EXCH : Official exchange rate refers to the exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market.</p> <p>LG : refers means money spent by the public sector on the acquisition of goods and provision of services such as education, healthcare, defense, and social protections.</p>		

Source : Prepared by the authors themselves based on World Bank data

4. Literature review

In the following table, we will present and analyze some previous studies that deals with almost the same methodology as ours:

Table 2. Presentation and analysis of some previous studies

Number	Author	Research title	Research objectives	Used tools	Study result
01	Mustapha Djaballah. (2022)	The nexus of monetary policy tools and inflation in Algeria: Whether structural break or Unit Root?	The research paper aimed to study the impact of monetary policy tools on the dynamic imbalances of inflation in the Algerian economy using analytical decomposition methods (FMOLS, DOLS and CCR)	The study included annual data during the period from 1970 to 2020, and based on data of the inflation rate, real exchange rate, money supply and interest rate in Algeria.	The study concluded that monetary policy in Algeria is ineffective through the money channel, while the effectiveness of monetary policy is through lending, and net domestic credit has a significant impact

Number	Author	Research title	Research objectives	Used tools	Study result
					on inflation.
02	Qontat Az-Zahra; Agus Widarjono (2022)	Determinants of Financial System Stability in ASEAN Countries.	This study aims to analyze the impact of financial inclusion, GDP and inflation on the stability of the financial system in the countries under study, using vector error correction model.	Data of GDP, inflation, financial inclusion and financial stability in Indonesia, Thailand and Malaysia during the period 2004 to 2016.	Economic growth has a positive impact on banking stability in Indonesia, inflation has a significant and long-run negative impact on banking stability, inflation is the smallest contributor to economic growth.
03	Zainuri, Zainuri. (2021)	Foreign Portfolio Investment Control Using Macroeconomic and institutional Policies: Evidence from Indonesia and Thailand.	The study aimed to analyze the impact of macroeconomic and institutional factors using the PVECM model.	The data of inflation rate, economic openness, corruption level and regulatory quality were analyzed for both Indonesia and Thailand from 2005 to 2019.	The economic and institutional variables used and the level of corruption have an impact on inflation, and the openness rate has an impact on foreign portfolio investment.
04	Annisa Anggreini Siswanto; Ahmad Albar Tanjung; Irsad Lubis. (2021)	Analysis of macroeconomics stability control of ICI countries (Indonesia, China, and India) based on transmission of monetary policy through interest rate channel.	This study aimed to analyze the variable control of macroeconomic stability based on money and interest rate using PVECM model.	The study used variables represented by: real interest rate, investment consumption, GDP and inflation in Indonesia, China and India with secondary data from 2000 to 2019.	Investment has a negative and significant effect on controlling economic stability, and has a positive and significant effect on GDP in the short term, and with regard to inflation control policies, it affects interest rates and consumption, and the inflation rate affects GDP.
05	Frederick Ikpesu. (2020)	Aid, inflation, and exchange rate in sub-saharan africa: empirical insights from panel vector error correction model (pvecm) approach.	The study aimed to know the impact of aid on inflation and exchange rate in South African countries, and this was done using the vector error correction model with panel data.	The study data included the volume of official development assistance, inflation rates, actual trade volume, import ratio, and gross domestic product for 35 countries in southern Africa, in addition to quarterly data during the period	The study found a co-integration relationship between the variables, the flow of aid causes an increase in the inflation rate, and increases in aid increase investment and exports in the region.

Number	Author	Research title	Research objectives	Used tools	Study result
				from 2000 to 2016.	
06	Marwa Sahnoun; Chokri Abdennadher. (2019)	Causality Between Inflation, Economic Growth and Unemployment in North Africa Countries	The aim of the study is to investigate the relationship between unemployment rate, economic growth and inflation rate in North African countries using the error correction model VECM.	Data on unemployment rate, economic growth and inflation rates for Algeria, Egypt, Morocco and Tunisia from 1965 to 2016.	There is a unidirectional relationship from inflation to economic growth, there is a relationship from economic growth to unemployment, and there is a relationship from inflation to unemployment.
07	Khaysy Srithilat; GangnSu; Thongphet Chathani vong; MakettaT havisay. (2018)	The relationship between inflation, exchange rate, and currency substitution: Evidence from panel vector error currency model approach.	The aim of this study is to verificate the relationship between inflation and exchange rate in Southeast Asian economies, using the VECM model using panel data.	Annual data from 1995 to 2015 are used for the real exchange rate, inflation rates, and currency exchange rates for Southeast Asian countries (Cambodia, Indonesia, Vietnam, Philippines, Laos).	The study confirmed the existence of a long-run relationship between the study variables, the existence of a causal relationship between inflation and currency substitution, and the existence of a positive effect between currency substitution in the long term

Source: Prepared by the authors themselves based on the above-mentioned studies

5. Method

5.1 Model Used

We used in our study Panel Vecm model (vecm) because it takes into account the changes in time for the Cross-sections, so we will use in particular the tests related to stability, sensitivity, Cointegration and structural breaks. It is also considered one of the dynamic panel models that depend on the characteristics of the time dimension and the movement of variables over time, which leads to the formation of short- and long-run relationships that are achieved through stability in the variables and reducing structural breaks in the long panel data (Pesaran, 2015). The Panel Vecm model requires that the variables be stable in the first difference and that there is at least one cointegration relationship. It also provides us with the error correction factor, how to return to equilibrium and the time required for that through its negative sign (Engle & Granger, 1987).

5.2 Descriptive Study

In our descriptive study, we will try to present the data used for all variables, then show them in the form of time-varying graphic curves in order to know the general trend of these variables and their structural characteristics initially, in

addition to studying the correlation between the study variables and the nature of the distribution followed by all these intervals.

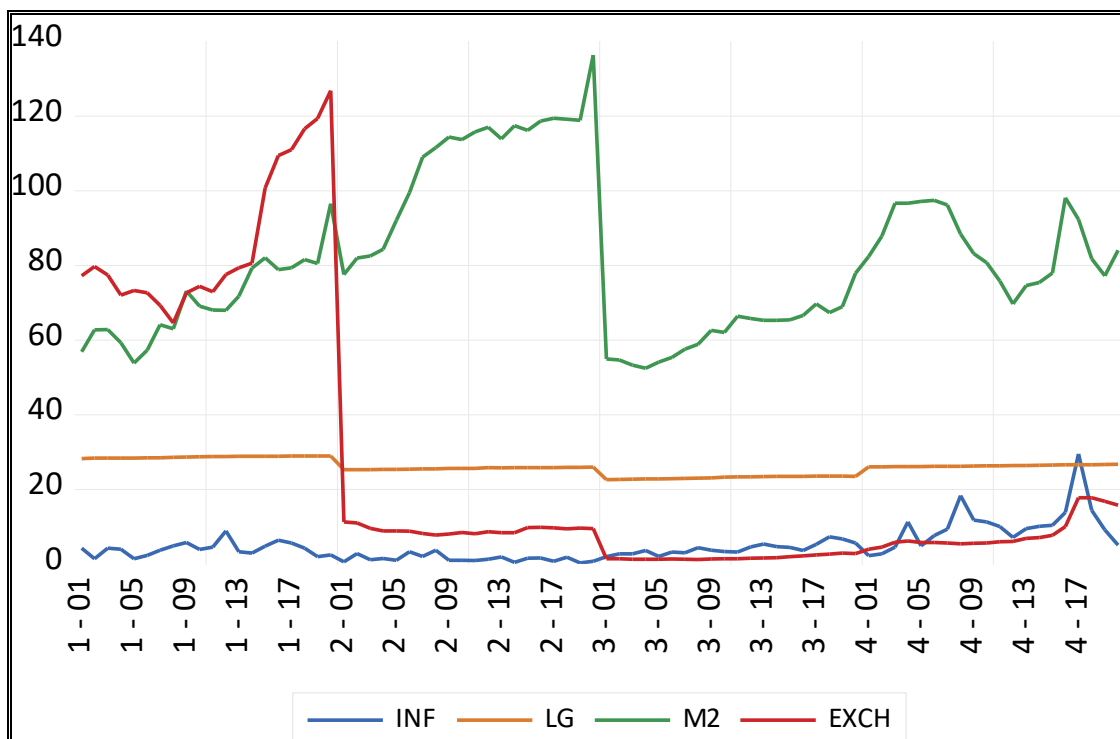


Figure 1. Developments of study variables for each country during the period (2001-2020)

Source: Prepared by the authors themselves based on Eviews 12 program outputs

- 1st Cross-section : refers to Algeria.
- 2nd Cross-section : refers to Morocco.
- 3rd Cross-section : refers to Tunisia.
- 4th Cross-section refers to Egypt.

Through Figure (1) which shows the graphical forms of the panel data in the case of integration of the economic variables under study, we notice that both the variables EXCH and M2 have almost the same path and (symmetrical) and a general positive trend and they are increasing rapidly during the study period. This is with regard to the cross-section for Algeria. About the cross-section of Morocco, we notice a rapid increase in the volume of M2, and the variable EXCH also has a general positive trend but it is increasing at a regular degree as it appears in a state of stability throughout the study period, even maintaining a certain level of stability. About Tunisia, we notice a regular increase in the volume of M2, while it is corresponding to the lowest level in EXCH compared to the sections of other countries during the study period. As for the cross-section of Egypt, we notice that EXCH and M2 decreased together in 2017 after they were in a state of relative stability, for the variable LG of all the countries under study, we notice that its time series is somewhat stable towards a fixed average from one

country to another, as it takes a horizontal form parallel to the interval axis, which shows us that it is free of trend.

5.2.1 Statistical (descriptive) characteristics of the study variables

Table 3. Descriptive characteristics of study variables

Variable	Obs	Mean	Std. Dev.	Min	Max
INF	80	4.931321	4.544424	.303386	29.50661
EXCH	80	26.37633	36.32922	1.232142	126.7768
M2	80	81.56573	20.69583	52.47725	136.3093
LG	80	25.94727	1.987171	22.61336	28.95544

Source : Prepared by the authors themselves based on Stata 17 program outputs

5.2.2 Testing normality distribution by skewness and kurtosis test

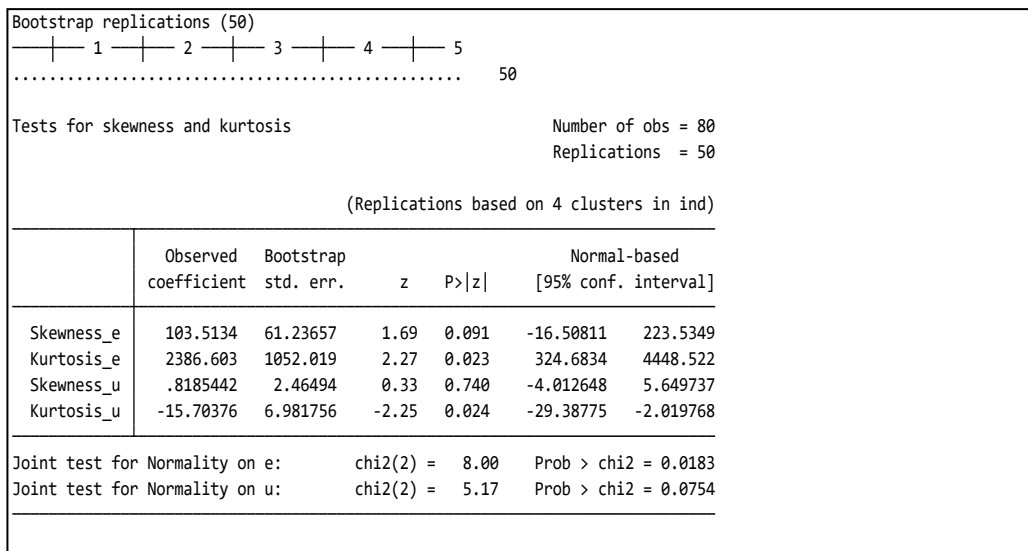


Figure 2. Testing normal distribution by Skewness and Kurtosis test
 Source : Prepared by the authors themselves based on STATA 17 program outputs

To ensure that the variables are normally distributed, we used the results of both Skewness and Kurtosis for the variables (Galvaoa.f, Montes-Rojas, Sosa-Escudero, & Wang, 2013). We concluded from the results of the table that after 50 experiments, the variables are normally distributed at a significance level of 5%, where a value of 0.07 was obtained, which is greater than 0.05.

5.2.3 Study of the correlation between the variables

Table 4. Correlation matrix between study variables

EXCH	M2	LG	INF	
-0.08387472745171731	-0.0857194936724209	0.1113463063465712	1	INF
0.8220874852486921	0.1419781448323265	1	0.1113463063465712	LG
-0.1893051312333465	1	0.1419781448323265	-0.0857194936724209	M2
1	-0.1893051312333465	0.8220874852486921	-0.08387472745171731	EXCH

Source : Prepared by the authors themselves based on Eviews 12 program outputs

From the previous table No 4 which shows the correlation matrix between the variables, which helps us to determine the extent of the correlation of the variables with each other while showing the inverse or direct relationship, through the sign of the obtained value, we find that the diameter of the matrix takes the number 1, which resulted from the relationship of each variable with itself and the rest of the matrix parameters take values confined between -1 and 1 and symmetrically reflect the correlation between one variable and another, as we see that the value of the correlation between the variables INF and M2 is -0.08, and between INF and EXCH is -0.08 (both are far from 1 and with a negative sign), and thus there is a weak and inverse correlation, meaning that M2 increases INF decreases, which allows us to say that there are other reasons for its increase, and since we are dealing with the economies of developing countries, their production base remains weak, which does not allow them to cover the total demand that has increased and from it resorting to import as a solution, and here EXCH plays the main role in this process, because its coverage is related to the status of the local currency and its stability and the general reserve of hard foreign currencies, which leads to the increase in the cost of import is accompanied by an increase in the consumer price index and thus in the inflation rate resulting from the prices paid by consumers annually and resulting from the increase in the cost of import. As for the correlation between INF and LG, it is a direct relationship, but it remains weak at about 0.111. Therefore, we can say that LG has a direct relationship and affects consumer prices, which is shown by the inflation rate resulting from the prices paid by consumers annually. We also noticed the existence of a relationship between the independent variables, especially between LG and Exch, where it took a value of 0.822, which requires us to carry out the process of verifying the existence of a linear relationship between these variables, which leads us to use the VIF.

5.2.4 VIF test (Variance Inflation Factor)

Table 5. Variance Inflation Factor

Variable	VIF	1/VIF
EXCH	4.38	0.228549
LG	4.31	0.232272
M2	1.45	0.691018
Mean VIF	3.38	

Source: Prepared by the authors themselves based on STATA 17 program outputs

In order to decide if there is a linear relationship between the independent variables, the average value of the VIF must be less than 5 (from 1 to 5) (Djedaiet, Ayad , & Ben-Salha, 2024), And in our case, the value is 3.38, So, there is no linear relationship between the independent variables, and there is no linear duplication.

5.2.5 Structural Breaks testing in data at all sections

Table 6. Structural Breaks test results in data between all sections

Bai Perron Critical Values				
	Test Statistic	Critical Value 1%	Critical Value 5%	Critical Value 10%
(1/0) F	0.76	6.09	4.66	4.03
(2/1) F	1.13	6.59	5.24	4.64
(3/2) F	0.40	6.92	5.61	4.99
(4/3) F	0.04	7.33	5.87	4.23
(5/4) F	-0.56	7.49	6.05	5.45

Source: Prepared by the authors themselves based on STATA 17 program outputs

From the previous table No 6, we notice that all the calculated statistical values are less than the tabulated values for the different degrees of significance: Significant at 1%, significant at 5%, significant at 10%. From this, we can say that there is no structural fracture (Karavias, Narayan, & Westerlund, 2022).

5.3 Model estimation by PVECM method

Estimation by the (PVECM) model for panel data, which is an extension of the (VECM) model in time series, but it also takes into account the correlations between the cross-sections in the panel data and the homogeneity between them, in addition to the conditions that were relied upon in the study of (VECM), which provides an opportunity for the process of expanding and integrating the various characteristics that characterize the latter, and the most important assumptions for it are that all variables are stable in the first difference, the existence of at least one Cointegration relationship, in addition to the error correction coefficient being negative and having statistical significance (Baltagi, 2015), Which means having economic significance to explain the existence of a relationship in the short-run by making differences on the variables in order to return to the state of equilibrium in the long run (Chudik, Pesaran, Mohaddes , & Raissi, 2013).

5.3.1 Unit Root test

To test the degree of stability, considering the time series stable is achieved only when the series do not contain a unit root, and one of the most prominent tests to discover the unit root or not in this case, taking into account the existence of (a constant and a general trend) is the test of each of (IPS. ADF. PP. LLC) (Levin, Chien-fu, & Chia-Shang, 2002), and they are all based on the following assumptions in general:

- {H₀: The Series is unstable and contains a unit root
- {H₁: The Series is stable and does not contain a unit root

All stability tests (IPS, ADF, PP, LLC) depend during the process of determining the stability of the series on the significance value p-value (Ficher, 1934), where when the significance is less than 0.05 or less than 0.10 or less than 0.01 (at a significance of 5% or 10% or 1%) we say that the series are stable and we accept the alternative hypothesis and reject the null hypothesis (Kyung, Pesaran, & Yongcheol, 2003), and vice versa, and through the results shown below Table No. 7 which show the results of the stability study at the level and in the cases (fixed and general trend), it is possible to accept the null hypothesis for the variables (INF, EXCH, LG, M2), meaning that they are not stable and contain a unit root, since the significance value for these variables is greater than 0.05 and 0.10, and since the (PVECM) model assumes that the series are stable in the first difference, we will retest the stability of the variables that did not stabilize at the level.

Table 7. Unit root test results

Method	Variables			
	INF	LG	M2	EXCH
LLC				
level	0.22	0.85	0.80	0.12
First difference	0.19	0.03***	0.34	0.00***
IPS				
Level	0.09	0.97	0.37	0.90
First difference	0.004***	0.03***	0.03***	0.005***
ADF				
Level	0.07	0.97	0.46	0.92
First difference	0.001	0.02	0.04	0.002
PP				
Level	0.08	0.96	0.74	0.15
First difference	0.00***	0.00***	0.05***	0.001***

Source : Prepared by the authors themselves based on Eviews 12 program outputs

***, Significant at 5%

After performing the first difference, the significance value of the variables became less than 0.05, and thus the series are stable in the first difference (constant and general trend), meaning we reject the null hypothesis that the series contain a unit root and accept the alternative hypothesis.

5.3.2 Cointegration Test

To verify the existence of a cointegration relationship or not, we will do a set of tests, which are: Pedroni test, Kao test and Johanson test.

-Pedroni's test for Cointegration: The Pedroni test for cointegration is based on seven results of cointegration tests between Cross-section, within units, with a constant and a general trend, and it depends in the decision-making process on the majority of the results, where if the p-value is less than 0.05, then we can say that there is at least one cointegration relationship (Pedroni, 2004), and the results of this test are summarized in the following table:

Table 8. Pedroni test results for cointegration

Pedroni test results for cointegration between variables (with constant and general trend)					
Within the units			Between units		
Test	Static	Prop	Test	Static	Prop
Group rho-statistic	0.960	0.831	Panel v-statistic	-0.122	0.889
Group pp-statistic	-6.136	0.00	Panel rho-statistic	0.514	0.696
Group adf-statistic	-1.656	0.04	Panel pp-statistic	-4.593	0.00
			Panel adf-statistic	-2.475	0.006

Source : Prepared by the authors themselves based on Eviews 12 program outputs

According to Pedroni cointegration test, we see most of the results had p-value less than 0.05, so we can say that there is at least one cointegration relationship.

-Kao's test for Cointegration: The Kao test for cointegration depends on the p-value of ADF, If it is less than 0.05, we can say that there is at least one cointegration relationship (Bai, Kao, & Ng, 2009), and we will test it in the following table:

Table 9. Kao test results for cointegration

Test	T-statistic	Prob
ADF	-3.189	0.0007

Source : Prepared by the authors themselves based on Eviews 12 program outputs

According to the results of Kao test, we see that the p-value of ADF is 0.0007, So we say there is at least one cointegration relationship.

-Johansson's cointegration test: The decision-making in Johansson's cointegration test depends on the p-value and Fisher's value, the trace test and the maximum value test. If the p-value is less than 0.05, we say that there is at least one cointegration relationship (Johansen, 1988). We can show the results of Johansson test in the follow table:

Table 10. Johansson test results for cointegration

Hypothesized No. of CEs	Fisher Stat*.)from trace test(Prob	Fisher Stat*. from max-eigen test	Prob
None	57.83	0.000	41.82	0.000
At most 1	23.70	0.0026	17.88	0.0221
At most 2	12.54	0.1287	13.71	0.0898
At most 3	5.771	0.6728	5.771	0.6728

Source : Prepared by the authors themselves based on Eviews 12 program outputs

From the Results of Johansson test, we notice that we have one or at most two cointegrating relationships, which is determined by the P-value at the 5% significance level.

5.3.3 Lag length selection information criteria based on unrestricted VAR estimates

Table 11. Lag length selection information criteria based on unrestricted VAR estimates

HQ	SC	AIC	FPE	LR	LogL	Lag
13.30552*	13.62083*	13.09859	5.740977	NA	-429.3522	1
13.46412	14.09474	13.05027*	5.491141*	31.13498*	-411.7090	2
13.98974	14.93567	13.36896	7.632262	8.506197	-406.5446	3

Source: Prepared by the authors themselves based on Eviews 12 program outputs

The previous table No. 11 shows the results of the test of the lag length selection information criteria according to the (AIC) standard (Lütkepohl, 2006), from the results of the table, the lag length degree is two delays for the model under study. After the stability test and the test of lag length selection information criteria corresponding to the model under study, we obtain the long- and short-run estimate (Engle & Granger, 1987), which is shown by the following equations:

$$INF_{it} = \alpha_i + \beta_{1i}EXCH_{it} + \beta_{2i}M2_{it} + \beta_{3i}LG_{it} + e_{1i} \quad \dots \dots (1)$$

$$e_{it} = INF_{it} - \alpha_{it} - \beta_{1i}EXCH_{it} - \beta_{2i}M2_{it} - \beta_{3i}LG_{it} \quad \dots \dots (2)$$

Where:

I is 1,2,3, I in equation 1 is the number of the cross-section in our panel model, t=1,2,3, T is the period, INF is the dependent variable, EXCH, M2 and LG are the independent variables, α and β are correspondent coefficient, e is residuals. To get residuals, we bring other variables to the right side of equation 1. Equation 2 describes the lag residuals (e_{it-1}) which explained the independent variable's long-run causal affiliation to the dependent variable (INF). That is denoted by ECT (ECT_{it-1}). The next step is to introduce the system of equations where ETC is incorporated with short-run relation dynamics.

$$\begin{aligned} \Delta INF_{it} = & \alpha_{1i} + \sum_k^n \cdot \beta_{11ik} \Delta INF_{it-k} + \sum_k^n \cdot \beta_{12ik} \Delta EXCH_{it-k} + \sum_k^n \cdot \beta_{13ik} \Delta M2_{it-k} \\ & + \sum_k^n \cdot \beta_{14ik} \Delta LG_{it-k} + \lambda_{1i} ECT_{it-1} \\ & + \mu_{1it} \quad \dots \dots (3) \end{aligned}$$

$$\begin{aligned} \Delta EXCH_{it} = & \alpha_{2i} + \sum_k^n \cdot \beta_{21ik} \Delta EXCH_{it-k} + \sum_k^n \cdot \beta_{22ik} \Delta INF_{it-k} + \sum_k^n \cdot \beta_{23ik} \Delta M2_{it-k} \\ & + \sum_k^n \cdot \beta_{24ik} \Delta LG_{it-k} + \lambda_{2i} ECT_{it-1} \\ & + \mu_{2it} \quad \dots \dots (4) \end{aligned}$$

$$\Delta M2_{it} = \alpha_{3i} + \sum_k^n \cdot \beta_{31ik} \Delta M2_{it-k} + \sum_k^n \cdot \beta_{32ik} \Delta EXCH_{it-k} + \sum_k^n \cdot \beta_{33ik} \Delta INF_{it-k} + \sum_k^n \cdot \beta_{34ik} \Delta LG_{it-k} + \lambda_{3i} ECT_{it-1} + \mu_{3it} \dots \dots (5)$$

$$\Delta LG_{it} = \alpha_{4i} + \sum_k^n \cdot \beta_{41ik} \Delta LG_{it-k} + \sum_k^n \cdot \beta_{42ik} \Delta EXCH_{it-k} + \sum_k^n \cdot \beta_{43ik} \Delta M2_{it-k} + \sum_k^n \cdot \beta_{44ik} \Delta INF_{it-k} + \lambda_{4i} ECT_{it-1} + \mu_{4it} \dots \dots (6)$$

Where:

- Δ is the first difference of variables, k is Optimal lag length our case it is 2, α, β and λ are Slope coefficient of the equation and μ are the residuals and n is size of sample which is 80

The results can be summarized in the following tables:

Table 12. Panel VECM Long-run representation: INF as a dependent variable

Panel VECM Long-run representation: INF as a dependent variable				
	Coefficient	Std. Error	t-Statistic	Probability
ECT	-0.289648	0.109427	-2.646954	0.0087
- Coefficient is significant at * 1% and * 5% level, the linear trend is determined in the data- no Trend in VAR. - Long-run coefficients are -0.001440, -0.165794, 0.339249 for LG ,M2 and EXCH, respectively. - R-squared is 0.512597, and Adjusted R-squared is 0.436965, DW statistics is 2.029424.				

Source : Prepared by the authors themselves based on Eviews 12 program outputs

From the previous table No. 12, which shows the estimation results of the Pvecm model in the long-run, considering the dependent variable INF, where its coefficient takes (-0.289) and with a statistical significance of P-value = 0.0087, it can be said that there is a causality in the long-run from the independent variables (EXCH, M2, LG) to the dependent variable INF. The negative sign of the coefficient of the INF variable in the long-run indicates the rate of return to equilibrium, which is called the speed of return to equilibrium, which can be calculated through $(\frac{1}{0.289})$, mean that in order to return to equilibrium, we needed a period of three and a half years, meaning the adjustment rate is 3.5% annually

Table 13. Panel VECM Short-run: Wald test

Panel VECM short-run: Wald test, Dependent Variable: INF				
Variable	Test Statistic	Value	df	Prob
LG	Chi-sq	0.07	2	0.9640
M2	Chi-sq	36.37	2	0.0000
EXCH	Chi-sq	3.785	2	0.1506

Source : Prepared by the authors themselves based on Eviews 12 program outputs

In order to test the short-run causality from the independent variables to the dependent variable, we used the World test (Wald, 1943), and from the test results, it was shown that there is a causal relationship from the independent variable M2 to the dependent variable INF, which was proven by the P-value =0.0000, and it is less than 5%

Conclusion

This research focused on studying the relationship between the consumer price index and the macroeconomic policy variables (LG, M2 and EXCH), in order to highlight the inflationary pressures resulting from each economic development policy, this study relied on data for North African countries (Algeria, Morocco, Tunisia, Egypt) in the period (2001-2020) which were taken in the form of panel data.

After applying the conditions of the Pvecm model that was chosen to express and highlight the targeted relationship, we concluded that there is at least one cointegration relationship, which was proven by the tests of Pedroni, Kao and Johanssen, and that the variables are stable in the first difference according to the unit root tests (IPS, ADF, PP and LLC), and the estimation process showed that there is a long-run causal relationship from the independent variables to the dependent variable (INF), which was proven by the results in Table (12), through the correction factor or return to equilibrium ECT, which took the value -0.289, which is a significant value at 5%, meaning that the return to equilibrium (which is represented by the negative sign of the value) was at a rate of 3.5% annually. As for the causal relationship in the short-run from the independent variables towards the dependent variable, we relied on the Wald test, which showed us that there is a short-run causal relationship from the independent variable M2 to the dependent variable INF, which was proven by the critical value (less than 5%).

The period of return to equilibrium (three and a half years to fix the imbalances that occurred in the shor-run) was an acceptable result, since the economies of the countries under study are characterized by their inflexibility in dealing with changes in inflationary pressures, which may result from an expansionary development policy being followed. The inflexibility of the economies of these countries can be explained by the weakness of the production base and the weakness of their local currency against other currencies, especially currencies widely used in commercial transactions, since many widely consumed materials are imported, and thus exchange rates also play an important role in determining the trends of inflationary pressures in these countries.

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