



Identifying the Sources of Economic Fluctuations in Tunisia: Modeling with the Structural Vector Autoregression (VAR) Model

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Article History

Received: 11 April 2026; Revised: 22 May 2026; Accepted: 29 May 2026;

Published: 30 June 2026

Abstract: This research aims to present the characteristics of economic fluctuations in Tunisia within a general analytical framework. To this end, we have chosen to use monthly data from 1990 to 2017. The set of variables covers the real, monetary and financial dimensions of the economy. In the modeling section, we employ an approach based on the SVAR model, Granger causality tests and the impulse response functions. The model estimation results suggest that supply and demand shocks predominantly explain cyclical movements in Tunisia. Additionally, the Tunisian economy appears to be less vulnerable to domestic and external shocks. Furthermore, we emphasize the growing importance of external shocks compared to domestic supply shocks. This implies a reduction in the magnitude of exogenous external shocks is implied, which can be achieved through the propagation of shocks between countries. This is an important and favorable factor for business cycle synchronization.

Keywords: Economic Fluctuation, Exogenous Shock, Endogenous Shock, Structural VAR, Tunisia

1. INTRODUCTION

In recent decades, the subject of economic fluctuations has taken centre stage in the global economy. The major crises of the 1920s, such as the one in

To cite this paper:

RABHI Wissem (2026). Identifying the Sources of Economic Fluctuations in Tunisia: Modeling with the Structural Vector Autoregression (VAR) Model. *Asian Journal of Economics and Business*. 7(1), 45-75.

1929, prompted economists and analysts to take a close interest in cyclical phenomena. Following the Great Depression of 1929, Hayek (1933) and Von Mises (1933) were the first to address the issue of economic fluctuations. Following the Second World War, theoretical and empirical debates on cyclical analysis advanced thanks to the work of economists such as Wicksell (1898), Frisch (1933) and Slutsky (1937). These economists emphasized the important role of exogenous and endogenous factors in explaining cyclical fluctuations in the economic system. Conversely, the classical school, represented by Lucas (1972, 1973 and 1977), focused on rational anticipation to understand cyclical phenomena, moving away from pre-Keynesian analysis. Monetary shocks lead to price variations and create random shocks to the money supply, which can lead to instability in economic activity.

In the context of the economic history of the 1980s, cyclical analysis has been extended by the theory of the real business cycle. Initially developed by Kydland and Prescott in 1982 and Long and Plosser in 1983, this theory has been further developed through this study. The theory emphasizes the importance of information systems and rational expectations, and aims to explain economic fluctuations resulting from the adverse effects of technological shocks on the economic system. These findings merit particular attention in the context of decision-making by public authorities. Central banks, government organizations and non-governmental organizations, for example, are interested in the impact of contingencies such as the effect of very short-term political changes.

Indeed, in recent years, the study of economic fluctuations has been one of the subjects that has captured the attention of researchers in this field. The field of study of cyclical fluctuations has expanded considerably, both in developed and developing countries. As emphasized by Trabelsi (2024), the overriding challenge lies in identifying the determining factors of cyclical fluctuations in a global context marked by transformations and crises likely to manifest themselves in periods of growth slowdown and depression, expressed mainly through internal and external shocks. This environment is therefore an important factor in explaining economic fluctuations between the world's economies.

Indeed, a number of studies have been carried out on the origins of cyclical fluctuations in Third World economies, notably the work of (Mendoza, 1995;

Rand and Tarp, 2002; Elachhab, 2007; Bousnina and Gabsi, 2023; Trabelsi, 2024 and Salhi et al. 2024). Referring to theoretical and empirical studies, we consider the SVAR model, by (Blanchard and Quah, 1989), to explain the real weight of impulse origins at the origin of fluctuations in Tunisia, i.e. to reformulate the different sources of cyclical fluctuations in a more efficient statistical framework. This methodology is widely used in the literature and has been adapted to consider the dynamic interaction of a small open economy (Ahmed et al., 1993; Clarida and Gali, 1994; Hoffmann and Roldós, 1996).

The rest of the article is as follows: The second section outlines the empirical study on the sources of economic fluctuations. Then, the third section describes the methodology based on the structural VAR model of Blanchard and Quah (1989). The fourth section presents the results of the model estimation. Finally, the fifth section summarizes the main findings of this study.

2. LITERATURE REVIEW

An important theoretical debate on the detection of impulse sources of economic fluctuations has emerged from the abundant literature, which is marked by theoretical controversy. The contribution of this topic can be seen in Keynesian theory, which explains the sources of cyclical analyses through demand shocks. In contrast, real cycle theory focuses on real supply shocks. Meanwhile, the quantitative theory of money attributes macroeconomic fluctuations in developing countries to monetary supply shocks.

However, to understand the sources of economic fluctuations, we must first understand the phenomena responsible for these cyclical fluctuations. Since the phenomenon of economic fluctuations is complex, it is important to note that understanding these cyclical fluctuations and analyzing their behavior enables us to control the economic environment, and thus ensure economic stability and growth. This is why the study of the sensitivity of economic shocks provides a better understanding of short- and long-term macroeconomic fluctuations. In this respect, numerous empirical studies have examined the sensitivity of these different types of shock in order to understand their effect of shocks on economic fluctuations that can affect the economy. Several statistical tools have been employed for this purpose. In particular, vector autoregressive VAR models (see, for example, Calvo and Mendoza, 1998; Bordo and Murshid, 2002). However, structural vector autoregressive

(SVAR) model appear to be a more accurate tool, as this model allows certain assumptions to be made concerning the reactions of variables to the different types of internal and external shocks that can affect the economy, thus ensuring a better interpretation of the results.

2.1. Studying the sources of economic fluctuations

According to Lucas (1981), identifying the characteristics of cyclical fluctuations in the economy is a fundamental step in controlling the economic environment. In this regard, the author conducted a study on 15 less developed countries, the result contributed that external shocks affecting the economies of developing countries are an important factor in short-term fluctuations in production. This finding informed public decision-makers in developing countries to pay more attention to the transmission factors of economic fluctuation following external shocks.

The underlying idea behind this research strategy is to understand the effect of shocks on economic fluctuations. As Ngomba Francis Ghislain (2018) points out, supply and demand shocks generally have the same effect on short- and medium-term economic growth. Thus, they have dynamic effects on the inflation rate and on real output. The importance of these types of supply and demand shocks in economic fluctuations is presented by Funke's (1997) study of the importance of supply and demand shocks in German business cycles over the period from the Q1-1968 to Q3-1992, using in this study the SVAR model of Blanchard and Quah (1989) on five macroeconomic variables (real GDP (Y) unemployment rate (U), GDP deflator (P), wage compensation (W), and money supply (M3). The empirical results of estimating this model suggest a synthesis in which it is recognized that both supply and demand shocks have significant effects. This result contributed to highlighting the important role played by supply shocks in explaining unemployment rates in Germany, while demand shocks represent the fundamental source of fluctuations in real GDP. In the same perspective, Canova and Nicolo (2003) examined the effect of these supply and demand shocks on economic fluctuations in several G-7 countries over a monthly period from January 1973 to December 1998, using a VAR-type model for each country. This result shows that demand shocks are an important factor in explaining output momentum and inflation fluctuations. In this category, nominal demand shocks are more important

than real shocks, so these results confirm empirically that nominal shocks are the driving force behind economic fluctuations. However, many studies have also relied on structural VAR modeling to analyze economic shocks based on series of macroeconomic variables.

In this respect, Goux (2006) studied the sensitivity of economic shocks on a set of Euro zone countries, considering that the structural VAR and VECM models responded to the choices of determining the sensitivity of economic shocks. This methodology is close to that of (Eichenbaum and Evans, 1995; Christiano et al. 2000; Kim and Roubini, 2000; and Kim, 2001), who proved that the dynamics of structural monetary policy and exchange rate shocks and their transmission channels in Euro zone countries are sensitive to monetary conditions (interest rates and exchange rates). In contrast, Gubler and Hertweck (2013) employed a structural vector autoregression (VAR) model to evaluate the effects of commodity price shocks on the US economy during the quarterly period from 1955 to 2007. This study's results suggest a significant correlation between commodity price shocks and macroeconomic fluctuations, such as inflation. As in other works that focus on fluctuations in developed countries, Oliveira et al. (2023) contributed in their article, to present the regularity of supply and demand shocks in some Euro zone countries over a 15-year period, from 2004 to 2019. They found that some countries in our sample showed a weak or even negative correlation in favor of demand. This is not the case for supply shocks, where there is a positive and significant link between the majorities of Euro zone countries, due to the specialization effects of certain economic activities. As a result, supply shocks play an important role in cyclical fluctuations in production and prices, which is not the case for demand shocks.

From another point of view, Dreger (2023) studied the effect of supply and demand shocks on inflation in euro zone countries and the United States. This specification is based on the SVAR modeling of Blanchard and Quah (1989). Indeed, this result showed that in the United States, the demand shock accounts for 75% of the explanation of inflation, while the supply shock explains only 25% of the evolution of inflation. In this respect, given the importance of supply shocks in influencing the euro zone economy in the long term, it is necessary and indispensable for these countries to take corrective measures against the risk of stagflation, which can consequently influence output levels and economic growth.

In contrast, there are other studies that describe economic fluctuations in low-income countries, focusing on the impact of economic shocks. Rand and Tarp (2002) concentrate on this topic, focusing on the origin of economic disturbances in a short-term period. As a result, the effect of supply shocks manifests itself essentially in the disruption of production levels in the short to medium term. In a similar vein, Mendoza (1995) showed that 50% of gross domestic product (GDP) volatility caused by terms-of-trade shocks. In Africa, however, few empirical studies have been devoted to sensitivity analysis of macroeconomic variables caused by trade and financial shocks. In the same context, the study by Kose and Reizman (2001) shows that, for imported goods such as intermediate goods, commercial goods, which are used in the majority of economic sectors, have a wider effect on the economy than financial shocks. Financial shocks account for over 50% of production volatility.

For Alabdulwahab and Abou-Zaid (2024), the result of SVAR model estimation for the case of Egypt, indicates that demand shocks have significant impacts on the real exchange rate. Conversely, the case for supply shocks and monetary shocks exert no effect on the real exchange rate throughout the study period (1980 and 2016).

In general, studies on identifying the characteristics of cyclical fluctuations have attracted considerable interest; with some authors have addressing this subject in their empirical work on Tunisia. In his article, Elachhab (2007) examines the impact of internal and external shocks on the Tunisian economy. Estimation by the SVAR model shows that supply shocks significantly contribute to cyclical volatility, accounting for 54% over a four-year period. Institutional reforms are therefore among the most significant supply shocks. For domestic demand shocks, their contribution hardly exceeds 35% of the variability of the cyclical gap. Subsequently, internal demand shocks exert a relatively small favorable transitory effect compared to supply shocks. Finally, external shocks account for only 18% of the fluctuation. This explains why external demand shocks play a lesser role in explaining cyclical volatility, which is better explained by import price shocks.

Using the same approach, Bousnina and Gabsi's (2023) study of the MENA region's economy suggests that the oil shock had a negative impact, resulting in deterioration in the current account and depreciation in the terms of trade. This implies that the oil shock helped to explain the disruption to economic growth

in this region. Furthermore, the impact of the deterioration in the current account is more significant in oil-importing countries than in oil-producing countries. Furthermore, Salhi et al (2024) studied the interaction between oil price shocks and stock market returns for all MENA countries, using daily data from 09/19/2003 to 12/31/2022. The results of the VAR model estimation show a causal relationship between oil prices and stock market returns for the Moroccan index and the three exporting countries in the sample.

In his article, Trabelsi (2024) examines the causes of variations in real output and inflation in Tunisia between 1993 and 2019. Estimation of the SVAR model suggests that real supply shocks are the main cause of fluctuations in real output. Conversely, the lack of effect of external demand shocks reflects growth in the domestic economy. Monetary demand shocks account for 60% of inflation and help to explain price fluctuations; meanwhile, supply and monetary policy shocks have no effect on inflation.

2.2. Identifying the nature of economic shocks

In the empirical literature, monetarist theory emphasizes the dynamic link between money supply and prices. Thus, as Kamar (2004) points out, the orientation of consumer demand is stimulated by an increase in the money supply, and he argues that an increase in the money supply is not only a source of inflation, but also of variation in the real exchange rate. The underlying idea of monetarist theory is that if the new demand for non-tradable goods is strong, the price of these goods rises, and the exchange rate appreciates. Conversely, if the new demand is weakly oriented towards tradable goods, the price falls and the real exchange rate depreciates, i.e. (domestic currency depreciates in real terms). Contrary to monetarist theories, Keynesians believe that the money supply does not play an active role in the price transmission mechanism. They stress that changes in the money supply act only on prices and not on real variables. This school of thought has been criticized for its implicit reliance on price and wage flexibility. But reality shows the opposite, particularly in emerging economies.

However, in the existing empirical literature, several works have identified and defined the nature of economic shocks, notably Gratti (2003) for foreign real demand shocks as terms-of-trade shocks, and monetary demand shocks as nominal cash demand shocks. Real demand shocks therefore refer to variations

in foreign demand for domestic goods. This is due to changes in consumption patterns emanating from abroad, and to losses in the competitiveness of the exporting country. In economic theory, real demand shocks affecting the economies of the world's low-income developing countries in particular require the intervention of monetary authorities to absorb the rise in prices provoked by this shock, by focusing on variations in the nominal exchange rate and the short-term interest rate.

We also note in the literature that exogenous changes in commodity or energy prices, productivity or wage shocks are considered real supply shocks, while unanticipated changes in consumption, investment or government spending are identified as real demand shocks. In the long term, these real demand shocks can have an impact on real balances and inflation. This framework is situated in the budgetary theory of the price level. In the same vein, a study by the International Monetary Fund (IMF, 2015) shows that developing countries are more affected by terms-of-trade shocks than emerging countries. For this reason, several empirical works have addressed the contributions of terms-of-trade shocks in explaining economic fluctuations in several low-income countries in particular (Mendoza, 1995; IMF, 2015; Schmitt-Grohé and Uribe, 2018). The results of these studies show that commodity terms-of-trade shocks act on potential output primarily by increasing capital accumulation. In addition, other research studies such as Haddou (2010) emphasize that over the past decade, the domestic supply and demand shocks that have affected the Tunisian economy have been of particular importance and represent a major source of uncertainty. Various events have demonstrated this, such as the subprime crisis, which led to a fall in export growth and tourism revenues, the sharp deterioration in the terms of trade of a commodity from 2002 onwards, and the drought period of 2005, which led to a significant drop in commodity prices, particularly cereal harvests.

A variety of empirical works have addressed the mechanisms of monetary policy transmission, focusing on the short-term interest rate, the money market rate, and the monetary base. Taylor (1995) defined the monetary policy transmission mechanism as a process that provides changes in monetary policy with macroeconomic variables, including growth and inflation. Unanticipated changes in monetary policy constitute monetary policy shocks. Other authors refer to the nominal exchange rate as the operational instrument for dealing with

monetary policy shocks. Elbourne and Haan (2004) studied the relationship between financial structure and monetary transmission in new and future EU members. In their paper, they present estimates of monetary transmission for 10 transition countries and found a weak link between financial indicators and monetary policy transmission.

From an economic policy perspective, this involves distinguishing between real supply, real demand, and monetary demand shocks. It is important to divide the effects of these shocks between budgetary and monetary authorities and structural funds. Real supply shocks are the responsibility of structural policies, real demand shocks are handled by budgetary authorities, and monetary demand shocks by monetary authorities. This is the Mundell efficiency principle. Thus, an unanticipated change in the money supply implies a money supply shock. Shocks to this policy therefore imply unanticipated variations in the short-term interest rate).

3. DATA AND METHODOLOGICAL SPECIFICATION

3.1. Data

In this article, we use monthly rather than quarterly data, due to the narrowness of the time series, in order to obtain more observation points (276 observations in our case). The data cover the period from January 1993 to December 2015. All time series variables were obtained from the accounts of National institute of the Statistics (INS); the International Financial Statistics (IFS) of the International Monetary Fund (IMF); the financial statistics of the Tunisian Central Bank (BCT); Data Stream and the Energy Information Administration (EIA). Indeed, most empirical work on the least developed countries uses the same monthly data series, due to the short quarterly time periods. Moreover, (Bernanke and Mihov, (1998) and Christiano et al., (1996 and 1999) show that the conclusions drawn must be inherent in such an assessment, whatever the data used. However, identifying the main sources of cyclical and trend trends in Tunisia required us to distinguish between two blocks of variables according to the nature of the shocks: exogenous shocks and endogenous shocks, including domestic and external shocks. This distinction guided our choice and ordering of variables. However, the first block of domestic exogenous shocks includes real supply shocks (IPI), monetary demand shocks (CPI), monetary policy shocks (MMR), money supply shocks (M3) and exchange rate shocks (NEER). While

the second block of endogenous shocks includes external real supply shocks (IPIE) and external real demand shocks (OP). All these variables are used in our model to generate structural shocks.

However, to correct the problem of normalization with respect to the national currency and the seasonality of the series, we use the Census X11 method. In fact, all series (except MMR) have been log-transformed and seasonally adjusted. Thus, the new notations of the different variables are presented as follows: the real industrial production index (LPIR), the real oil price (LOPR), the European industrial production index (LIPIE), the consumer price index (LCPI_SA), the monetary aggregate (LM3_SA), the nominal effective exchange rate TND/USD (LNEER_SA), and the money market rate (LMMR).

The visual data, presented in Table 1 above, indicate that all the series show a left-hand asymmetry that is thinner than the normal distribution. In fact, we can consider all series as platykurtic. Furthermore, we reject the hypothesis of normality of the series through the Jarque-Bera test.

Table 1: Descriptive statistics for transformed variables

	<i>LOPR</i>	<i>LIPIE</i>	<i>LPIR</i>	<i>LNEER_ SA</i>	<i>LCPI_ SA</i>	<i>LM3_SA</i>	<i>LMMR</i>
Average	0.835	0.349	0.991	4.768	4.400	9.888	1.738
Median	0.816	0.352	0.997	4.803	4.376	9.853	1.655
Maximum	1.069	0.377	1.034	4.979	4.858	10.944	2.387
Minimum	0.579	0.315	0.935	4.421	3.985	8.791	1.151
Standard deviation	0.117	0.017	0.023	0.179	0.236	0.663	0.272
Skewness	-0.008	-0.429	-0.546	-0.363	0.224	-0.003	0.591
Kurtosis	1.787	1.973	2.207	1.648	2.058	1.728	2.852
Jarque-Bera	16.908	20.621	20.944	27.073	12.516	18.604	16.341
Probability	0.000	0.000	0.000	0.000	0.002	0.000	0.000
Observations	276	276	276	276	276	276	276

Source: author's calculation

Before moving on to estimating the model, we began by investigating the stationarity of the variables and whether there is a long-term relationship between them. To this end, we used the stationarity test of Lee and Strazicich (2003) and the cointegration test of Gregory and Hansen (1996). The results of these tests are presented in Tables 2, 3 and 4 below.

Table 2: Results of Lee and Strazicich (2003) in first difference with 1 break

Variables	Model A			Model C		
	Tb	t-statistics	K	Tb	t-statistics	K
LIPIR	1997M04	0.9330	12	2004M02 2004M02	4.4157 -8.7152***	12
LIPIE_SA	2010M07	0.6541	11	2007M03 2007M03	-1.7192 -5.3999***	11
LOPR	2004M06	1.2109	12	1999M01 1999M01	-3.6710 -7.2033***	12
LNEER_SA	2013M06	-0.0006	0	2013M10 2013M10	-1.4635 -4.7663**	0
LCPI_SA	2005M07	0.8526	11	2001M02 2001M02	-3.1985 -6.9711***	11
LM3_SA	1997M09	2.0125	08	2001M01 2001M01	4.8365 -12.018***	0
LMMR	2011M08	-4.4362*	01	2009M10 2009M10	0.8662 -0.878	01

Source: author's calculation

Note: The critical values for the LS test: model A: -4.24, -3.57 and -3.21; model C: (-5.05 to -5.11), (-4.45 to -4.51) and (-4.17 to -4.21) at 1%, 5% and 10% levels, respectively. ***, ** and * represent statistical significance at the 1%, 5% and 10% levels, respectively. K: number of delays. Tb: break date.

Indeed, when comparing two models, LS tests with two breaks produce more evidence against the unit root hypothesis than those with a single break, and the C model with two breaks seems to fit the data better than the C model with a single break.

An analysis of the results in Tables 2 and 3 suggests that Model A of the LS test indicates that all series are stationary with a single break, primarily at a significance level above 5%. The only break date that synchronizes with the date of economic crisis is (2011M08) in Model A. Since in the previous section, we showed that all variables are integrated of order 1 and with the existence of significant breaks in the trend. Although theory suggests the possibility of a long-term relationship between the variables under consideration, we will use the cointegration test to determine whether there is a long-term relationship between these variables.

In this respect, the results reported in table 4 below indicate the existence of a long-term cointegration relationship in the presence of a significant structural break for each variable in our model, according to the critical values in the

Table 3: Results of Lee and Strazicich (2003) in first difference with 2 breaks

Variables	Model A			Model C		
	Tb	t-statistics	K	Tb	t-statistics	K
LPIR	2001M06 2009M04	-1.2295 -0.5157	12	2000M12	8.8891	12
				2000M12	-12.154***	
				2006M11	-4.1700***	
				2006M11	11.9290	
LIPIE_SA	2000M11 2010M08	1.8297 1.4403	11	2008M04	-8.0480***	04
				2008M04	8.7599	
				2011M03	0.6695	
				2011M03	-7.9601***	
LOPR	2002M02 2008M04	1.7995 1.0837	12	1999M01	-3.9687	12
				1999M01	-7.6645***	
				2011M06	0.6301	
				2011M06	-3.9331	
LNEER_SA	2004M10 2013M06	-1.0367 -0.0689	0	2003M02	-1.4079	0
				2003M02	-5.2854*	
				2011M11	-1.4510	
				2011M11	0.6814	
LCPI_SA	2005M05 2012M01	1.2863 3.5034	02	2000M12	-4.8787	12
				2000M12	8.3881	
				2004M09	0.2729	
				2004M09	-6.3255***	
LM3_SA	2000:03 2010M02	0.1919 -2.3394	02	2001M01	5.3245	0
				2001M01	-12.4571***	
				2008M05	0.7202	
				2008M05	5.0786	
LMMR	2001M02 2011M08	-0.2642 -4.4599**	01	2001M03	2.8272	01
				2001M03	5.6869	
				2010M05	-1.4901	
				2010M05	5.7601	

Source: author's calculation

Note: Critical values for LS test: Model A: -4.545, -3.842 and -3.504; Model C: -5.823, -5.286 and -4.989 at 1%, 5% and 10% levels, respectively. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels respectively. K: number of delays. Tb: break date.

article by Gregory and Hansen (1996), which are higher than the calculated statistics at the 5% critical threshold. Consequently, based on the results of the cointegration tests, it is appropriate to conduct our study of the sources of economic fluctuations using the VECM (vector error correction model).

The theory of multivariate cointegration, within the framework of the empirical VAR approach, makes it possible to define a model with level variables.

VECM-type modeling is a statistically acceptable method that reintroduces the long-run relationship lost through the differentiation of variables by including lagged error correction terms.

Table 4: Cointegration test with presence of break: Gregory and Hansen (1996)

<i>Models</i>	<i>Model 2 : Level change</i>	<i>Model 3 : Level change with trend model</i>	<i>Model 4 : Regime change</i>
ADF procedure			
t-statistics	-6.147	-6.221	-8.103
Delay	1	1	1
Break date	1996M05	1996M05	1998M04
ADF procedure			
Za-stat	-124.180	-127.197	-172.174
Za-break	1996M04	1996M04	1998M02
Zt-stat	-9.2119	-9.341	-11.691
Zt-break	1996M04	1996M04	1998M02

Source: author's calculation

Note: The critical values at 5% for the model with constant is -5.56, for the model with constant and trend is -5.83 and for the model with regime is -6.41.

Before moving on to estimating our model, determining the number of lags is an important step in model specification. Indeed, the choice of the number of lags is selected by specifying the VAR model, with a maximum lag for each variable. The choice of lag number is based on the Akaike (AIC), Schwarz (SC) and Hannan Quinn (HQ) information criteria, which seek to minimize the logarithm of the variance of the residuals, taking into account additive penalties based on model size.

Table 5: Order selection criteria

<i>Delays</i>	<i>LR</i>	<i>AIC</i>	<i>HQ</i>	<i>SC</i>
0	N.A	-23.69	-23.59	-23.65
1	6581.382	-48.64	-47.89*	-48.33*
2	137.889	-48.81*	-47.41	-48.25
3	72.359	-48.75	-46.68	-47.92
4	90.816*	-48.76	-46.04	-47.67

Source: author's calculation

Note: AIC: Akaike information criterion; HQ: Hannan Quinn information criterion; SC: Schwarz information criterion; LR: likelihood ratio information criterion.

Based on information criteria and statistical tests, we can't choose the exact number of delays. Generally speaking, these tests underestimate the number of lags. Several empirical studies have shown that sequential tests (Wald and LR) are more reliable. We therefore favor the result given by the LR (Likelihood Ratio) test. We will therefore retain 4 lags for the VECM model estimated later.

3.2. Methodological specification

Let be the standard VAR model of the following reduced form:

$$X_t = H_1 X_{t-1} + \dots + H_k X_{t-k} + \mu + \omega D_t + e_t \quad (1)$$

with $t = 1, \dots, T$; k is the number of delays ; X_t is the vector of model variables. In our case is of dimension $(7;1)$ and defined by $X_t' = [\text{LOPR}, \text{LIPIE_SA}, \text{LIPIR}, \text{LNEER_SA}, \text{LCPI_SA}, \text{LM3_SA}, \text{LMMR}]$.

H is a matrix of coefficients, e_t is an error term $(0, \Sigma)$, D_t is a vector including non-stochastic variables (seasonal variables, trend) and μ is a constant.

According to Engle and Granger's (1987) theorem, the standard VAR in reduced form can be reformulated as an error-correction model (VECM) in the presence of a cointegration relationship:

$$\Delta X_t = \Gamma + \Delta X_{t-1} + \dots + \Gamma_{k-1} + \Delta X_{t-k+1} + \Pi X_{t-1} + \mu + \omega D_t + e_t \quad (2)$$

In this model, two matrices Γ and Π group together equations whose relationships are stationary in the short term and others that are non-stationary in the long term. The representations of the VAR model and its VECM form by relations (1) and (2) correspond to the following reduced form of structural VAR:

$$A(L)X_t = B\varepsilon_t \quad (3)$$

where A is the polynomial matrix with delay operator L , B is a diagonal matrix, ε_t is the vector of orthogonal structural shocks with variance-covariance matrix Ω . Following a series of treatments, we arrive at the following relationship:

$$\varepsilon_t = C_0 e_t \quad (4)$$

$$\text{with } \varepsilon_0 = B^{-1}A_0 \text{ and } \Omega = c_0^{-1} \sum (C_0^{-1}).$$

The parameters of the structural form can be determined from the parameters of the estimated reduced form of the VAR model, subject to

constraints linked to the large number of identification restrictions. These constraints may be long-term or short-term (contemporaneous relations). Following the example of Cordahi and Goux (2007), we have chosen to impose only constraints on the matrix of instantaneous coefficients of the structural form, insofar as the long-term restrictions are introduced into the VECM at the level of the cointegration relationships.

The imposition of short-term constraints rather than long-term restrictions is advocated by some researchers, as they are based on less restrictive theoretical assumptions (Eichenbaum and Evans, 1995; Clarida and Prendergast, 1999).

Our methodological approach is based on two essential steps. First, the cointegrating space representing the matrix of long-run coefficients of the structural form of the constrained VAR $C(L)$ is defined. Secondly, C_0 the matrix of short-term coefficients is identified.

3.2.1. Imposition of short-term constraints

Several techniques for identifying the short-run and long-run matrix are used in the empirical literature by imposing certain restrictions on the structural form, the short-run restriction method of Sim (1980), and the long-run restriction method of Blanchard and Quah (1989). To determine the identification of the short-term matrix C_0 , we will proceed with short-term restrictions using the variance-covariance matrix and Cholesky's method.

The Cholesky method is used to the identification of shocks, and by retaining the order of variables recommended by Peersman and Smets (2001), in line with Goux (2006) for the zone. It may be interpreted that certain authors chose the order of variables from the most exogenous variable to the least exogenous. In other words, the most exogenous variable is introduced at the beginning (the variable which responds only to its own shock and therefore has no effect on the other variables) and the most endogenous variable at the end (the variable that reacts to shocks affecting the system).

In the context of our work, and to identify the matrix C_0 contains n^2 elements (where n is equal to seven, the number of dependent variables), it is necessary that these relate to the condition of orthogonality of structural shocks such as $(\varepsilon_t, \varepsilon_t') = I$. Indeed, $\varepsilon_t = C_0 e_t$ must verify the hypotheses of linearity and orthogonality, which implies the following relationship:

$$\Omega = C_0^{-1} \sum (C_0^{-1}) \quad (5)$$

For the identification of the matrix C_0 , based for the SVAR model of Blanchard and Quah (1989), 21 short-term numerical restrictions are imposed to identify the matrix with $[n(n-1)/2]$ the structural form. In addition, another method, called Choleski, based on Bernanke and Quah's (1998) identification technique, is used to determine the short-term variance-covariance matrix contains $[n(n+1)/2]$ independent restrictions. In our case, the matrix Ω contains 28 independent restrictions ($28=7(7+1)/2$)

Returning to our reduced-form VAR model, the vector corresponding to the seven logarithmic variables is divided into two blocks and ranked in order of increasing exogeneity. The first block comprises the external variables of the real oil price (LOP) and the European industrial production index (LIPIE). The second block comprises the following domestic variables: the logarithm of the industrial production index (LIPI); the logarithm of the nominal effective exchange rate (LNEER); the logarithm of the consumer price index (LCPI); the logarithm of the money supply (LM3); and the logarithm of the money market rate (LMMR).

ε is the structural innovation vector that $\varepsilon' = [\varepsilon_t^{OP}, \varepsilon_t^{IPIE}, \varepsilon_t^{IPIR}, \varepsilon_t^{NEER}, \varepsilon_t^{CPI}, \varepsilon_t^{M3}, \varepsilon_t^{MMR}]$ which responds to our system's respective external real supply shock, external real demand shock, real supply shock supply shock, exchange rate shock, monetary demand shock, monetary supply shock supply shock and the economic policy shock. e_t is the vector of residuals in the reduced form $e_t^{OP}, e_t^{IPIE}, e_t^{IPIR}, e_t^{NEER}, e_t^{CPI}, e_t^{M3}, e_t^{MMR}$ with $C_0 = B^{-1}A_0$. Our system will be schematized as follows:

$$C_0 = \begin{bmatrix} c_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ c_{21} & c_{22} & 0 & 0 & 0 & 0 & 0 \\ c_{31} & c_{32} & c_{33} & 0 & 0 & 0 & 0 \\ c_{41} & c_{42} & c_{43} & c_{44} & 0 & 0 & 0 \\ c_{51} & c_{52} & c_{53} & c_{54} & c_{55} & 0 & 0 \\ c_{61} & c_{62} & c_{63} & c_{64} & c_{65} & c_{66} & 0 \\ c_{71} & c_{72} & c_{73} & c_{74} & c_{75} & c_{76} & c_{77} \end{bmatrix} \begin{matrix} \Leftarrow \text{Real Oil Price} \\ \Leftarrow \text{IPI Europe} \\ \Leftarrow \text{IPI Real} \\ \Leftarrow \text{NEER} \\ \Leftarrow \text{CPI} \\ \Leftarrow \text{M3} \\ \Leftarrow \text{MMR} \end{matrix} \quad (6)$$

Based on the empirical literature (Kim and Roubini, 2000; Kim, 2001;

Sims and Zha, 2006; Goux, 2006), we can see that the diagonality of the B matrix is characterized by an absence of over-identification. Conversely, the shock impulse pattern reveals connections between exogenous shocks and changes in the reduced form, expressed as follows: $B\varepsilon_t = A_0 e_t$:

$$\begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & b_{55} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & b_{66} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & b_{77} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{OP} \\ \varepsilon_t^{IPIE} \\ \varepsilon_t^{IPIR} \\ \varepsilon_t^{NEER} \\ \varepsilon_t^{CPI} \\ \varepsilon_t^{M3} \\ \varepsilon_t^{MMR} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & 0 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 & 0 \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 \end{bmatrix} \begin{bmatrix} e_t^{OP} \\ e_t^{IPIE} \\ e_t^{IPIR} \\ e_t^{NEER} \\ e_t^{CPI} \\ e_t^{M3} \\ e_t^{MMR} \end{bmatrix}$$

Referring to the theoretical work of Blanchard and Quah (1989) and Giannini (1992), our model estimates 28 parameters ($28 = 7(7+1)/2$) that meet certain identification conditions. The model matrices comprise 7 equations based on theoretical studies that reveal the short-term relationship between structural shocks and variations in reduced form.

The Choleski decomposition shows that some coefficients of the estimated parameters of the A_0 and B matrices are statistically insignificant. Following Giannini et al (1995) and Goux (2003), in order to improve our identification, we impose additional short-term restrictions on the insignificant parameters.

Considering the lower triangular form of the matrix A_0 , real supply shocks e_t^{IPIR} can affect the competitiveness of companies in the short term. As Blanchard and Quah (1989) demonstrate, supply shocks influence the production of goods for domestic consumption only, leaving production for foreign markets unaffected.

Consequently, external supply and demand for domestic goods and services, and hence the European IPI and real oil price, do not respond to the domestic real supply shock in the short term, but rather in the long term. In other words, these two types of external shock have no short-term effect on the level of domestic production. Consequently, the external shock is considered an exogenous variable, since its long-term effect contributes only to itself. This restriction is justified by the fact that our study focuses on small economies with limited market power. This hypothesis corroborates Cushman and Zha's (1997) idea that external variables are exogenous.

The exchange rate shock instantly influences external variables such as the European IPI and the price of oil. The reaction function of the real exchange rate on the industrial production index is zero, implying that exchange rate shocks have no effect on real production, which influences economic growth (Citu and Twanddle, 2003; Touzani and Abidar, 2025). This manipulation of the theoretical consideration therefore imposes a further restriction on the insignificant coefficient. ($a_{43} = 0$).

Indeed, if we refer to economic theories, one of the most imposed restrictions is predicated on the assumption of the IS-LM model by Gali (1992) and Clarida and Gali (1994), according to which money supply shocks have no effect on output and exchange rate shocks in the long term. Following this assumption, we show zero effects of the money supply (M3) on the real effective exchange rate in the short term. Traditional Keynesian thinking stipulates that money supply only enters contemporary monetary policy and money supply equations. This specification implies the nullity of the short-term impact of money supply shocks on real output and the real effective exchange rate. This finding confirms the results of Alabdulwahab and Abou-Zaid (2024). Given the lower triangular form of the matrix A_0 , we impose a further restriction on the insignificant coefficient ($a_{63} = a_{64} = 0$).

According to Kim and Roubini (2000), the money supply and the nominal exchange rate are considered variables that determine short-term monetary policy. Nevertheless, other studies, such as one by Sims and Zha (2006), claim that policy shocks negatively impact the economy, particularly real output and prices.

Following the same principle as the other authors, Peersman and Smets' (2001) fundamental idea is to argue that monetary authorities make decisions despite the absence of real prices and output. However, the absence of immediate interest rates in response to structural shocks to real supply and monetary demand is particularly justifiable in the context of monetary policy in Tunisia due to the BCT's smoothing of short-term interest rates to preserve financial stability. In the context of our work, this translates to imposing a short-run nullity constraint on insignificant coefficients ($a_{73} = a_{75} = 0$).

Short-term domestic monetary variables cannot affect foreign variables. This explains why foreign supply and demand shocks are not affected by short-term domestic monetary shocks. Hence ($a_{61} = a_{62} = a_{71} = a_{72} = 0$).

The identification scheme thus becomes:

$$\begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & b_{55} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & b_{66} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & b_{77} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{OP} \\ \varepsilon_t^{IPIE} \\ \varepsilon_t^{IPIR} \\ \varepsilon_t^{NEER} \\ \varepsilon_t^{CPI} \\ \varepsilon_t^{M3} \\ \varepsilon_t^{MMR} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & a_{34} & 0 & 0 & 0 \\ a_{41} & a_{42} & 0 & 1 & 0 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & a_{65} & 1 & 0 \\ 0 & 0 & 0 & a_{74} & 0 & a_{76} & 1 \end{bmatrix} \begin{bmatrix} e_t^{OP} \\ e_t^{IPIE} \\ e_t^{IPIR} \\ e_t^{NEER} \\ e_t^{CPI} \\ e_t^{M3} \\ e_t^{MMR} \end{bmatrix}$$

In addition, the system is composed of the following 7 equations:

$$\begin{aligned} b_{11}\varepsilon_t^{OP} &= e_t^{OP} \\ b_{22}\varepsilon_t^{IPIE} &= a_{21}e_t^{OP} + e_t^{IPIE} \\ b_{33}\varepsilon_t^{IPIR} &= a_{31}e_t^{OP} + a_{32}e_t^{IPIE} + e_t^{IPIR} + a_{34}e_t^{NEER} \\ b_{44}\varepsilon_t^{NEER} &= a_{41}e_t^{OP} + a_{42}e_t^{IPIE} + e_t^{NEER} \\ b_{55}\varepsilon_t^{CPI} &= a_{51}e_t^{OP} + a_{52}e_t^{IPIE} + a_{53}e_t^{IPIR} + a_{54}e_t^{NEER} + e_t^{CPI} \\ b_{66}\varepsilon_t^{M3} &= a_{65}e_t^{CPI} + e_t^{M3} \\ b_{77}\varepsilon_t^{MMR} &= a_{74}e_t^{NEER} + a_{76}e_t^{M3} + e_t^{MMR} \end{aligned}$$

The observation of the first and second equations implies that we are in the presence of an exogenous external real demand and supply shock. This hypothesis is in line with the work of (Blanchard and Quah, 1989; Cushman and Zha, 1997 and Goux, 2003), which highlights the exogeneity of real supply shocks and foreign shocks. For the third equation is a production function that is influenced by foreign supply and demand shocks, as well as by the real exchange rate. While, the fourth equation corresponds to an exchange rate equation, insofar as the exchange rate responds to external supply and demand shocks. The reaction function of the real exchange rate on the industrial production index is zero, which implies that there is no effect of exchange rate shocks on domestic production. Touzani and Abidar (2025).

However, the fifth equation is a domestic price function where the monetary demand shock is influenced by the real output principle of aggregate supply, as well as by the real exchange rate. Moreover, in our case, these prices are instantaneously determined by external shocks of the real supply and demand type. This domestic price function is in line with that of (Kim and Roubini, 2000 and Goux, 2003). Furthermore, the sixth equation refers to a

money supply function essentially explained by the general price level. Finally, the seventh equation corresponds to the monetary policy equation, which is determined on the basis of the money supply and the short-term nominal exchange rate. In line with the work of (Kim and Roubini 2000; Sims Zha, 2006), this function implies that the monetary authorities determine the short-term interest rate as a function of the values of these two variables (money supply and nominal exchange rate). However, other studies, notably that of Trabelsi (2024), show that the values of real output and inflation do not enter into the immediate reaction function of short-term monetary policy.

4. RESULTS AND DISCUSSION

The results of matrix estimation using the SVAR model are presented in Table 06. With reference to theoretical expectations, some of the signs of the contemporaneous coefficients are controversial. Indeed, we find that the external shock has a negative but significant effect on the oil price (coefficient a_{21}). In the context of an emerging the effect of foreign shock on the exchange rate is significantly positive (coefficient a_{42}).

Table 6: Contemporary coefficients for the structural model

Coefficient	Value	Standard deviation	z-statistic	Probability
a_{21}	-0.0175	0.0065	-2.6958	0.0070
a_{31}	-0.0219	0.0243	-0.9019	0.3671
a_{32}	-0.0064	0.0269	-0.2372	0.8125
a_{34}	-0.0008	0.0087	-0.0942	0.9249
a_{41}	0.1645	0.2269	0.7248	0.4686
a_{42}	-0.6544	0.2475	-2.6441	0.0082
a_{51}	-0.0946	0.0814	-1.1617	0.2454
a_{52}	0.0122	0.0217	0.5599	0.5755
a_{53}	-0.1289	0.0548	-2.3487	0.0188
a_{54}	-0.0024	0.0199	-0.1228	0.9022
a_{65}	0.3353	0.1976	1.6968	0.0897
a_{74}	0.1192	0.2009	0.5933	0.5530
a_{76}	0.4174	0.1855	2.2498	0.0245
b_{11}	0.0170	0.0007	23.3238	0.0000
b_{22}	0.0018	7.83E-05	23.3238	0.0000

<i>Coefficient</i>	<i>Value</i>	<i>Standard deviation</i>	<i>z-statistic</i>	<i>Probability</i>
b_{33}	0.0067	0.0003	23.3238	0.0000
b_{44}	0.0074	0.0003	23.3238	0.0000
b_{55}	0.0024	0.0001	23.3238	0.0000
b_{66}	0.0080	0.0003	23.3238	0.0000
b_{77}	0.0246	0.0010	23.3238	0.0000

Source: Author's calculation

In depreciation of the nominal exchange rate favors an increase in demand from demand from trading partners. Finally, in line with the theoretical model theoretical model of Sims Zha (1998) and Kim and Roubini (2000), we find a positive and significant response from the monetary policy instrument (MMR) with the exchange rate and money supply M3 (coefficients a_{65} and a_{67}). This function implies that the monetary authorities determine the interest rate according to the values of these two variables (money supply and nominal money supply and nominal exchange rate).

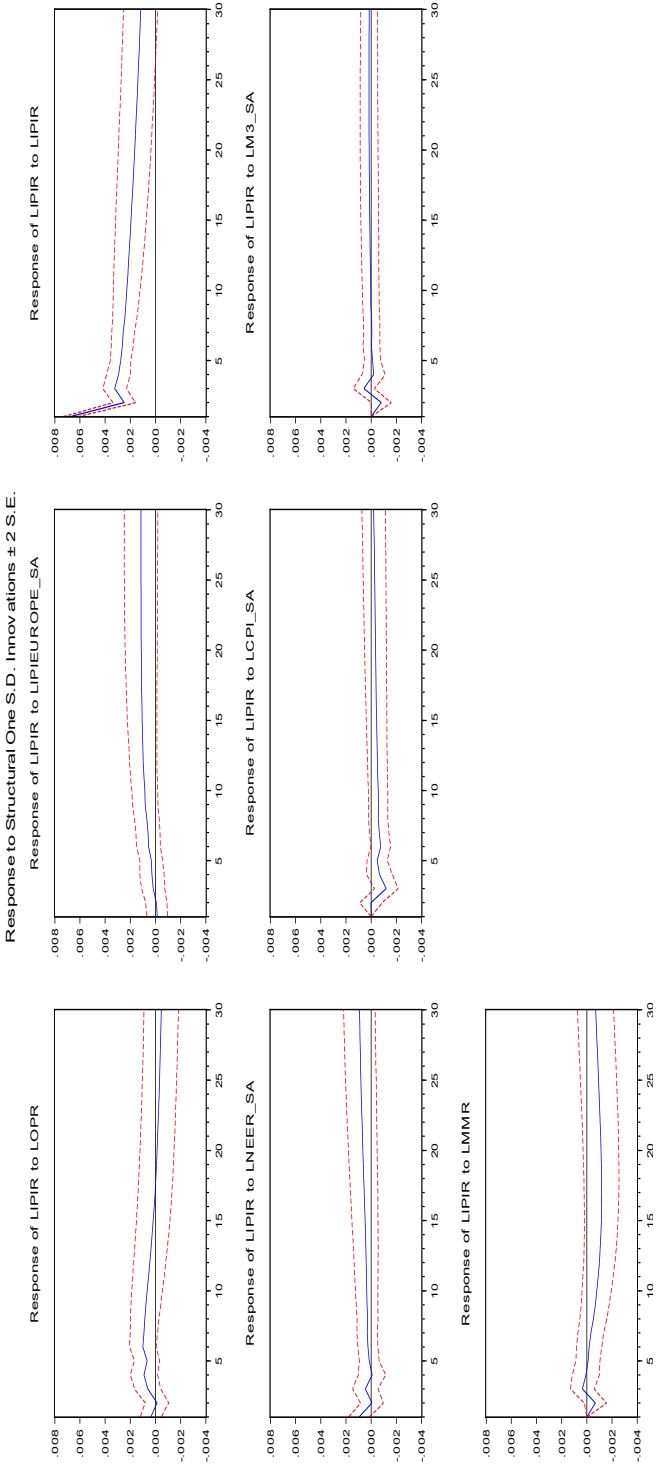
Of the 7 shocks found, only 5 were significant for the seven variables in the model. In fact, and according to Table 7, examination of the signs of the coefficients corresponding to the variables used indicates that the real supply shock is negative and significant in early 1999. By The model also reveals that external shocks, including those of the European the IPI in Europe, proved

Table 7: Impact of various shocks on the Structural model

<i>Variable choc</i>		<i>LOPR</i>	<i>LIPIEUROPE_ SA</i>	<i>LIPIR</i>	<i>LNEER_ SA</i>	<i>LCPI_SA</i>	<i>LM3_SA</i>	<i>LMMR</i>
d99m01	Coefficient	0.0271	0.0020	-0.0162**	-0.0046	0.0022	0.0021	-0.0002
	Standard deviation	(0.017)	(0.001)	(0.007)	(0.008)	(0.002)	(0.008)	(0.026)
d00m01	Coefficient	0.0037	-0.0023	-0.0078	-0.0002	0.0012	-0.0727***	0.0035
	Standard deviation	(0.017)	(0.001)	(0.007)	(0.008)	(0.002)	(0.008)	(0.026)
d08m04	Coefficient	0.0161**	-0.0015**	-0.0024	-0.0018	0.0023	-0.0099	0.0079
	Standard deviation	(0.000)	(0.000)	(0.007)	(0.007)	(0.002)	(0.008)	(0.026)
d11m12	Coefficient	0.0146	-0.0030	-0.0047	-0.0037	-0.0051**	0.0058	0.0213
	Standard deviation	(0.019)	(0.002)	(0.008)	(0.009)	(0.002)	(0.009)	(0.029)
d14m04	Coefficient	-0.0013	0.0004	-0.0015	-0.0240***	0.0014	-0.0004	-0.0035
	Standard deviation	(0.017)	(0.002)	(0.007)	(0.008)	(0.002)	(0.008)	(0.026)

Source: author's calculation

Note: ** and *** significance at 5% and 1%, respectively.



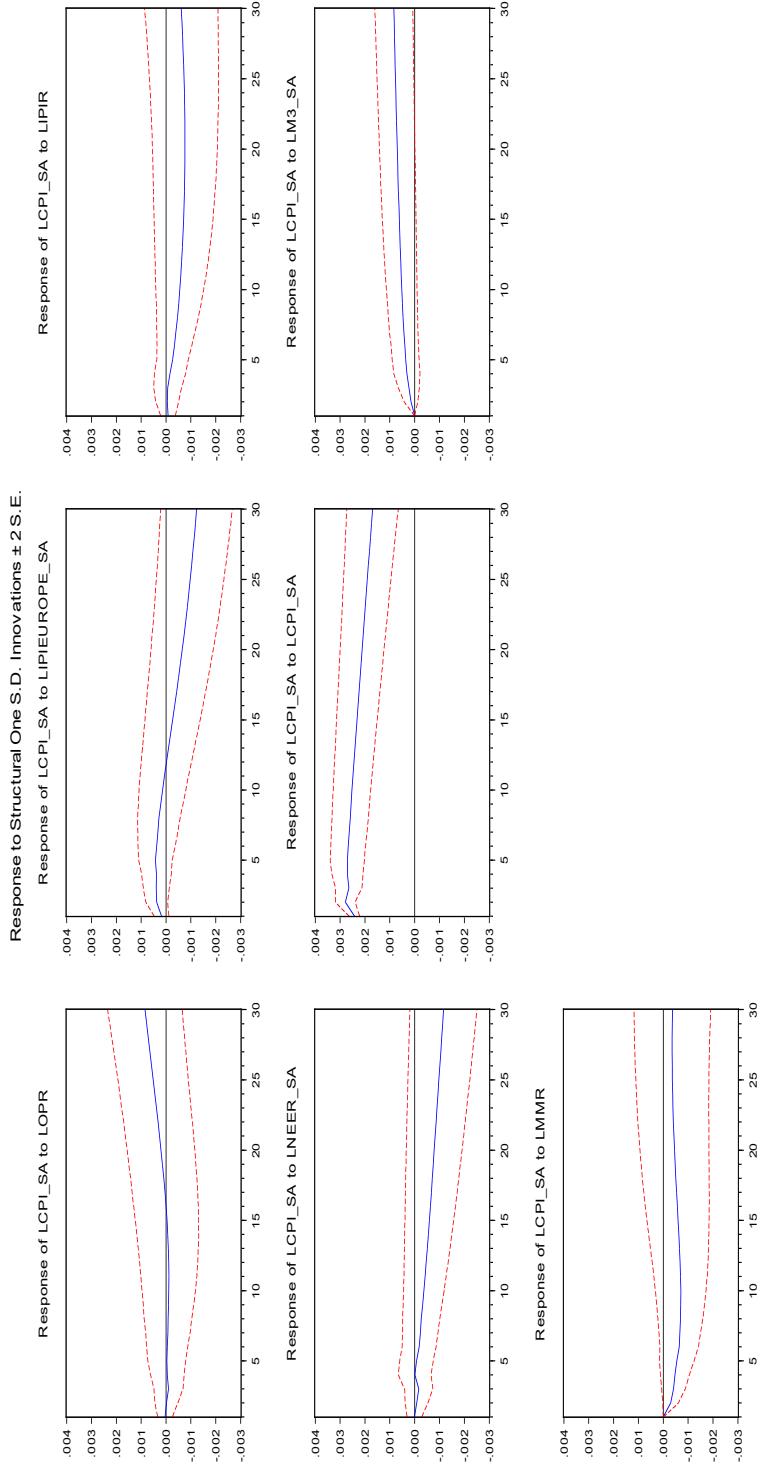
Graph 1: Reaction of various shocks on IPIR

to be economically negative and significant for Tunisia. This negative effect manifests itself insofar as the external shock affects Tunisia, which is both an importer and exporter of raw materials. Indeed, given the fragility and sensitivity of the Tunisian economy to international conditions, the subprime crisis in 2008 affected most emerging countries and Tunisia in particular, exerting a negative impact on domestic production, which manifested itself in disruptions to Tunisia's demand function around the first quarter of 2008.

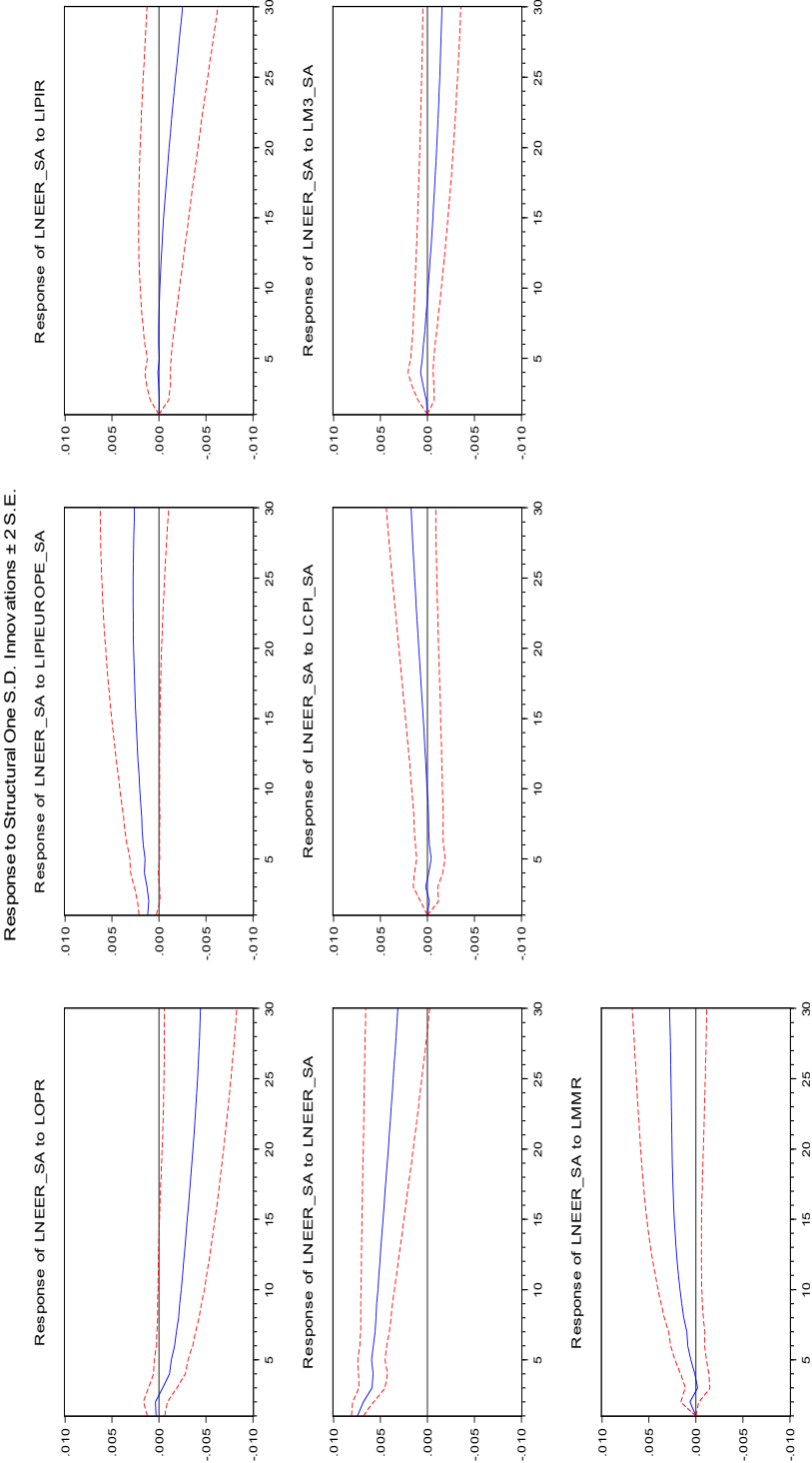
The effects of shocks on variables are seen as dynamic indicators that can help us understand the economic system. This tool illustrates how different shocks affect variables. In the case of the real IPI, for example, the shock response function confirms previous results and provides additional information. These shock response functions are presented in Figure 1, in line with the empirical literature in the work of Elachhab (2007) and Trabelsi (2024), who consider that a negative real supply shock leads to a persistent fall in real output. In the long term, the effects of this shock are reflected in slight rises in oil prices and the IPI in Europe. Following the reaction to the long-term real supply shock, there is an instantaneous increase in the M3 monetary aggregate.

Although they are persistent in the long term, the effects of real supply shocks on the exchange rate, prices, and monetary policy are statistically insignificant. This result confirms the IMF (2015) and Schmitt-Grohe and Uribe (2018) theories that the real exchange rate on industrial production is zero. This indicates that an exchange rate shock has no impact on domestic production. Consequently, the price response to a real supply shock does not align with the theoretical predictions of Clarida and Gali (1994) or the aggregate supply mechanisms of Blanchard and Quah (1989).

In addition to analyzing fluctuations in the level of production, the visualization of graph 2 allows us to understand variations in other key macroeconomic variables. These include the consumer price index (CPI). Indeed, the impulse functions following CPI shocks suggest that oil shocks have a weak effect on the long-term price level. Consequently, the impact of external shocks on prices is insignificant. In short, our various empirical investigations reveal, through the shock response functions, a predominance of domestic shocks in explaining fluctuations, which account for over 90% of price level changes. However, the nature of the effect of external shocks is



Graph 2: Reaction of various shocks on CPI



Graph 3: Reaction of various shocks on NEER

unclear insofar as the increase in foreign demand is followed by a fall in prices, a result that is difficult to argue (Price Puzzle).

Depending on the nature of their shock effects, the response functions indicate that a positive supply shock leads to nominal exchange rate depreciation. This outcome is neither consistent with reality nor with theoretical teachings. This confounding impact is of little significance, as the variance decomposition highlights the insignificant effect of real supply shocks on the exchange rate.

On the other hand, the shock reaction functions show an insignificant and almost null effect of monetary shocks (CPI and M3) and the real supply shock on the level of the nominal exchange rate.

Finally, the contribution of external shocks (OP and IPIE) to nominal exchange rate fluctuations is shown in graph 3 to be significant. These two types of external shock contribute around 35% of nominal exchange rate variability. Real supply shocks account for the largest share, generally exceeding 20%.

CONCLUSION

This article examines the effects of domestic and external shocks on the Tunisian economy. The main results show the predominance of supply and demand shocks in explaining fluctuations in Tunisia. Furthermore, in the short term, external factors (oil shocks and external shocks) play a moderately important role in explaining economic fluctuations and affecting the dynamics of domestic economic activity. However, this finding does not mean that the Tunisian economy appears to be very vulnerable to the international economic situation. This is explained by the important role played by external factors in explaining economic fluctuations in Tunisia. Ultimately, the reduction in the magnitude of exogenous external shocks, which can be achieved through the propagation of shocks between countries, is an important factor that can promote the transmission of a faster economic cycle, which depends essentially on trade and financial factors.

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