Evaluating the Effectiveness of Monetary Policy on the Variables of the Magic Square of Kaldor in Egypt

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Evaluating the Effectiveness of Monetary Policy on the Variables of the Magic Square of Kaldor in Egypt

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Abstract

The objective of this study was to analyze the effectiveness of monetary policy in controlling the variables in Kaldor magic square (economic growth, unemployment, inflation, and balance of payments) and their impact on Egypt's macroeconomic variables during the study period by addressing the effectiveness of monetary policy in reducing unemployment rates, achieving high economic growth, adjusting inflation to the target rate established by the competent monetary authorities, as well as its effectiveness in achieving a surplus balance of payments, to establish an appropriate monetary policy that would contribute to correcting imbalances in the structure of the Egyptian economy. The VAR methodology was used to study the causal relationship between monetary policy and Kaldor magic square variables over the Egyptian economy during the study period. The study concluded that Egypt's monetary policy during the study period had had an impact on Kaldor variables but to an insufficient extent. The results indicated that monetary policy had not sustained positive effects in the short and long term and thus had not had a significant impact on achieving optimal rates of macroeconomic variables in Egypt.

Keywords: Monetary policy, Square-like magical role, Macroeconomics, Structural imbalances, Egyptian economy, VAR model.

1. Introduction

Monetary policy is one of the important economic policies that monetary authorities are implementing to achieve their growth and stability goals. It is also important among other policies because it can play an important role in achieving the multiple goals of the national economy, thanks to their multiple instruments of economic management for economic development and the elimination of problems that impede economic stability. Monetary policy varies in application from state to state, depending on the variables of each country. The view of developed countries on monetary policy differs from that of developing countries in terms of objectives. The developed countries consider that the primary objective of monetary policy is to achieve monetary stability and reduce inflation, while the developing countries view monetary

policy as much further since it aims, to achieve high rates of growth, stabilize the overall level of prices, achieve full use of resources, and achieve a balance of payments. Together, these objectives represent variables in the magic square of Kaldor (Nicolas Kaldor), which can be achieved through an effective monetary policy, see Özkaya and Alhuwesh (2021). This study seeks to determine the form and nature of the relationship between Egypt's monetary policy and the Kaldor magic square variables using a standard study showing the impact of monetary policy control and optimal management of the monetary supply on inflation, employment, economic growth, and the balance of payments in the Egyptian economy in the period from 2000 to 2023. In response to the problem of the study, the following two assumptions have been formulated:

- The effectiveness of monetary policy is determined by the extent to which it can achieve the objectives of Kaldor magic square through its impact on the cash supply.
- The Kaldor magic square variables and monetary policy are causally related.

The objective of the study is to analyze and measure the effectiveness of monetary policy in achieving the objectives of Kaldor Magic Square by building a standard model that measures the effectiveness of monetary policy and its impact on the variables of Kaldor Magic Square (economic growth, unemployment, inflation, and balance of payments), which represent the objectives of Egypt's economic policy during the study period, see Hilmi Özkaya and Alhuwesh (2023). The importance of that study may lie in the fact that it examines the effectiveness of monetary policy in controlling the variables made up of the Kaldor magical square by projecting them on Egypt's situation in the period from 2000 to 2023 to produce results that will help in policy-making and decision-making, especially since Egyptian libraries suffer from the scarcity of economic research on the relationship between monetary policy and the magic square of Kaldor.

The study's methodology was dictated by the demands of the subject matter: it used quantitative analysis to gauge how monetary policy affected the magic square variables over the course of the investigation, and it presented the conceptual framework of the relationship between monetary policy and Kaldor's magic square variables through an analytical descriptive approach.

The organization of this paper was as follows: Section 2 is a review of the literature; Section 3 discusses the concept of monetary policy and its impact on Kaldor magic square variables. Section 4 presents the evolution of Kaldor magic square variables in the Egyptian economy during the period from 2000 to 2023. While in Section 5 offers the empirical application. Section 4 presents the vector auto-regressive (VAR) model and results. Finally, Section 6 reviews conclusions and recommendations.

2. Literature Review

In order to choose the best monetary policy to address structural imbalances in the country's economy and accomplish the goals of the Kaldor magic square (high economic growth, zero inflation, zero unemployment, and balance of payments), Lebza and Difallah (2017) examined the effectiveness of monetary policy in optimizing the variables of the Kaldor magic square in Algeria from 1990 to 2014. A self-degradation ray model (VAR model) was used to test the research theory. The study found that Algeria's monetary policy during the period 1990–2014 failed to optimize macroeconomic variables, under the assumptions of the Kaldor magic square, and that its impact on unemployment and inflation was greater than on economic growth and the balance-of-payments index, mainly because those objectives in Algeria were affected by changes in world prices for petroleum.

Abdelhafid and Mohammed (2023) studied the role of economic reform, which is the role of economic policies in influencing economic growth, inflation, unemployment, and trade deficits. Also, it predicted the prospects of the appropriate economic policy for 2018 to achieve institutional reform in Libya through economic reform. It relied on the long-term relationship to test Kaldor variables between the years 1990 to 2021. They found a two-way causal relationship between the long-term monetary base of political and security instability over the rate of economic growth. The rate of inflation and unemployment showed that there was no causal link in the long term between them and political, security, or institutional instability. Finally, the study recommended the need for a deflationary monetary policy aimed at structural and institutional reform.

Eid (2015) introduced the impact of monetary policy on Saudi Arabia economic growth, focusing on two variables: the narrow monetary supply of expressed in monetary policy and the gross domestic product (GDP) expressed in economic growth. The analytical-descriptive approach was drawn upon through the use of a standard model that was applied using time

series and joint integration to demonstrate the impact of monetary policy on economic growth during the period 2001–2015. The study reached some conclusions, the most important of which was a positive relationship and a clear short-term impact between the independent variable and the dependent variable, which then began to disappear in the long term. It also found that changes in tight monetary supply had a moral impact on changes in GDP.

Nizhegorodtsev and Goridko (2021) focused on the effects of money supply on Pakistan's GDP. Total variables consisting of GDP and money supply were tested using annual data, covering 46 annual periods from 1972 to 2018. The results showed a positive impact on GDP in the case of Pakistan. On the other hand, Khalaf et al. (2022) studied the impact of monetary policy on the variables of the Kaldor magic square and highlighted the extent to which they contributed to the seizure of those variables in Iraq in the period 2000-2015. The study reached several conclusions, the most important of which was that Iraq's monetary policy during the period 2000-2015 was effective in achieving the goal of stability in the overall level of prices, while it was unable to achieve the goal of increasing economic growth, reducing unemployment rates, and balancing the balance of payments.

which remain linked to changes in the international situation, particularly the volatility of petroleum prices in world markets.

3. Concept of Monetary Policy and its Impact on Kaldor Magic Square Variables

In this section of the study, we will examine the definition of both monetary policy and the magic square variables of Kaldor, as well as the impact of monetary policy on these four variables.

3.1 Concept of monetary policy

The concepts of monetary policy, although different in meaning, have been varied, but they have agreed in substance. They can be defined as the set of mechanisms and instruments used by the Central Bank to control and influence the monetary bloc in line with economic activity, to achieve economic objectives over a certain period. These objectives are to stabilize the overall level of prices (combating inflation), achieve full employment (combating unemployment), achieve high economic growth rates, and achieve the external balance of payments by ensuring the stability of the value of the national currency, foreign counterparts, and try to balance the trade balance.

These four final objectives are known as the objectives of Kaldor Magic Square. To achieve these objectives, one or more monetary policy instruments are used, depending on the economic conditions of the state and the suitability of the markets for that state to accept those instruments to achieve those objectives. It should be noted that it is the monetary policy mechanisms that transfer the effect of changes from the monetary side to the real side of the economy. The economic literature has identified five channels through which the effects of monetary policy are transmitted to the real economy: interest rate, exchange rate, asset prices, credit, and expectations, see Mishkin (2001). The importance of those channels in shifting the impact of monetary policy increased during the 1960s when economists and politicians unanimously agreed on the importance of monetary policy in controlling the level of economic activity and stabilizing prices, especially after the relative importance of fiscal policy in achieving economic stability had diminished in the light of increasing budget deficits, which had led to decisions on setting tax rates and government spending that were not in line with the conditions for general economic stability in terms of both those rates and their timing, and hence the growing importance of monetary policy in influencing the real economy, particularly with the emergence of the Males School, see Sorenson et al. (2008).

3.2 The Impact of monetary policy on the four variables of Kaldor magic square

Monetary policy strives to achieve a set of macroeconomic objectives. It aims to influence the amount of money in the national economy and interest rates to affect economic performance in general, as well as to ensure general economic balance in both internal and external terms. Internal balance is achieved by ensuring stable overall price levels (combat inflation), full employment (combat unemployment), and economic growth. The external balance is the balance of the balance of payments achieved by ensuring stability in the value of the local currency vis-à-vis its foreign counterparts and by attempting to balance the trade balance, sees Elson and Cagatay, (2000). Monetary policy is effective if it can achieve the four objectives referred to earlier, known as "magic square objectives," defined by the English economist "Nicholas Kaldor" in 1960 as a four-head chart containing the four basic objectives of economic policy, which are the following:

- **Stabilization of the overall level of prices**

measured by inflation, according to Kaldor, inflation is better at zero, which is consistent with Milton Friedman's view that a low level of inflation, with the goal of full operation, requires an average GDP growth of 5% to 6% per year, and an increase in the amount of cash supply of the same percentage avoids the national economy's risk of exposure to economic fluctuations, see Abonazel and Rabie (2019). However, the majority of economists currently concur that maintaining price stability and the purchasing power of the domestic currency should be the main goals of monetary policy for economic stability. This means that inflation should stay low, ideally between 1% and 4% annually, and that the government should pledge not to implement deficit financing policies by raising the money supply, see Benachenhou, (2022).

- **Full employment**

This is measured by the percentage of unemployment in the total working population. According to Kaldor, the unemployment rate must be zero percent. High employment is an essential objective of any economic policy. Monetary policy can help achieve this goal by increasing effective demand. When monetary authorities increase the cash supply, which in turn contributes to the raising of effective demand, both investment and employment in the national economy increase and thus decrease unemployment rates. It must be noted, however, that economic policy's pursuit of the goal of full employment does not mean that the rate of employment of the labor force is equal to 100% or that the unemployment rate is equal to 0%, see Allegret and Benkhodja (2015).

- **Achieving the highest level of economic growth:**

High rates of economic growth are measured by the rate of growth in GDP. According to Kaldor, the rate of economic growth must be 6%. Monetary policy has a significant impact on economic growth through its direct impact on the rate of interest, then on investment decisions and levels, and then on operation. If the Central Bank reduces the rate of rebate, reserve, or entry into the financial market as a securities buyer, this increases the amount of money offered in the economy as well as the monetary reserves of banks, which increase their capacity to grant credit. Banks reduce the rate of interest without compromising the level of inflation, which is otherwise counterproductive, which, in turn, increases the volume of investment and consumption and thus the level of aggregate demand that drives producers to

increase the volume of production towards the level of full operation, increasing the level of national output and national income, thereby increasing the rate of economic growth, which, of course, must be greater than the population growth rate for the same time period, see Firme and Teixeira (2014).

- **Balance of payments:**

The percentage balance of payments for GDP is measured by the percentage balance of the balance of payments, and according to Kaldor, it would be preferable for the balance of payments to be in surplus of up to 2%. By increasing the exchange rate, the central bank uses monetary policy to decrease the deficit in the balance of payments, which drives commercial banks to raise interest rates on loans that lower the demand for credit and domestic demand for goods and services, thereby lowering the overall level of prices within the state, thereby encouraging domestic exports and reducing demand for foreign products. Higher interest rates at the domestic level also led to the entry of more foreign capital, thus helping to address the balance of payments deficit. Kaldor Square is named the “magic square” because of the difficulty of achieving these goals together at good rates because of the conflict between them.

It is difficult to reduce inflation and achieve full employment at the same time. The goal of achieving sustained economic growth and lowering inflation is also an expansionary monetary policy that can lead to high rates of economic growth but at the expense of high inflation rates. As a result of the difficulty of achieving those goals combined because of the conflict between them, Kaldor proposed in 1966 a law known as the "Kaldor-Ferdourn" through which he tried to illustrate the relationship between the economic growth rate and the other three rates by giving quantitative values to those rates, as shown in Figure 1.

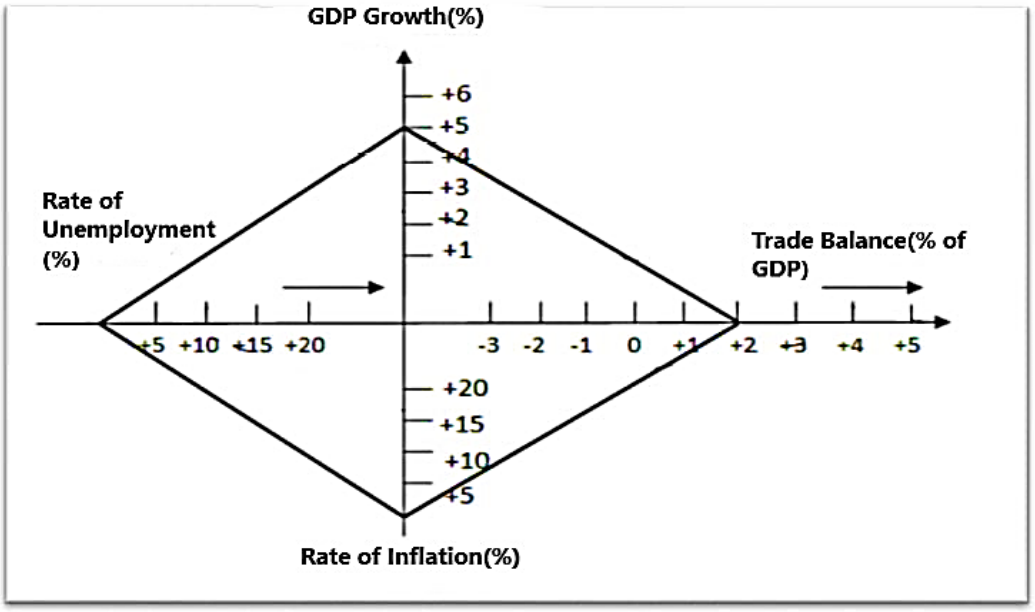


Figure (1): Chart of Kaldor magical square.

Thus, depending on the characteristics of Kaldor Square, the impact of economic policies can be measured by linking the various components of economic policies to each other. If the rate of economic growth is high, the overall price level has been stable, there has been low unemployment, and, in addition to the positive balance of external payments, the magic square of Kaldor suggests to a state the ideality of the functioning of the national economy and shows the effectiveness of monetary policy pursued by the monetary authority, see Picek (2017). The optimal position of the magic square axes is achieved when the economic growth rate is 5% per year. The inflation rate is non-existent, i.e., zero percent. The unemployment rate is 0%. The balance of payments should preferably be in surplus, in the order of 2%. Thus, the link between the four points constitutes the Kaldor magic square, thus reflecting the economic status of the state over a certain period through the extension of the square points and the breadth of its space. The more these heads go into the magic square along the axes, the more difficult the state's economic situations become, and vice versa, see Arabi (2019).

4. The Evolution of Kaldor Square Variables in the Egyptian Economy

In this section, we will discuss the development of the Kaldor Square Variables in the Egyptian economy during the study period from 2000 to 2023.

4.1 The evolution of Kaldor magic square variables in the Egyptian economy during 2000

The recession and crises began in the late 1990s, specifically in 1997, for internal and external reasons. The Egyptian economy was affected by the financial crisis in the countries of Southeast Asia, in addition to the events that occurred at the end of the year in the shortest, which harmed tourism income. In 2000, however, economic indicators began to improve because of the banking reform policies adopted by Egypt during its implementation of the economic reform program during the 1990s. The real growth rate was 6.4%, and inflation fell to 2.7% in 2000 because the government funded the budget deficit from real resources through the issuance of bonds and Treasury authorizations at high-interest rates, which led to the withdrawal of monetary liquidity from the market. Thus, the Central Bank's adoption of a deflationary monetary policy led to a reduction in inflation, but the state was unable to achieve the goal of full employment because it was unable to reduce the unemployment rate, which was around 9% in 2000, because of the slowdown in economic growth in Egypt, where the rate of economic growth fell to 3.5% in 2001 compared with 6.5% in 2000. According to these data, monetary policy in 2000 gave priority to price stability, lower inflation, and lower balance-of-payments deficits, which fell from $97 billion in 2000 to $38 billion in 2001. The objectives of employment and maximizing economic growth were neglected, as shown in Table (1) on Kaldor Magic Square in Egypt in 2000, and those data confirm what has been said, namely, the difficulty of achieving good results for all the goals of Kaldor magic square, because of the conflict between them, see Mohammed and Nasif (2019)

4.2 The evolution of Kaldor magic square variables in the Egyptian economy during 2010:

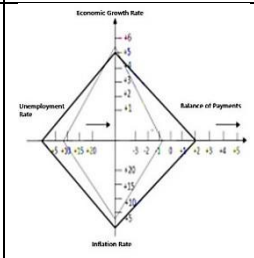
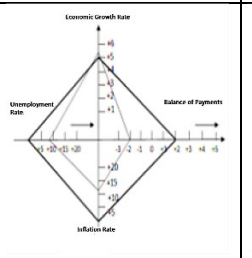
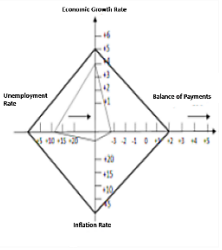
During the year, monetary policy was unable to maintain the low inflation rates it achieved during the period 2000–2003 when the inflation rate did not exceed 4.5%. Despite the central bank's adoption of decision No. 88 of 2003, which stipulates that price stability and lower inflation are among the main

priorities of the central bank's monetary policy, however, the monetary authority was not unable to control inflation, which continued to grow to 11.3%, nor was it able to solve the unemployment problem during the same year. The unemployment rate did not reach the recognized 4% annual rate of unemployment at around 9.2% in 2010, but the monetary policy was able to sustain an acceptable economic growth rate of 5.1% in 2010, and the monetary policy was able to maintain a reduction in the balance of payments deficit of $4.50 billion in 2010. As demonstrated in Table (1) on Kaldor Magic Square in Egypt in 2010, these statistics reveal that monetary policy prioritized stabilizing economic growth rates and lowering the balance-of-payments deficit in 2010 above operational goals and lowering inflation rates.

4.3 The evolution of Kaldor magic square variables in the Egyptian economy during 2023

The economic indicators studied in 2023 indicate that the central bank's monetary policy decisions on the liberalization of the exchange rate of the pound against the dollar on November 3, 2016, harmed some macroeconomic variables, with inflation rising from 13.8% in 2016 to about 21.6% in 2023, which was the highest rate of inflation for the Egyptian economy during the study period. Monetary policy also failed to maintain high and stable growth rates, with real growth falling from 4.3% in 2016 to 3.7% in 2023 and unemployment rates falling to normal, with unemployment falling from about 12.7% in 2016 to 7.6% in 2023. Monetary policy also failed to reduce the balance-of-payments deficit, with only a slight decline in the amount of the deficit, which fell from 20.49 billion dollars in 2016 to 20.21 billion dollars in 2023. These data indicate that monetary policy in 2023 failed to achieve any of the economic objectives of Kaldor Magic Square, as shown in Table (1) for Kaldor Magic Square in Egypt in 2023.

Table (1): Evolution of Kaldor magic square variables in Egypt for years 2000, 2010, and 2023.

Macroeconomic variables	**2000**	**2010**	**2023**
Growth rate	6.4	5.1	3.7
Inflation rate	2.7	11.3	21.6
Unemployment rate	9	9.2	7.6
Balance of payments surplus/deficit	-97,100	-4.50	-20.21
Kaldor magic square in Egypt.			

Source: researcher based on World Bank data, various years.

5. Empirical Application

In this part of the study, the effectiveness of Egypt's monetary policy, expressed in terms of total monetary supply, will be measured in the broad sense of GDP concerning the four variables of the magical role of inflation, unemployment, economic growth, and Egypt's balance of payments for the period from 2000 to 2023. Given the nature of the topic, which includes four dependent variables of Kaldor magic square variables, the EViews software (version 10) has been used to conduct statistical analysis to achieve the study's objectives.

5.1 Study variables and source of the dataset

The dataset used in the study for all variables was obtained from the World Bank database, except the size of the surplus or the balance of payments information taken from the International Monetary Fund (IMF) dataset. The variables used in the study can be defined as follows:

- The independent variable is the total cash supply as a proportion of GDP (the rate of growth of the real currency mass M2/GDP), defined as the total currency outside the bank system M1, semi-cash containing non-current deposits in local currency (with the central bank and commercial banks) and foreign currency deposits (with the central bank, commercial banks, and branches of foreign banks), and bank checks and securities such as negotiable certificates of deposit (https://data.albankaldawli.org/indicor/).
- While the dependent variables are as follows:

➢ **Real GDP growth rate (GDPG)**, which is the annual growth rate of GDP at market prices based on a fixed local currency price. The totals are based on the 2010 fixed price of the United States dollar. https://data.albankaldawli.org/indicator/.

➢ **Inflation rate (INF)**, reflecting the annual change in the percentage of the cost to the average consumer of a basket of goods and services that can be proven or changed over specific periods https://data.albankaldawli.org/indicor/.

➢ **The unemployment rate (UNEM)**, as a percentage of the total labor force, refers to the proportion of members of the workforce who do not have a job but are available for work and seeking jobs.

➢ **Balance of payments surplus or deficit (BOP)**, as a proportion of GDP, defines the balance of payments as a statistical statement that systematically summarizes the economic transactions of an economy with the rest of the world in a specified period, see Bloavi (2012).

5.2 Descriptive statistics and correlation matrix for variables

Before we begin to analyze the data in question and test the hypotheses of the study, we should first look at some descriptive statistics of the study variables.

Table (2): Some descriptive statistics of study variables

Variables	Mean	Median	Max.	Min.	Std. Dev.	JB. Test	P-value
M2	85.0333	85.3000	98.1000	67.7000	9.7375	1.7047	0.4264
GDPG	4.3792	4.2500	7.2000	1.8000	1.6149	1.1557	0.5611
INF	10.7708	10.1000	29.5000	2.4000	6.6495	5.2137	0.0738
UNEM	10.2375	10.2500	13.4000	7.3000	1.8872	1.4410	0.4865
BOP	-7.8413	-6.4600	62.2400	-97.1000	27.6152	20.4856	0.0003

Table 2, above presents some descriptive statistics of study variables and the results of the normal distribution test, the Jarque-Bera test of Normality. The results show that the P-value value of the test is greater than 0.05 for most variables, so we may conclude that the data do not face significant variation and are distributed naturally.

Table (3): Correlation matrix between all study variables

Variable	M2	GDPG	INF	UNEM	BOP
M2	1				
GDPG	0.276874	1			
INF	0.115049	0.228467	1		
UNEM	-0.134883	-0.379218	0.050745	1	
BOP	0.403705	-0.147677	0.024761	0.160184	1

Table 3 above, the linkage matrix of all study variables, shows that the correlation between the independent variable M2 and BOP, is the highest, with a correlation value of 0.43705, while the lowest correlation between the INF and the BOP was 0.024761. As can be seen from the results of the above table, all the study variables showed a correlation of less than 80%, see Kamel and Abonazel (2023). This indicates that there is no problem of Multicollinearity in the dataset.

5.3 Historical evolution of the study variables

In this part of the study, we review the historical evolution of the study variables for the period 2000-2023, as shown in Figure 2 of the study variables of the real M2 as an independent variable and the four dependent variables of the magical square: GDPG, INF, UNEM, and BOP, which during the study period have experienced marked vagaries characterized by ups and downs in some years.

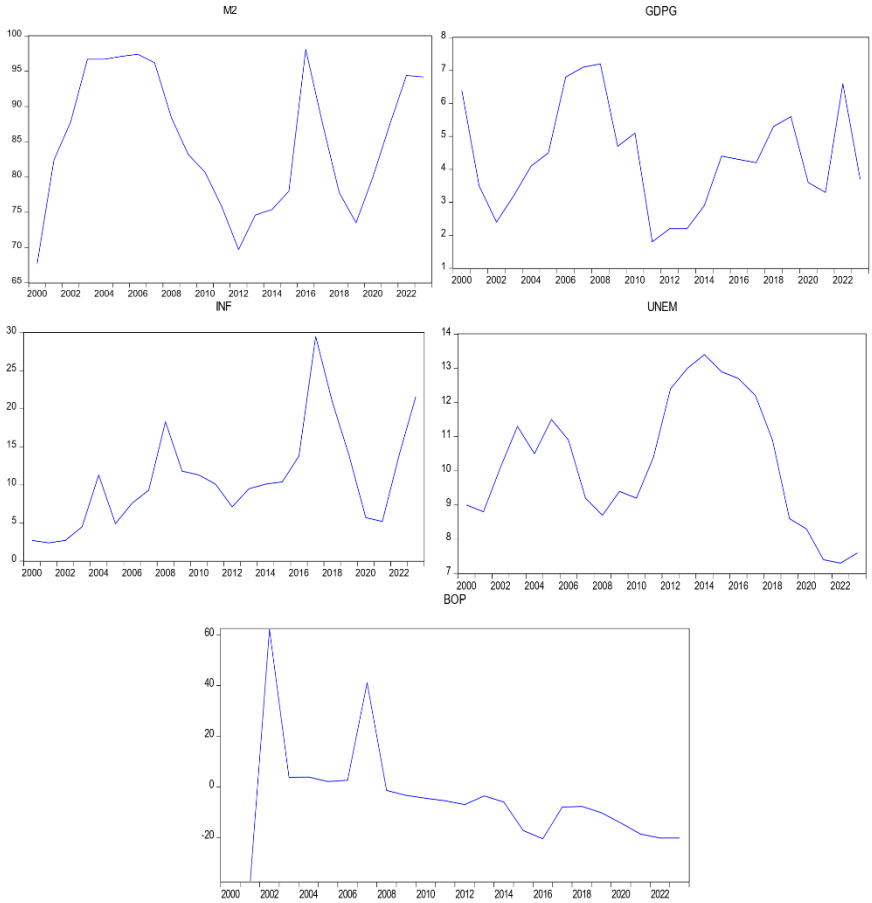


Figure (2): Historical path of study variables during the period from 2000 to 2023.

5.4 Unit Root Test

The stability test is used to study the characteristics of the time series, ascertain their stability, determine their degree of integration, and, before they are used in statistical analysis, to avoid the emergence of the problem of false regression and thus to obtain misleading results. The present study relied on the use of the Augmented Dickey Fuller (ADF) test, and the results of the time series stabilization test were as follows:

Table (4): Unit root test results.

ADF test Statistics					
Level			**Different First**		
variables	ADF	p-value	variables	ADF	p-value
M2	-2.355200	0.1646	D(M2)	-3.979192	0.0063*
GDPG	-3.298387	0.0474*		----------	
INF	-2.738595	0.0837	D(INF)	-4.285130	0.0032*
UNEM	-1.983368	0.2913	D(UNEM)	-3.032897	0.0473*
BOP	-0.976970	0.7380	D(BOP)	-5.542885	0.0003*

* indicate statistical significance at ٥%.

The results of the ADF test, as shown in Table (4) above, showed that the GDPG variable was stationary at level I (0), with the P-value being less than 5%. In contrast, the remaining variables still contain the unit root (Abonazel and Rabie, 2019), which requires taking the initial differences of these variables. After taking the first differences of non-stationary variables, we can get rid of the unit root as in the above table and note that the probability of P-value for these variables is less than 5%, which means that these variables have become stationary and integrated at the first different I (1).

5.5 Causality test for variables

In this part of the applied study, the direction of causal relationships between the study variables will be determined to highlight the relationship between the variables using the causality test, and the following table shows the results of Granger's causality tests among the variables studied.

The results of Granger's causality test as shown in the table above indicate that:

- Relationship between GDPG-M2/GDP: It is a single causal relationship from the cash supply or the real monetary mass to the actual GDP, not the other way around. The assumption was rejected that the real monetary mass did not explain changes in the real GDP because the P-value (0.0165) is less than 5%, which indicates that changes in the real monetary mass explain changes in the real GDP growth rate. In contrast, the assumption was accepted that changes in the real GDP growth rate did not explain changes in the real monetary mass because the P-value (0.9062) is greater than 5%.

Table (5): Granger's causality test results.

Null Hypothesis, Lags: 1	Obs.	F-Statistic	P-Value
M2 does not Granger Cause GDPG	23	6.85474	0.0165*
GDPG does not Granger Cause M2		0.01424	0.9062
M2 does not Granger Cause INF	23	6.29254	0.0209*
INF does not Granger Cause M2		11.5250	0.0029*
M2 does not Granger Cause UNEM	23	0.84299	0.3695
UNEM does not Granger Cause M2		0.38156	0.5437
M2 does not Granger Cause BOP	23	1.77856	0.1973
BOP does not Granger Cause M2		0.49976	0.4878

*indicate statistical significance at ٥%.

- The relationship between M2/GDP-INF: a two-way causal relationship from real monetary mass to inflation and vice versa. The assumption was rejected that changes in real monetary mass did not explain changes in inflation because the P-value (0.0109) is lower than 5%, indicating that changes in real monetary mass explained changes in INF. The assumption was also rejected that changes in inflation did not explain changes in real monetary mass because the P-value (0.029) is less than 5%, i.e., changes in INF explained changes in real monetary mass.
- Relationship between M2/GDP-UNEM: We accept the premise that there is no causal link between changes in the real monetary mass and the UNEM and in both directions because the P-value is greater than 5%.
- Relationship between M2/GPDP-BOP: We accept the premise that there is no causal link between changes in the real monetary mass and the balance of payments in both directions because the P-value is greater than 5%.

5.6 Co-integration test for the models

The common integration test is used to determine the relationship between the variables in the model and whether these variables have a long-term equilibrium relationship. The Johansen Test joint integration test was used in this study, and the results of the test were as follows:

Table (6): Results of the Johansson's Joint Integration

Models	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value	P-Value
Model 1	None	0.341252	12.62371	15.49471	0.1294
	At most 1	0.167827	13.85800	8.841466	0.4956
Model 2	None	0.312474	10.39639	15.49471	0.2515
	At most 1	0.093267	2.153963	3.841466	0.1422
Model 3	None	0.351578	11.91524	15.49471	0.1610
	At most 1	0.102720	2.384527	3.841466	0.1225
Model 4	None	0.628119	11.84995	15.45298	0.1034
	At most 1	0.241738	8.087974	3.156298	0.2136

From the results of Table (6) above, it is clear that the probability value of the P-value for all the models studied is greater than 5%, so it can be said that there is no common integration between the independent variables (M2/GDP) and the four variants of Kaldor magic square, which confirms the stability of the time series and their different degree of integration. The most appropriate methodology in this study is therefore the use of the self-degradation model, which is used to illustrate the degree of integration of the variables, and there is no requirement for a common integration of the study variables.

6. Vector Auto-regressive (VAR) Model

The VAR methodology was used in this study to study the causal relationship between the independent variable (M2) and the dependent variables (GDPG, INF, UNEM and BOP) of the Egyptian economy during the study period (2000–2023). The equations of the study models were formulated as follows:

$$\mathrm{GDG}_{it} = \beta_0 + \beta_1 \mathrm{M2}_{it} + \varepsilon_{it} \quad (1)$$

$$\mathrm{INF}_{it} = \beta_0 + \beta_1 \mathrm{M2}_{it} + \varepsilon_{it} \quad (2)$$

$$\mathrm{UNEM}_{it} = \beta_0 + \beta_1 \mathrm{M2}_{it} + \varepsilon_{it} \quad (3)$$

$$\mathrm{BOP}_{it} = \beta_0 + \beta_1 \mathrm{M2}_{it} + \varepsilon_{it} \quad (4)$$

where β_0 the constant of the model equation, β_1 the independent variable coefficient, and ε_{it} represent the random error of the model.

6.1 Lag order select for the models

Before the VAR model is estimated, the appropriate delay period for the model, which gives the lowest value for the following indicators, must be determined, so the appropriate delay period for the study variables is estimated at one time (Lag=1), as shown in table (7), which illustrates the results of the selection of the appropriate delay period for the study models.

Table (7): Results of lag order select for the models

Lag	LogL	LR	FPE	AIC	SC	HQ
VAR Model 1						
0	-113.6384	NA	208.0075	11.01318	11.11266	11.03477
1	-102.5358	**19.03308***	**106.1576***	**10.33674***	**10.63518***	**10.40151***
2	-98.80868	5.679433	110.5659	10.36273	10.86012	10.47068
3	-97.07101	2.316890	141.9391	10.57819	11.27454	10.72932
VAR Model 2						
0	-144.6895	NA	4003.093	13.97043	14.06991	13.99202
1	-127.8705	**28.83260***	**896.6953***	**12.45584***	**12.95323***	**12.56378***
2	-120.7863	10.79505	1185.305	12.74957	13.04801	12.81434
3	-118.4018	3.179258	1082.366	12.60970	13.30605	12.76082
VAR Model 3						
0	-119.8674	NA	376.4576	11.60642	11.70589	11.62800
1	-98.36033	**36.86920***	**66.80508***	**9.858899***	**10.23751***	**9.966845***
2	-93.51844	7.378125	71.32597	9.939079	10.35629	10.00385
3	-91.57061	2.597107	84.06163	10.05434	10.75069	10.20547
VAR Model 4						
0	-159.9304	NA	17091.39	15.42194	15.52142	15.44353
1	-148.8605	**18.97698***	**8749.896***	**14.74862***	**15.04705***	**14.81338***
2	-145.9803	4.388895	9878.764	14.85526	15.35265	14.96321
3	-144.9659	1.352485	13586.27	15.13961	15.83596	15.29073

* 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**.**

6.2 Results of the VAR models

The VAR model has been used to estimate the parameters of the study models and to study the causal relationship between monetary policy and Kaldor magic square variables in the Egyptian economy. The following table shows the results of the assessment of the models as follows:

Table (8): VAR models results

Variable	VAR Model 1	VAR Model 2	VAR Model 3	VAR Model 4
Dependent Variable (-1)	0.316947 (0.17302) [1.83186]	0.557625 (0.16642) [3.35075]	0.873457 (0.11983) [7.28900]	0.080173 (0.16805) [0.47709]
D M2(-1)	0.076374 (0.02917) [2.61816]	0.272913 (0.10880) [2.50849]	-0.020779 (0.02263) [-0.91814]	0.645790 (0.48424) [1.33363]
Constant	-3.569877 (2.36842) [-1.50728]	-17.71975 (9.33998) [-1.89719]	3.007743 (2.37404) [1.26693]	-58.03121 (41.7382) [-1.39036]
Goodness-of-fit Measures				
R-squared	0.419044	0.479132	0.734772	0.480387
Adj. R-squared	0.360948	0.427045	0.708249	0.428425
F-statistic	7.213000	9.198730	27.70335	9.245075
Akaike AIC	3.440481	6.166380	3.022086	6.840834

Table (8) shows the results of the VAR models, which shows the following:

❖ **Statistical evaluation**

- The results of the VAR model analysis show that the models used are statistically significant because the calculated F-statistic value is greater than the tabulated F-statistic for each model, indicating a statistically significant moral impact of the independent variable on the four dependent variables.
- The coefficient of determination of the estimated models ranged from 42% to 73%, which is a good ratio that shows M2 capacity to some extent in explaining changes in the GDPG, INF, UNEM, and BOP in Egypt.

❖ **Economically evaluation**

- **Model 1:** Measuring the impact of M2 on the GDPG (real GDP growth)

1. Table (8) shows that the value of the R-squared coefficient was 0.419044, which indicates a positive impact of the large monetary supply relative to GDP (real mass growth rate) on the real GDP growth rate. The 1% increase in the volume of the real cash pool necessitates a 0.42% increase in real GDP growth rates in Egypt during the study period.
2. The positive indication of the teacher associated with the real GDP growth rate by a one-year delay indicates that there is a correlation between the real GDP growth rate and its initial AS value. This indicates that if the real GDP growth rate rises by one year, it is expected that this increase will continue in the coming year.
3. The positive signal of the teacher associated with the size of the real monetary mass (M2/GDP) by one year's delay indicates a positive effect, a correlation, and high flexibility between the real monetary mass growth rate and the real GDP growth rate. An increase of 1% in the real monetary mass growth rate by one year will contribute to an increase in the real GDP growth rate of 0.76% in the following year. This result is in line with economic theory since monetary policy has a positive impact on aggregate demand levels in both investment and consumption, which in turn contributes to higher rates of economic growth.

- **Model 2:** Measuring the impact of M2 on the INF

1. Table (8) shows that the value of the R-squared coefficient was 0.479132, which indicates that the size of the monetary supply in broad terms relative to GDP accounts for about 48% of the change in the inflation rate and that the remainder is explained by other factors not included in the model but due to the effect of other random factors.
2. The positive indication of the inflation rate associated with a one-year delay indicates that there is a correlation between the inflation rate and its initial rear value. This means that if the inflation rate rises for one year, it is expected that it will continue to rise in the coming year.
3. The positive indication of the teacher associated with the size of the real monetary mass by one year's delay indicates the correlation between the real monetary mass growth rate and the inflation rate. An increase of 1% in the real monetary mass growth rate by one year will contribute to an increase in the inflation rate of 0.27% in the following year.

- **Model 3:** Measuring the impact of M2 on the UNEM

1. Table (8) shows that the value of the R-squared coefficient was 0.734772, which indicates that the size of the monetary supply in broad terms relative to GDP accounts for about 73% of the change in the unemployment rate and that the remainder is explained by other factors not included in the model but due to the effect of other random factors.
2. The positive indication of the teacher associated with the unemployment rate by one year's delay indicates that there is a positive relationship between the unemployment rate and its initial rear value. This means that if the unemployment rate rises for one year, it is expected to continue to rise in the coming year.
3. The negative reference to the teacher associated with the size of the real monetary block by one year's delay points to the inverse relationship between the real monetary mass growth rate and the unemployment rate. A 1% rise in the real monetary mass will contribute to a reduction of the unemployment rate by 0.21% in the following year, which is a weak effect, i.e., that the real monetary mass does not significantly affect the unemployment rate.

- **Model 4:** Measuring the impact of M2 on the BOP

1. Table (8) shows that the value of the R-squared coefficient was 0.480387, which indicates that the size of the monetary supply in broad terms relative to GDP accounts for about 48% of the change in the balance of payments balance and that the remainder is explained by other factors not included in the model but due to the effect of other random factors.
2. The balance of payments and its original rear value have a positive connection, as seen by the suggestive one-year delay in the balance of payments. This indicates that if the balance of payments rises in a particular year, these increases are anticipated to persist in the subsequent year.
3. The positive reference to the milestone associated with the size of the real monetary mass by one year's delay indicates the correlation between the real monetary mass growth rate and the balance of payments. The rise in the real monetary mass growth rate by 1% of a year will contribute to the increase in the balance of payments by 0.646% in the following year. This is consistent with economic theory. The increase in the supply of domestic currencies leads to a decline in their value, thereby lowering domestic factor costs compared with their foreign counterparts, leading to a decline in domestic prices, thereby increasing the demand for national exports abroad and thus increasing the balance of payments.

6.3 Diagnostic tests of the VAR models

6.3.1 Normality test

Testing of the normal distribution of VAR models was studied by the Jarque-Bera test of normality, as shown in Table (9) below. The P-value for the test for all models is greater than 5%. Therefore, the null hypothesis that the residuals follow a normal distribution is accepted, which is a good indicator of the quality of the models used in the study.

Table (9): Results of the normal distribution test for the VAR models

Component	Jarque-Bera	df	P-Value
VAR Model 1			
1	0.286874	2	0.8664
2	0.571523	2	0.7514
Joint	0.858396	4	0.9305
VAR Model 2			
1	0.859772	2	0.3946
2	1.597622	2	0.1725
Joint	2.457394	4	0.0925
VAR Model 3			
1	0.132566	2	0.9359
2	1.372361	2	0.5035
Joint	1.504927	4	0.8258
VAR Model 4			
1	1.005445	2	0.6049
2	1.427799	2	0.4897
Joint	2.433245	4	0.6566

6.3.2 Heteroscedasticity test

Heteroscedasticity test for error variation in VAR models, the lack of Heteroscedasticity of error is tested through the Breusch-Pagan-Godfrey test. The results of Table (10) below show that the probabilities of the P-value for this test for all VAR models are greater than 5%. Thus, the VAR models studied do not have the problem of Heteroscedasticity, see Kamel and Alqarni (2022).

Table (10): Results of the Heteroscedasticity test for VAR models

Chi-sq	df	P-Value
VAR Model 1		
9.800564	12	0.6335
VAR Model 2		
15.02734	12	0.2399
VAR Model 3		
15.69420	12	0.2056
VAR Model 4		
13.84458	12	0.3107

6.3.3 Serial Correction Test

The Durbin-Watson test was used to detect the problem of serial correction between the residuals. This problem means that the residuals in the current year are linked to the other residuals in the previous or next year, and the test results are as follows:

Table (11): Results of the serial correction test for VAR models

VAR Model 1	
Durbin-Watson D-statistic	2.013743
VAR Model 2	
Durbin-Watson D-statistic	1.983318
VAR Model 3	
Durbin-Watson D-statistic	1.861439
VAR Model 4	
Durbin-Watson D-statistic	2.060017

The test values of Durbin-Watson for all models studied in Table (11) above indicate that there is no problem of serial correction for residuals of models since the test value of Durbin-Watson is approximately the value of 2 for each VAR model.

On the other hand, we will rely on the graphs of the autocorrelation of the residuals to determine whether these residuals are significant statistically or not. Figure (3), shows the autocorrelation functions for the remaining equations two-by-two, showing that most of them fall within the confidence range, that is, they are statistically significant, which supports the validity of accepting the null hypothesis H_0 and confirms that there is no autocorrelation

of errors in the VAR models, and the VAR models also do not contain outliers values, If the data contains outlier values, then the classical estimator is not efficient, a robust estimator must be used to estimate the parameters. Many robust estimators are discussed by many papers in several regression models, see e.g. Kamel (2021), Youssef et al. (2022), Alharbi and Kamel (2022), Alharbi et al. (2022), and Kamel et al. (2022).

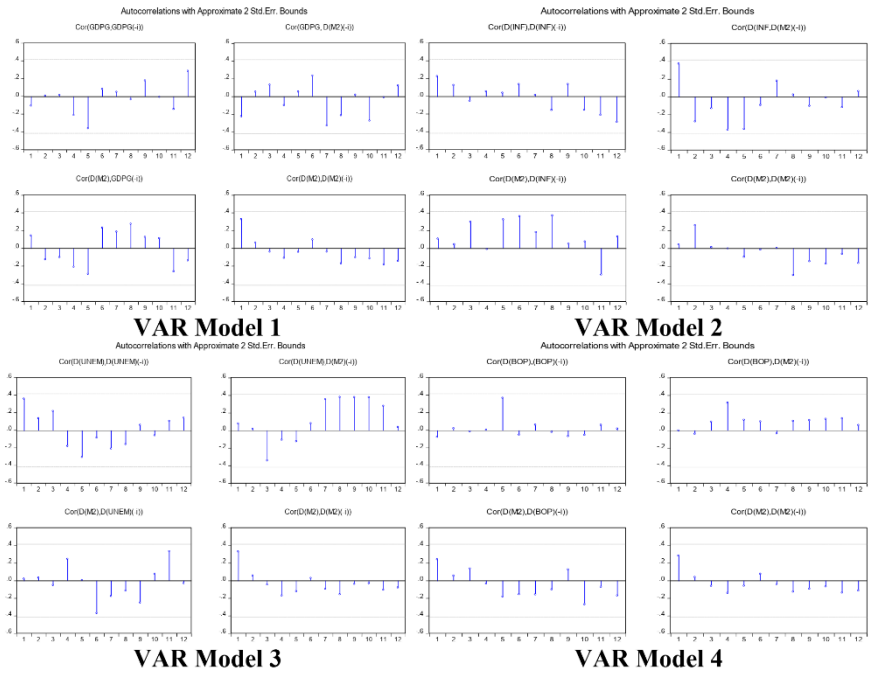


Figure (3): Autocorrelation functions of residuals for VAR models.

6.3.3 Stationary test of residuals for VAR models

A stationary test with the remaining models in question to ensure that the VAR models are stabilized according to the single period selected (Lag =1), the multiple root properties test has been applied, as the requirement for the VAR model to be stabilized is less than one valid, meaning that all the roots fall within the unit circle, as illustrated in Figure 4 below:

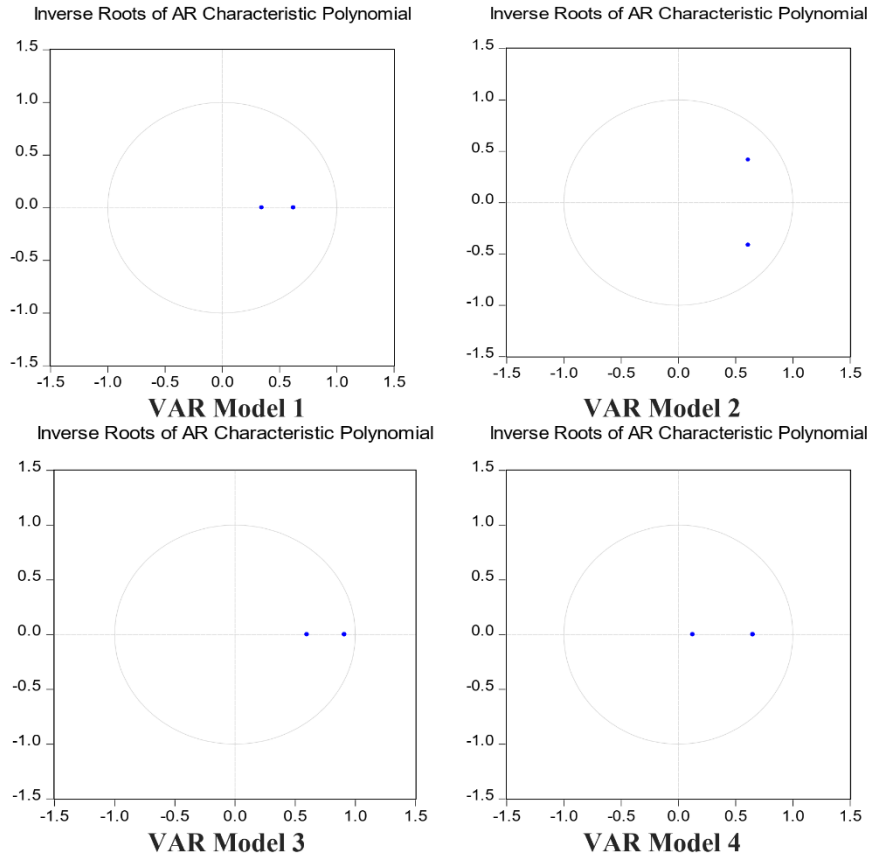


Figure (4): Results of the stationary test of residuals for VAR models

Figure4, shows that the estimated VAR models meet the stationary requirements as all roots fall within the unit's circle, that is, all transactions are smaller than one, indicating that the models used do not suffer from the problems of serial correction and heteroscedasticity, therefore the VAR models are quite stable and statistically significant.

6.3.4 Impulse-response functions for VAR models

Through our study of the immediate response role of applying structural shocks to one of the study variables and determining their future transition to other variables (10 years), Figure 5 illustrates the results of the analysis of the immediate response function, the following becomes clear;

- When there is a positive shock in the size of the real monetary mass of a standard deviation of one unit (1%), we note the lack of response in the first year to the rate of economic growth expressed in the rate of GDP growth. By the beginning of the second year, the positive effect begins to rise to its highest level, continues to rise until the third year, and then starts to decline slowly until the impact fades at the end of the study period.

- When there is a positive shock in the size of the real monetary mass with a standard deviation of one unit (1%), we note the absence of a response in the first and second years to the inflation rate. At the beginning of the third year, the positive impact of this shock starts at 1.8%, while in the fourth year, it has a positive impact at 1%, then it starts to decline at decreasing values and has a negative effect from the sixth year until the impact fades at the end of the study period.
- When there is a positive shock in the size of the real monetary mass of a standard deviation of one unit, i.e., 1%, we note the negative effect beginning in the first year, and the unemployment rate continues to decline at decreasing values until the end of the school period is reversed, with the unemployment rate returning to normal at the end of the period. • When there is a positive shock in the size of the real monetary mass with a standard deviation of one unit (1%), we note the lack of response in the first year for the balance of payments, so that the positive effect starts to rise to its highest level in the second year by 5% and continues to decline positively until the end of the period.

7. Conclusions and Recommendations

The objective of this study was to analyze the effectiveness of monetary policy in controlling changes in Kaldor Magic Square and their effects on the Egyptian economy from 2000 to 2023 by talking about how well monetary policy works to lower unemployment, achieve rapid economic growth, control inflation to the target rate set by the responsible monetary authorities, and achieve balance of payments. The combined achievement of these objectives will therefore increase the effectiveness of monetary policy in achieving economic policy objectives and thus adjust the variables in the Kaldor magic square in Egypt during the period of study:

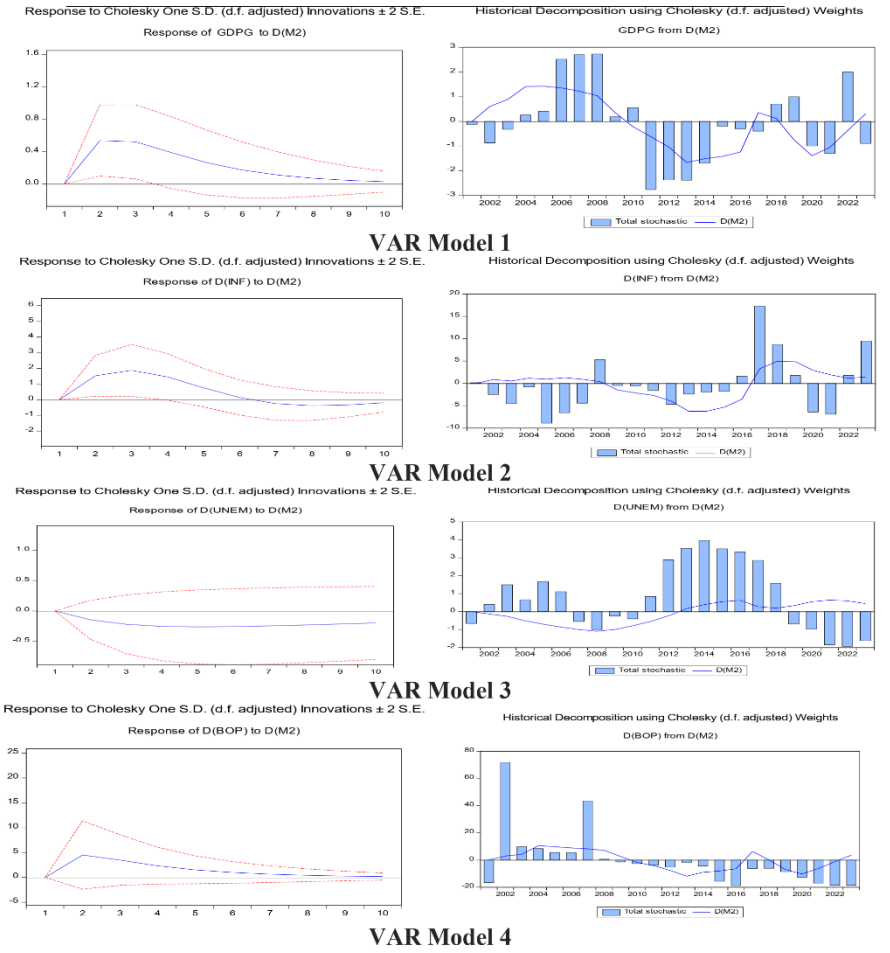


Figure (5) Results of impulse-response functions for VAR models.

Through the above, a series of conclusions have been reached, including the following:

- Economic performance is decent as Kaldor Magic Square's area gets bigger, i.e., low rates of unemployment and inflation, higher rates of economic growth, and a high surplus balance of payments. The achievement of the four goals of the Kaldor Magic Square is therefore extremely difficult because of their conflicting objectives.
- The impact of monetary policy on the four Kaldore magic square variables depends on its ability to influence the monetary supply, which confirms the validity of the first hypothesis.
- The diagnostic tests of the study models showed that the models used in the study did not have the problem of instability or the problem of self-inclusion of errors, and the condom series of all models tracked natural distribution, which was a good indicator of the quality of the models used in the study.

- Estimated VAR models satisfy stabilization requirements as all roots are located within the unit, i.e., all transactions are smaller than the correct one, indicating that the models used are fully stable and statistically significant. The results of the analysis of the study models using the VAR model showed that the models used are statistically rational because the value of the F-statistic is greater than the scale values of each model. This indicates that there is a moral impact and statistically significant relationship between the independent variable monetary policy and the four dependent variables. This confirms the validity of the second hypothesis. According to the reaction response test, any sudden change in the real monetary mass growth rate has a positive effect on the inflation rate at the beginning of the second year, continues to rise until the third year, and then starts to decline slowly until the end of the study period, as increased cash supply leads to higher demand and thus higher overall price levels.
- As for the response of the unemployment rate to the shock of changing the rate of growth of the real monetary mass, it has a negative impact. The increase in the real monetary mass leads to an increase in development projects, which increases employment levels and reduces unemployment rates.
- Concerning the balance-of-payments balance, the shock of the change in the rate of growth of the real monetary bloc has been positive throughout the period, which is consistent with the logic of economic theory since the growth of the real monetary bloc leads to investment projects, which increase the value of exports and decrease imports, reflecting positively about the balance of payments.
- The monetary policy of the competent monetary authorities of Egypt during the study period (2000–2023) did not rise above the control of the variables of Kaldor magic square. Monetary policy did not have a significant impact on achieving the goal of balance and stability in the overall level of prices by lowering inflation rates to the lowest level or stabilizing the balance of payments. Monetary policy was also unable to achieve high economic growth and lower unemployment due to its greater influence on expansionary fiscal policy.

Through the results, a set of recommendations could be made they are the following:

- A balanced monetary policy must be introduced to contain inflationary pressures and reduce the price increases experienced by the Egyptian economy, especially after the exchange rate float in 2016.
- The need to coordinate monetary policy with other economic policies, particularly fiscal policy, to achieve economic objectives most effectively.

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تقييم مدى فعالية السياسة النقدية على متغيرات المربع السحرى لكالدور في مصر

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الملخص:

هدفت هذه الدراسة إلى تحليل مدى فعالية السياسة النقدية في ضبط متغيرات المربع السحري لكالدور (النمو الاقتصادي ، البطالة، التضخم، رصيد ميزان المدفوعات) ومدي تأثيرها علي متغيرات الاقتصاد الكلى في مصر خلال فترة الدراسة التي تمثلت من عام ٢٠٠٠ حتي عام ٢٠٢٣ وذلك من خلال التطرق إلى مدى فعالية السياسة النقدية في تخفيض معدلات البطالة، تحقيق نمو اقتصادي مرتفع، ضبط معدل التضخم بما يتماشى مع المعدل المستهدف الذي تقرره السلطات النقدية المختصة بالإضافة إلى مدى فعاليتها في تحقيق فائض في ميزان المدفوعات، وذلك بهدف وضع سياسة نقدية مناسبة تساهم في تصحيح الاختلالات في هيكل الاقتصاد المصرى. وقد تم استخدام منهجية نموذج متجه الانحدار الذاتي Vector Auto-Regressive (VAR) لدراسة علاقة السببية بين السياسة النقدية ومتغيرات المربع السحرى لكالدور على الاقتصاد المصرى خلال فترة الدراسة. وبينت نتائج الدراسة إلى أن السياسة النقدية في مصر خلال فترة الدراسة كان لها تأثير كبير على متغيرات المربع السحرى لكالدور، كما أشارت النتائج إلى أن السياسة النقدية لم يكن لها آثار إيجابية مستمرة في الأجلين القصير والطويل، وبالتالي لم يكن لها أثر كبير في تحقيق معدلات مثلى لمتغيرات الاقتصاد الكلى في مصر.

الكلمات المفتاحية: السياسة النقدية ، مربع كالدور السحرى، الاقتصاد الكلي، الاختلالات الهيكلية، نموذج متجه الانحدار الذاتي.