

# “Monetary policy transmission and growth of the manufacturing sector in Algeria”

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## Monetary policy transmission and growth of the manufacturing sector in Algeria

### Abstract

The principal objective of this study is to investigate the relationship between monetary policy and growth of the manufacturing sector in Algeria. Using a structural vector autoregressive model and quarterly frequency data for the period 1980Q1 to 2010Q4, the study finds no evidence that money supply responds to fluctuations in manufacturing sector growth or Gross Domestic Product (GDP) growth. Interest rates, however, are seen to explain nearly a third of the variations in manufacturing output growth, suggesting that the manufacturing sector is sensitive to interest rates. The study also reveals that money supply variations are largely explained by changes in interest rates. A peek at the monetary transmission process reveals that Algeria employs monetary aggregates as the primary operating tool of monetary policy. The monetary authorities adjust total money supply in response to any movements in the rate of interest, probably to keep the rate of interest within a certain target given other developments in the fundamentals. The interest rates, in turn, play an important role in determining variations in manufacturing sector growth. In addition, the interest rates significantly affect exchange rates, which are observed to respond to changes in overall GDP growth. It is the overall GDP growth that has the largest influence on manufacturing sector growth, probably due to strong forward and backward linkages between the manufacturing sector and other sectors of the economy.

**Keywords:** monetary policy, transmission mechanism, manufacturing output, oil price shocks.

**JEL Classifications:** E23, E31, E52.

### Introduction

Located in North Africa on the Mediterranean coast, Algeria is the largest country in Africa. The country relies on natural gas exports to Europe and on oil production. It has the 17<sup>th</sup> largest oil reserves in the world and it is the second largest producer of oil in Africa after Nigeria. Oil is the largest foreign exchange earner for the country and it accounts for the largest proportion of the country's gross domestic product (GDP). The oil sector contributes about 46.4 percent to the country's GDP (2007 estimate) and accounts for 97 percent of the total export earnings. The situation is nearly the same for almost all of Africa's oil exporting countries (AOECs). The enormous financial resources generated from oil production in the AOECs, however, have not translated into overall economic development (World Bank, 2012; International Monetary Fund (IMF), 2010). The prevalence of unemployment, poverty, large quantities of imported manufactured goods, decaying infrastructure, unreliable power supply and low human development (as measured by the Human Development Index) are examples of the poor state of these economies.

In Algeria, wealth from oil resources has led to an increase in expenditure and the effect has put pressure on the prices of manufactured consumer goods (spending effect of "Dutch Disease"). However, the dwindling nature of oil reserves in most AOECs and

myriads of problems facing these countries has resulted in a warning by the International Monetary Fund (IMF) in 2010 that if by the end of the next two decades there are no positive efforts towards diversification, most of these economies will run into a deep recession.

Both the World Bank and the IMF have emphasized the need for the oil exporting countries in Africa to embrace diversification. They have described this as a panacea for their economic problems (see World Bank 2004; IMF, 2008). The manufacturing sector, specifically, has been tipped as a major sector that can help in the diversification process. This sector has been described as a major catalyst that can boost local output of the real sector of the AOEC. For instance, among 65 countries that can be classified as natural resources-rich, only Botswana, Indonesia, Malaysia and Thailand had long-term investment exceeding 25% of their GDP between 1970 and 1998, and also recorded Gross National Product (GNP) per-capita growth exceeding 4% per year (see Olomola, 2007; Gylfason, 2001). The main reason for the success of these economies was their ability to effectively diversify through accelerated growth in domestic output, which was made possible through a vibrant manufacturing sector (Olomola, 2007).

Algeria has been subsidizing manufactured consumer goods for many years. This subsidy bill has risen from United States dollar (US\$)175 million in 2009 to about US\$3 billion in 2012. The contribution of the manufacturing sector to the country's GDP is estimated at 3 percent (2011 estimate). Clearly, the focus on the oil sector only has led to the neglect of the manufacturing sector. Many of the AOECs are

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heavily dependent on imported manufactured goods. This and excessive spending of oil revenues has led to a fall in domestic output of the manufacturing industries leading to a rise in prices of local manufactured consumer goods.

Efforts to revitalize the ailing manufacturing sector in Algeria do not appear to be succeeding. This is evident in the dwindling manufacturing output of the country, which fell from about 17.21 % of GDP in 1970 to 11.38 % of GDP in 1990 and 7.46 % of GDP in 2000. The economic outlook for the sector appears gloomy. According to the IMF (2013), Algeria's manufacturing output growth and some other AOECs may become negative for the first time by 2017 if relevant policies are not put in place to stimulate the growth of the sector. The approach of the Algerian government to solving the problem has been to employ fiscal policy rather than monetary policy. This is evident in the efforts of the Algerian government where total public expenditure increased by about 2.5% in 2013 due to subsidies in the manufacturing sector. Following this apparent policy failure, a host of studies have suggested that a monetary approach to solving the manufacturing sector problems in Algeria would be more appropriate than the fiscal policy approach (see Bouchaour and Al-Zeaud, 2012).

This study, therefore, aims at contributing to the existing literature by investigating the relationship between monetary policy and growth of the manufacturing sector in Algeria. As far as we know, there is no study that has analyzed the relationship between monetary policy and manufacturing sector growth in Algeria. Bouchaour and Al-Zeaud (2012) examined the influence of oil price shocks on monetary policy variables in Algeria; while Majid (2001) and Mohamed (2011), among others, only included Algeria in a panel of countries studied. It is expected that findings of this study will lead to an understanding of how monetary policy can be effectively employed to solve problems in the ailing manufacturing sector in Algeria.

The remaining part of the paper is organized in four sections. Section 1 is a brief overview of monetary policy and growth of the manufacturing sector in Algeria and other AOECs. Section 2 outlines the methodology used in the study, while Section 3 presents estimation results. A summary and conclusion conclude the paper in Final.

## 1. Monetary policy and manufacturing sector growth in Algeria and other AOECs

In the literature, there is no consensus on the relevance and role of monetary policy in solving the myriads of problems confronting the AOECs manufacturing sectors (see for example, Mohamed, 2011;

Corden and Neary, 1982; Lama and Medina, 2010). Several studies have argued that administration of monetary policy in many developing countries, including the AOECs, contribute to the woes of the manufacturing sector due to the fluctuations in oil revenue (see Woodford, 2001; Jordi and Mark, 2007; Clarida and Gali, 2000; Gali and Monacelli, 2005).

Other studies, however, maintain that monetary policy in developing countries and AOECs neutralizes the negative effect that oil revenue fluctuations have on macroeconomic performance (see Degrauwe, 2000; Gregory, 2007). They add that the type of inflation and exchange rate policies in practice can also be used to absorb threats from oil prices or revenue fluctuations in such a way that monetary policy instruments will be less responsive to oil price shocks (see for example, Degrauwe, 2000; Gregory, 2007).

There is near agreement, though, that monetary policy has only transitory effects on economic activity. The process through which monetary policy affects economic activity, however, has been a subject of debate for many years. While many studies on the subject have been carried out in developed economies, there are only a few studies on developing economies (see Ngalawa and Viegli, 2011).

The situation is even worse for oil rich countries in Africa. The largest number of studies have been carried out on Nigeria, which is the largest oil producer in Africa. Bouchaour and Al-Zeaud (2012) examined the effect of oil price fluctuations on the Algerian economy with particular focus on monetary policy variables such as money supply and interest rates. The study applied the Vector Error Correction Model (VECM) and covered the period 1980-2011. Bouchaour and Al-Zeaud (2012) found that there are no significant short-term effects of oil prices on most of the variables, especially money supply and interest rates; that there is a significant positive effect of oil prices on real GDP and inflation, and a negative impact of oil prices on unemployment and the real effective exchange rate in the long run; and that there is no relationship between oil prices and money supply.

Onyeiwu (2012) examined the impact of monetary policy on the growth of the Nigerian economy using the ordinary least squares estimation technique. Results of the study showed that money supply has a positive impact on growth and balance of payments in Nigeria and a negative impact on the rate of inflation. The study recommended that monetary policy should be used to facilitate provision of a favorable climate for investment through appropriate exchange rates, interest rates and liquidity management.

Another study on Nigeria was carried out by Nenbee and Madume (2012), who examined the role of monetary policy in maintaining macro-economic stability in the country. The study made use of a cointegration and error correction model and the results revealed that there is a long-run relationship between monetary policy variables and macro-economic stability in Nigeria. Money supply was observed to have a significant positive impact on the growth of the country.

Ibrahim and Amin (2005) investigated the relationship between exchange rates, monetary policy and manufacturing output growth in Egypt. Using a vector autoregressive model (VAR), the study found that exchange rate shocks have a significant impact on manufacturing output more than on the overall growth of the economy. The study also showed that monetary policy tightening leads to a negative response of real activities. On the whole, the study found that manufacturing output responds sharply to both monetary and exchange rate shocks more than the overall output of the Egyptian economy.

In Algeria, the decline in the growth of the manufacturing sector and the country's over-dependence on oil have aggravated the existence of structural imbalances in terms of high inflation rates and an increase in the unemployment rate. The structural imbalances coupled with economic instability in the country have made inflation rate and exchange rate policies ineffective in resuscitating the ailing manufacturing sector. Building a virile non-oil sector that will be able to make a significant contribution to GDP has been identified as a way of reducing dependence on the oil sector and promoting development of the AOECs (African Development Bank Group (ADB), 2010). According to the ADB (2010), this undertaking requires a thorough assessment of the monetary policy administration to understand the strategic synergies between both the exchange rate and inflation rate policies in order to create an enabling environment for the non-oil sector to thrive.

## 2. Methodology

**2.1. Theoretical framework.** Consistent with Arrow's seminal work on the economies of learning by doing, the endogenous growth model of Romer (2006) points out that investment in knowledge (experience) has a strong linkage with an increase in productivity. According to Romer (2006), the indexes of experience by cumulative investment follow the following production function:

$$Y_{it} = F(K_{it}, A(t)L_{it}) \quad (1)$$

where  $Y_{it}$  is the output of firm  $i$ ,  $A(t)$  is the stock of knowledge of firm  $i$  at period  $t$ , and  $K_{it}$  and  $L_{it}$  are capital and labor of the firm at period  $t$ . Romer

(2006) argues that labor is more productive due to the accumulation of knowledge, which also depends on experience. However, experience is a function of past investment. Consequently, the growth rate of output of the firm can be written as a function of indexes of experience by cumulative investment as follows:

$$G(t) = \int_{-\infty}^t I(v)dv = k(t) \quad (2)$$

where  $G(t)$  is the growth rate of the output of the firm and  $I(v)dv$  is the index of cumulative investment, which is equal to capital stock  $k(t)$ . The growth rate of output of the firm, according to Romer (2006), is equal to the per-capita production function (real output/income) given by:

$$y = k(t) \quad (3)$$

Substituting equation (3) in equation (2) shows that:

$$G(t) = y \quad (4)$$

where  $y$  is the real output.

Again, in the definition of a money demand function, Romer (1996) postulates a relationship between inflation, money growth and interest rates. He argues that demand for real money balances is a decreasing function of interest rates and an increasing function of real income. That is:

$$\frac{M}{P} = L(r, y) \quad (5)$$

This can be written in linear form as:

$$\frac{M}{P} = \alpha y - \beta r \quad (6)$$

Therefore:

$$\alpha y = \frac{M}{P} + \beta r \quad (7)$$

Dividing both sides by  $\alpha$  leads to:

$$y = 1/\alpha \left(\frac{M}{P}\right) + \alpha/\beta(r) \quad (8)$$

where  $1/\alpha$  and  $\alpha/\beta$  are elasticities of real money balances and interest rates, respectively. Substituting equation (8) into equation (4) gives:

$$G(t) = 1/\alpha \left(\frac{M}{P}\right) + \alpha/\beta(r) \quad (9)$$

Thus the growth rate of a firm can be presented as a function of the real money balances and interest rates, which determine change in capital stock (investment), where labor remains constant.

Our estimation model is a modification of equation (9). In our attempt to study monetary policy transmission and growth rate of the manufacturing sector output in Algeria against a backdrop of oil price shocks, a number of variables are included in the model. Apart from the monetary policy instruments (interest rates and money supply), we also include

policy variables (exchange rate, growth rate of the manufacturing sector output, and inflation rate) in the model. Oil prices and oil revenue are included in the model as exogenous variables.

The linear specification of the estimation model is expressed as:

$$m_{gr_t} = [intr_t, msgr_t, inf_t, exr_t, gdpgr_t, oilgr_t, poil_t] \dots 10$$

where  $m_{gr}$  is manufacturing output growth,  $intr$  is interest rates,  $msgr$  is money supply growth rate,  $inf$  is inflation rate,  $exr$  is exchange rate,  $gdpgr$  is GDP growth rate,  $oilgr$  is oil resources growth rate, and  $poil$  is oil price.

**2.2. The VAR model.** The main objective of this study is to examine the relationship between monetary policy transmission and growth of the manufacturing sector in Algeria using a Structural VAR model. Generally, VAR models are seen as independent large-scale macro econometric models that do not rely on unrealistic assumptions (Elbourne, 2007). The foremost theoretical framework of VAR analysis as proposed by Sims (1980) used Choleski decomposition to get impulse responses. However, the Choleski decomposition used in VAR models has been criticized for being prone to incredible causal ordering if one is interested in analysing more than just monetary shocks (see Bernanke, 1986; Elbourne, 2007). In addition, the Choleski decomposition in VARs uses partial identification, which can identify only one of the underlying structural shocks. All other shocks are treated as responding contemporaneously to the identified shocks (Elbourne, 2007). On the other hand, the structural VAR (SVAR) provides economic information for the rationale behind the restrictions that helps in identifying both monetary policy shocks and other shocks. This study is interested in studying the short-term and medium-term behavior of the selected variables since there is a near consensus that monetary policy can only influence output significantly in the short run (see Gul, Mughal and Rahim 2012; Sirdrauski 2008).

Since Algeria is a net oil exporter in Africa, we cannot ignore the influence of both oil resources and oil price shocks besides the monetary policy shocks, hence the suitability of an SVAR approach for this study. The construction of our VAR model follows the conventional method where the primitive equation is specified as:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \dots + A_p y_{t-p} + \mu_t \quad (11)$$

where  $y_t$  represents an  $(n \times 1)$  vector containing  $n$  endogenous variables,  $A_i (i = 1, 2, \dots, p)$  are  $(n \times n)$  matrices of coefficients, and  $\mu_t$  is an  $(n \times 1)$  vector containing error terms. The error terms  $\mu_t$  tend to be contemporaneously correlated in all the equations.

There exist  $pn^2$  parameters in the  $A$  matrices. Equation (11) can be rewritten in compact form where the lag operator  $L$  is selected using  $L^k x_t = x_{t-k}$ , as:

$$A(L)y_t = \mu_t \quad (12)$$

where:

$$A(L) = A_0 L^0 - A_1 L^1 - A_2 L^2 - \dots - A_p L^p$$

$A_0 = I$  is an identity matrix. It is required that  $A(L)$  lies outside the unit circle if the model is to be stationarity.

### Variance Decomposition and Impulse Response Functions

Both variance decomposition and impulse response functions are computed by respecifying our autoregressive (AR) function:

$$A(L)\mu_t = y_t \quad (13)$$

where  $y_t$  represents a stationary stochastic process in the system,  $L$  is a lag operator and  $\mu_t$  is a white noise error term. The theory also requires roots of  $\det(I-A(z))=0$  to lie outside the unit circle, where  $\det(I-A(z))$  is invertible. The interpretation of our VAR is based on the vector moving average (MA) presented in the following form:

$$y_t = \phi_t + \sigma(L)\mu_t E(\mu_t) = 0 \quad (14)$$

$$E(\mu_t \mu_{t-k}) = Q, |k| = 0 \quad (15)$$

$$E(\mu_t \mu_{t-k}) = Q, |k| \neq 0 \quad (16)$$

where  $Q$  represents the sample covariance matrix,  $\phi_t$  is perfectly predictable, and the matrix of coefficients of  $\sigma(L)$  using lag zero is the identity matrix. Equation (14) can be normalized to generate the impulse response functions and forecast the error decomposition.

**Model Identification.** The SVAR requires imposition of enough restrictions so as to identify the orthogonal structural components of the error terms that are present in the shocks. Note that this is at variance with the standard recursive Cholesky orthogonalization.

The orthogonality assumption of the structural innovations is given by  $\sum E[v_t \hat{v}_t]$ . This imposes identifying restrictions on matrices  $A$  and  $B$  as given by:

$$A v_t = B \mu_t \quad (17)$$

where  $v_t$  and  $\mu_t$  are vectors with lag length  $k$ ;  $v_t$  is the observed residual; and  $\mu_t$  represents the unobservable structural innovations.  $A$  and  $B$  are  $k \times k$  matrices, which are to be estimated. The innovation  $\mu_t$  is assumed to be orthogonal in nature. Accordingly, the covariance is an identity matrix  $E[\mu_t \mu_t'] = I$ . Imposition of restrictions on matrices  $A$  and  $B$  is made possible due to the orthogonal assumption of  $\mu_t$ . Thus, we obtain:

$$A \Sigma \hat{A} = B \hat{B} \tag{18}$$

The link between the reduced form and the structural form of the VAR model is presented as follows:

$$B(L) = B_0 + B^+(L) \tag{19}$$

$$A(L) = -B_0^{-1} B^+(L) \tag{20}$$

$$\Sigma \hat{=} B_0^{-1} A B_0^{-1} \tag{21}$$

Equation (19) divides the structural relationship into contemporaneous correlations  $B_0$  and  $B^+(L)$ . The former represents correlations at lag zero while the

latter represents correlations at all strictly positive lags. Equation (20) separates each reduced form coefficient into its structural counterparts; and  $B_0$  is identified through the reduced form.

Due to the vulnerability of long-run restrictions to serious misspecification problems, we use contemporaneous restrictions on  $B_0$  matrix to identify the shocks as shown in the system of equations (22), especially since this study is interested in short-run and medium-term responses (see Leeper, Sims and Zha, 1996; Elbourne, 2007).

$$\begin{bmatrix} v_t^{poil} \\ v_t^{oilgr} \\ v_t^{intr} \\ v_t^{msgr} \\ v_t^{infr} \\ v_t^{exr} \\ v_t^{mgr} \\ v_t^{gdpgr} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ B_{21}^0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ B_{31}^0 & 0 & 1 & 0 & 0 & 0 & 0 & B_{38}^0 \\ B_{41}^0 & 0 & B_{43}^0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & B_{53}^0 & B_{54}^0 & 1 & B_{56}^0 & 0 & 0 \\ B_{61}^0 & B_{62}^0 & 0 & 0 & B_{65}^0 & 1 & B_{67}^0 & 0 \\ B_{71}^0 & B_{72}^0 & B_{73}^0 & B_{74}^0 & B_{75}^0 & B_{76}^0 & 1 & 0 \\ 0 & 0 & 0 & 0 & B_{85}^0 & B_{86}^0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \mu_t^{poil} \\ \mu_t^{oilgr} \\ \mu_t^{intr} \\ \mu_t^{msgr} \\ \mu_t^{infr} \\ \mu_t^{exr} \\ \mu_t^{mgr} \\ \mu_t^{gdpgr} \end{bmatrix}$$

There are eight variables in the SVAR model. Oil price (*poil*) is an exogenous variable. Endogenous variables include oil resources growth rate (*oilgr*), interest rates (*intr*), money supply growth rate (*msgr*), inflation rate (*infr*), exchange rate (*exr*), manufacturing output growth (*mgr*) and GDP growth rate (*gdpgr*).

Oil price is viewed as an external shock to the entire system, meaning that it affects all other variables in the system of equations without any feedback being allowed for. The oil output growth rate is included because of the controversy regarding the relationship between global oil price shocks and the oil output levels in oil exporting countries. In a study of Oman and United Arab Emirates, Berument (2009) found that oil price shocks affect the economic policies of these countries through their output levels. They argued that since these countries are heavily dependent on oil, the influence of oil prices on the output levels of oil is translated to economic wealth, which dictates the behavior of economic policies.

However, Jiménez-Rodríguez and Sanchez (2005) counter argued that most of the oil exporting countries run very open and liberal economies, which make their economic policies highly susceptible to external shocks. They argued that since these countries are heavily dependent on oil, fluctuations in global oil prices affect economic policies without necessarily passing through their output levels.

**2.3. Data.** The study employs quarterly frequency data from 1980Q1 to 2010Q4. The estimation model has eight variables and the data are collected from the World Bank database, except oil prices and growth rate

of oil output, which are sourced from the database of the Organization of Petroleum Exporting Countries (OPEC). It should be noted that the growth rate of the variables such as money supply, GDP, manufacturing output and oil output are used, as this presents a clearer and more realistic perspective in examining the variables (see Olomola, 2007).

### 3. Results and discussions

**3.1. Non stationarity.** This study follows Uhlig (2005), Peersman and Smets (2005), Vonnak (2005), Clements and Hendry (1995), Fève and Guay (2006) and Ibrahim and Amin (2005), among others, that have estimated VARs in levels. Estimation in levels prevents loss of some vital information in the data, which might occur in the course of differencing. It has also been argued that the inclusion of lags in the variables in VARs enable the residual to be stationary even with a non-stationary series (see Berkelmans, 2005). Many recent studies have also followed the same procedure (see for example, Ngalawa and Viegi, 2011; Elbourne, 2007; Mordi and Adebisi, 2010; Mahmud, 2009).

**3.2. Impulse response analysis.** The impulse response functions are discussed under three different headings, namely: responses of selected variables to shocks from oil prices; the impact of oil output growth rate shocks on selected variables; and the monetary policy transmission process.

Figure 1 shows responses of all variables in the model to a one standard deviation shock to oil prices. The figure shows that the shock leads to a fall in oil output growth rate, which becomes significant after seven

periods. This might be due to increases in demand for oil on the international market, which may have led to the initial oil price increase. The implication is that the rate of growth in production is too slow to catch up with the increase in demand for oil. This may also be the case if there are disturbances such as political con-

flicts in major oil producing regions. In addition, the oil price shock causes interest rates to fall initially, at least for the first four periods before they start rising. This response, however, is not significant. Money supply, on the other hand, declines significantly from about the third period, bottoming out after nine periods.

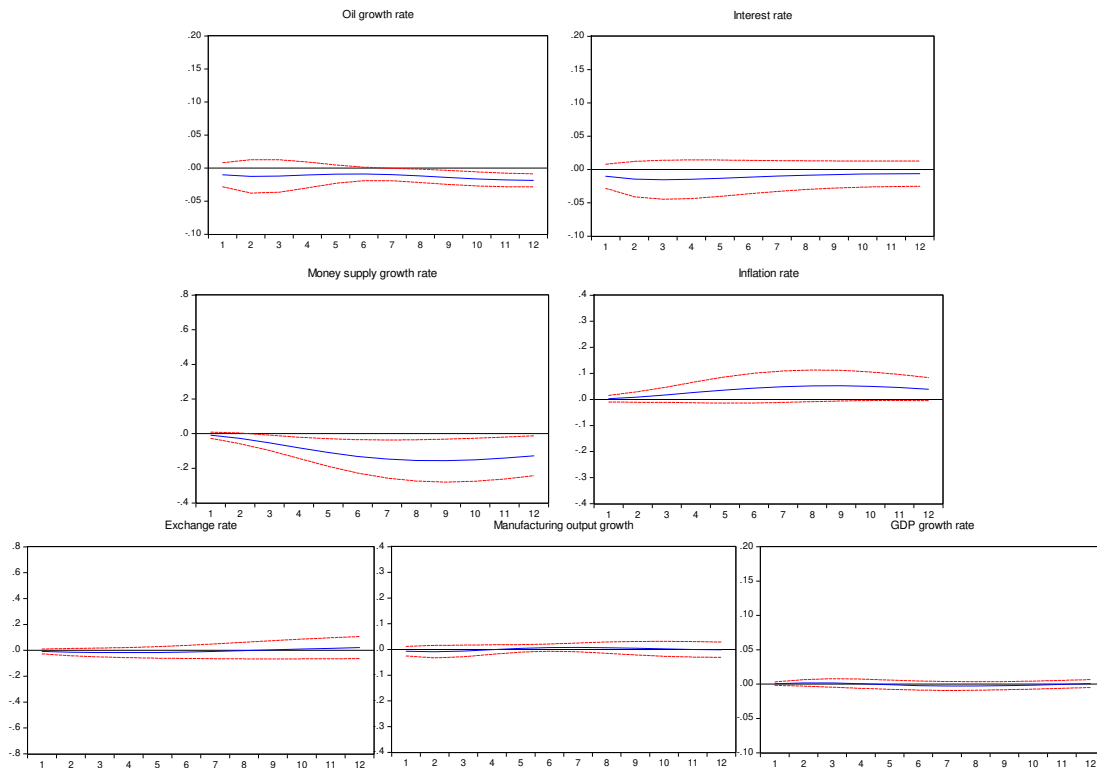
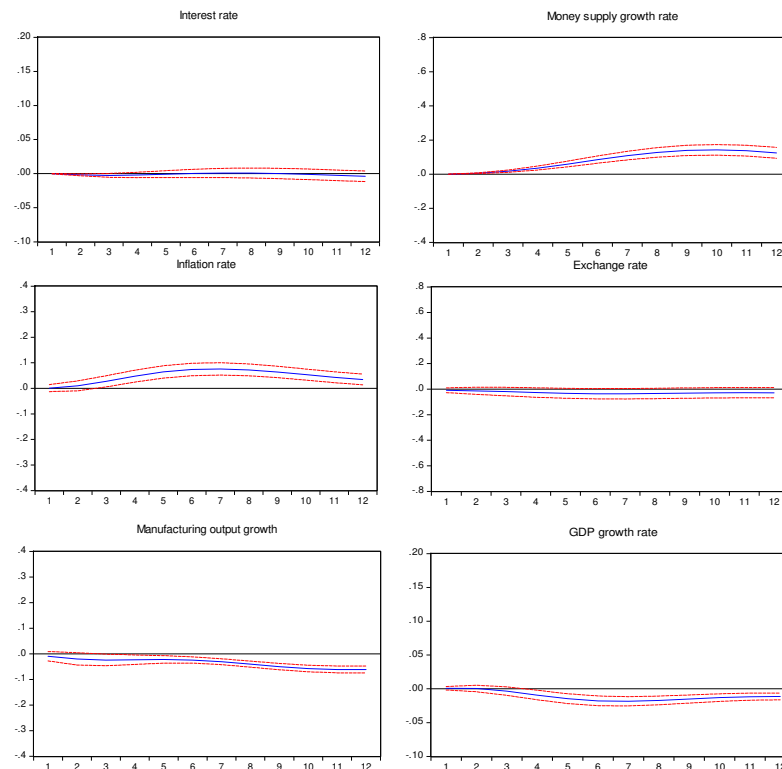


Figure 1. Responses of selected variables to oil price shocks in Algeria

Notably, money supply is decreasing when interest rates are rising, which is consistent with a priori theoretical expectations of an inverse relationship between the two variables. It is also observed that the rate of inflation rises following a positive oil price shock. This rise indicates that the impact of the positive oil price shock dominates the effect of the decreasing money supply on inflation. Bouchaour and Al-Zeaud (2012) also obtained similar results and concluded that the inflation that occurs as a result of oil prices can be categorized as imported inflation and not as a result of increasing money supply in Algeria. The exchange rate shows a very sluggish positive response to the oil price shock, while manufacturing sector growth also exhibits

the same response and in the same direction. Both responses, however, are insignificant.

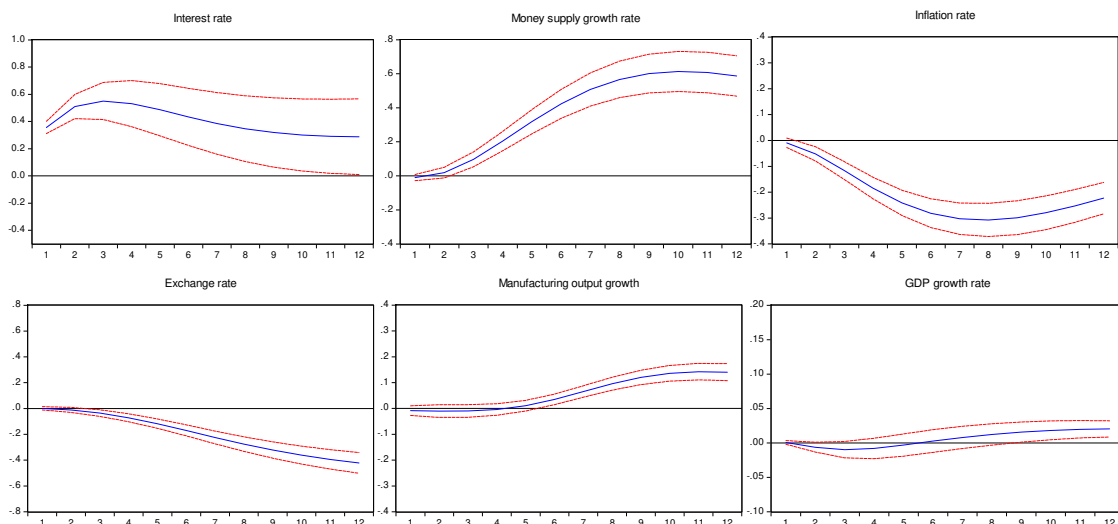
The slow response of the exchange rate might be due to the controlled “flexible” exchange rate policy practiced in Algeria, where the monetary authorities intervene constantly on the exchange rate market to prevent excessive undervaluation of the currency (see Bouchaour and Al-Zeaud, 2012; De Bock and Gijon, 2011). The incessant interference normally limits the response of exchange rates to external shocks. However, it appears that this has not been having a positive influence on the manufacturing sector of the economy going by the observed sluggish downward trend. The figure 1 also shows a sluggish insignificant response of GDP growth rate to a positive oil price shock.



**Figure 2. Responses of selected variables to an oil output growth rate shock in Algeria**

Figure 2 shows the responses of selected variables to an oil output growth rate shock. The effect of an oil growth rate shock on interest rates follows the same pattern as the oil price shock. Interest rates respond by adjusting downwards, albeit insignificantly, as money supply rises. The rate of inflation also responds with an increase that is in tandem with increasing money supply following an oil output growth shock. The local currency, on the other hand, appears to appreciate, while manufacturing output growth falls in response to the shock. GDP growth rate follows the same pattern too. It decreases in response to the shock. This reveals that a currency appreciation may be a disincentive for manufacturers to increase output. Considering the fact that in-

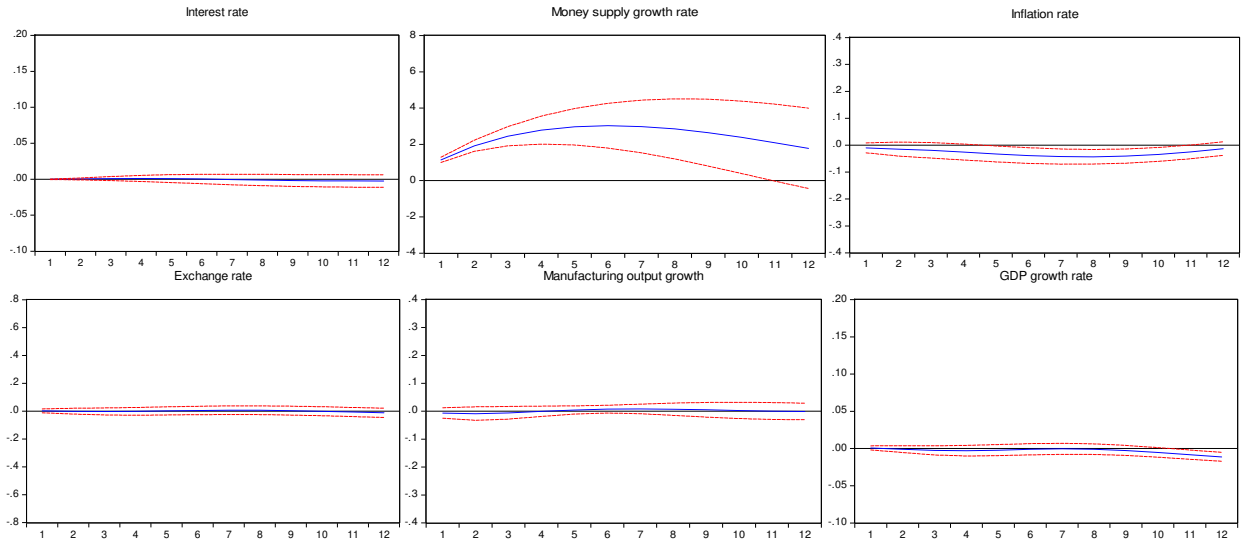
flation rises while manufacturing output falls in their separate responses to both oil price and oil output shocks, it is probable that an oil price shock puts pressure on prices of tradable goods, which in turn causes the rate of inflation to rise. According to Ireland (2007), the rise in inflation might have adverse effects on output, hence the significant fall in manufacturing output growth that is observed. The exchange rate channel of the monetary transmission process shows that the effect of oil prices and oil output shocks causes the exchange rate to appreciate. According to Olomola (2007), such a phenomenon is capable of squeezing out the tradable goods sector.



**Figure 3. Responses of selected variables to an interest rate shock in Algeria**

Figure 3 shows that money supply increases sharply in response to an interest rate shock. The rate of inflation, however, falls following the shock, again confirming that inflation in Algeria might not be a result of money supply changes. The shock further causes the exchange rate to fall and manufacturing output to decline, initially bottoming out in the fourth period and increasing thereafter. The currency appreciation might be the cause of the initial fall in the manufacturing output. Beginning about the fifth

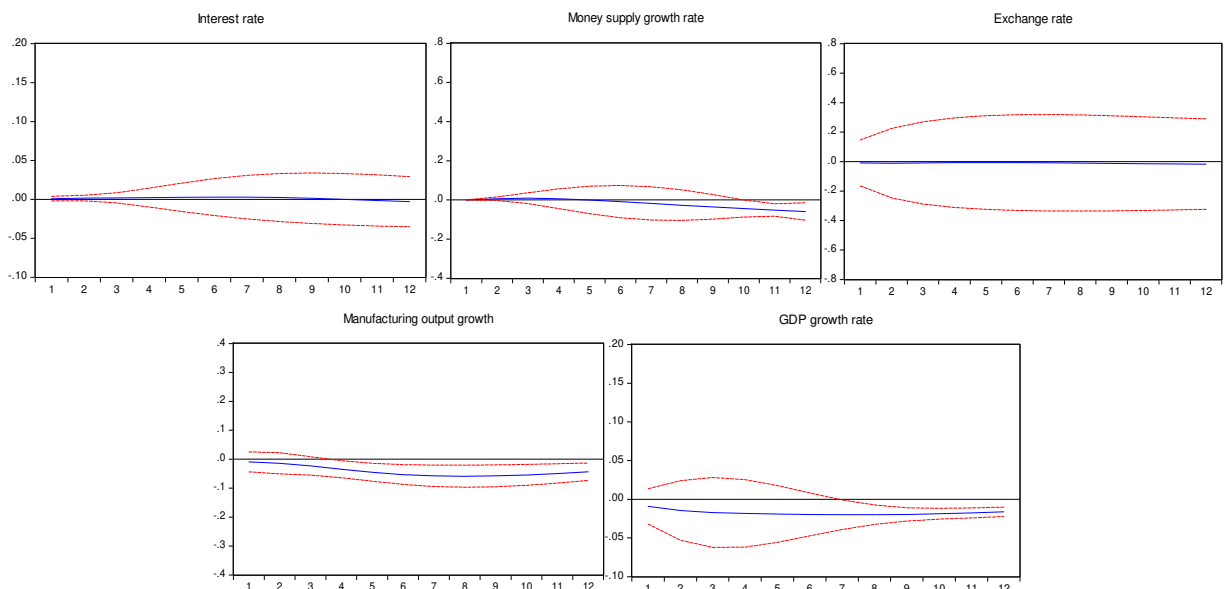
month, manufacturing output growth starts rising significantly, probably as a result of the sharp decline in the rate of inflation. As expected, GDP growth rate also follows the same growth pattern. These results suggest that interest rates are likely to have a significant impact on output growth of the manufacturing sector in Algeria. According to Dgrul and Ugur (2010), if interest rate policy is used to curtail a rise in the rate of inflation, real output in an oil exporting country will increase significantly.



**Figure 4. Responses of selected variables to a money supply shock in Algeria**

In Figure 4, the rate of inflation decreases slowly but significantly following a money supply shock. The exchange rate and manufacturing output growth, on the other hand, respond insignificantly to the shock. Sur-

prisingly, GDP growth remains more or less constant until the eleventh period when it starts declining significantly.



**Figure 5: Responses of selected variables to an inflation rate shock in Algeria**

In Figure 5, an inflation rate shock does not have any significant effect on interest rates and exchange rates. This might be due to the incessant interference

in Algeria's foreign exchange rate market by the monetary authorities. Often, the central bank of Algeria in its pursuit to stabilize the rate of inflation

and exchange rates, uses external reserves of the country to augment any imbalances (Bouchaour and Al-Zeaud 2012). This regular interference has been preventing monetary policy instruments from demonstrating appropriate and natural responses to shocks from inflation rates and the exchange rates (see Francois and Mignon, 2008).

The figure also shows that the growth rate of money supply decreases following a positive inflation shock, probably as a response by the monetary authorities to reduce inflationary pressure arising from the shock. This response becomes significant only in the tenth period. Manufacturing output growth and GDP growth also decline significantly commencing in the fourth and seventh periods, in that order, in response to the positive inflation shock. Thus, it can be argued that inflation in Algeria is an impediment to the growth of GDP generally and manufacturing output specifically. The fall in manufacturing output and GDP growth may be a response to the observed contractionary monetary policy (decline in money supply) that occurs in response to a positive inflation shock characterized by an unanticipated increase in the rate of inflation.

**3.3. Variance decomposition.** In this section, we carry out a variance decomposition analysis aimed at getting insights into the operations of Algeria's monetary policy transmission process. We pay particular attention to manufacturing output growth as a policy goal in the investigation of the mechanism.

Table 1 shows that oil output growth, oil prices, money supply growth and inflation rates, each account for less than one percent of the variations in interest rates in any period up to a year. GDP growth (among the variables in the model), accounts for the largest proportion of the variations in interest rates, which increase from 0.32 percent after three periods to 1.06 percent after six periods, 3.41 percent after nine periods and 5.99 percent after twelve periods. The contribution of manufacturing output growth to interest rate variations is relatively small at less than one percent in each period up to nine periods and rising to 1.28 percent after twelve periods. Similarly, the contribution of manufacturing output growth to interest rate variations is small at less than one percent in each period up to nine periods and rising to 1.06 percent after twelve periods. These results reveal that domestic interest rates in Algeria do not respond by large margins to any of the variables in the model. They also show that manufacturing output growth is a less important policy goal than GDP growth generally. In addition, it is observed that monetary authorities do not adjust interest rates as a tool for the stabilization of inflation rates, i.e. there is no evidence of direct transmission from interest rates to inflation rates. Table 1 shows that inflation rates account for less than 0.1 percent of the interest rate variations in each period up to at least 12 periods.

Table 1. Variance decomposition of interest rates

Period	Standard error	Oil prices	Oil output growth	Interest rates	Money supply growth	Inflation rates	Exchange rates	Manufacturing growth	GDP growth
3	0.241012	0.936829	0.017356	98.69360	0.001520	0.012655	0.019942	0.001708	0.316393
6	0.355559	0.835934	0.011856	97.58076	0.002400	0.021771	0.277225	0.210049	1.060003
9	0.416112	0.739469	0.009643	94.30725	0.004277	0.024733	0.718717	0.788827	3.407084
12	0.461031	0.661947	0.018976	90.95664	0.011230	0.025352	1.055934	1.280472	5.989451

Table 2 shows that besides its own changes, money supply variations are largely explained by changes in interest rates. The table reveals that interest rate changes account for 9.62 percent, 46.86 percent, 63.45 percent and 70.33 percent of the fluctuations in money supply after three, six, nine and twelve periods, in that order. This suggests that to a great extent, monetary authorities respond to interest rate fluctuations by adjusting the growth of money supply. Oil prices are also observed to play an important role in explaining variations in money supply. Table 2 shows that oil price changes account for 3.57 percent, 5.56 percent, 5.44 percent and 5.00 percent of the fluctuations in money supply after

three, six, nine and twelve periods, respectively. This indicates that monetary authorities respond to oil price changes by adjusting money supply, probably to curb consequent inflationary pressures. Oil production and manufacturing growth account for a small albeit noticeable proportion of the changes in money supply. It is observed that 0.32 percent, 1.75 percent, 2.98 percent and 3.41 percent of the fluctuations in money supply are attributed to changes in the growth of oil production, while manufacturing growth accounts for 0.74 percent, 1.58 percent, 1.36 percent and 1.04 percent of the variations in money supply after three, six, nine and twelve periods, in that order.

Table 2: Variance decomposition of money supply

Period	Standard error	Oil prices	Oil output growth	Interest rates	Money supply growth	Inflation rates	Exchange rates	Manufacturing growth	GDP growth
3	0.319537	3.575931	0.317982	9.624737	85.17430	0.111178	0.247669	0.744989	0.203216
6	0.841934	5.564502	1.746828	46.86021	43.49735	0.032267	0.666155	1.581269	0.051423
9	1.416207	5.442392	2.980515	63.45253	26.12216	0.126233	0.478793	1.364032	0.033344
12	1.832696	5.000503	3.410883	70.33137	18.94270	0.316203	0.306221	1.039257	0.652857

Consistent with the impulse response analyses, it is observed that most of the fluctuations in the rate of inflation, besides own changes, are due to variations in interest rates followed by GDP growth, growth of oil production and oil prices, in that order (see Table 3). The table shows that interest rates account for 20.59 percent, 41.98 percent, 47.84 percent and 50.57 percent of the fluctuations in inflation rates after three, six, nine and twelve periods, respectively. GDP growth accounts for 6.71 percent, 24.67 percent, 29.14 percent and 29.14 percent of the variations in the rates of inflation after three, six, nine and twelve months, in that order. It is further observed in the table that money supply growth, exchange rates and growth of manufacturing sector output individually contribute less than one percent to the inflation rates fluctuations in each of the third, sixth, ninth and twelfth periods, in that order. These

results show that while monetary authorities in Algeria do not use interest rates as the main operating tool of monetary policy to curb inflationary pressures as observed in Table 1, interest rate adjustments are very effective in driving inflation rates in a particular direction. Accordingly, there is need for the monetary authorities in Algeria to change their focus and prioritize interest rates as a primary operating tool of monetary policy in the fight against inflation. The results also suggest that inflation in Algeria is not necessarily driven by changes in money supply. The relatively small contribution of money supply growth to inflation variations confirms this. On the other hand, the higher contribution of GDP growth to inflation variations shows that inflation in Algeria may also be caused by structural rigidities in the economy.

Table 3. Variance decomposition of inflation rate

Period	Standard error	Oil prices	Oil output growth	Interest rates	Money supply growth	Inflation rates	Exchange rates	Manufacturing growth	GDP growth
3	0.281932	0.516769	1.069329	20.58701	0.865833	69.24148	0.757319	0.248144	6.714122
6	0.669029	0.970810	2.838451	41.98115	0.871760	27.53939	0.416223	0.710831	24.67139
9	0.984337	1.261831	2.868420	47.83664	0.950501	17.16261	0.365950	0.418090	29.13596
12	1.138859	1.420550	2.601777	50.56804	0.863324	14.48438	0.438649	0.479145	29.14413

Table 4 shows that besides own changes, variations in exchange rates are largely explained by changes in interest rates. In the third, sixth, ninth and twelfth periods, interest rate changes account for 1.89 percent, 17.58 percent, 39.53 percent and 53.58 percent of the changes in the exchange rate, respectively. Oil prices, inflation rates, growth of money supply and manufacturing growth account for less than one percent of the exchange rate fluctuations in any period up to 12 quarters. GDP growth, on the other hand, makes a relatively larger contribution to exchange rate fluctuations albeit still lower than the contribution of interest rates. It is observed that GDP growth accounts for 3.44 percent, 8.57

percent, 10.57 percent and 11.69 percent of the variations in exchange rates after three, six, nine and

twelve periods. To the extent that interest rates are the main variable explaining exchange rates, these results suggest that capital movements in Algeria play an important role in determining the value of the local currency on the foreign exchange rate market. It may also be that monetary authorities keep an eye on the exchange rate and they attempt to control it by making adjustments to the bank rate. Oil prices and manufacturing output growth, however, are passive players in the determination of exchange rate movements in the country (see Table 4).

Table 4: Variance decomposition of exchange rates

Period	Standard error	Oil prices	Oil output growth	Interest rates	Money supply growth	Inflation rates	Exchange rates	Manufacturing growth	GDP growth
3	0.271925	0.742382	0.844015	1.889646	0.011991	0.397429	92.43763	0.239517	3.437389
6	0.528697	0.460013	1.340992	17.58272	0.012474	0.156851	71.62539	0.253684	8.567877
9	0.839913	0.193791	1.020606	39.53477	0.017257	0.106281	48.18137	0.195773	10.75015
12	1.176813	0.158075	0.694539	53.57782	0.022548	0.107686	33.63627	0.114981	11.68808

The variance decomposition of manufacturing output growth is presented in Table 5. The table shows that besides own fluctuations, GDP growth accounts for the largest proportion of the variations in manufacturing sector growth. It is estimated that 6.72 percent, 26.24 percent, 34.84 percent and 35.80 percent of the variations in manufacturing output growth are attributed to changes in GDP growth. This may be due to strong forward and backward linkages between the manufacturing sector and other sectors of the economy. Interest rates and inflation

rates are also important in explaining changes in manufacturing output growth. The table shows that interest rates and exchange rates, respectively, account for 1.73 percent and 7.24 percent of the variations in manufacturing output growth after six periods, 16.11 percent and 9.27 percent after nine periods, and 28.02 percent and 7.73 percent after twelve periods, in that order. Oil prices and money supply growth, however, individually account for less than one percent of the variations in manufacturing output growth in any period up to 12 quarters.

Table 5: Variance decomposition of manufacturing output growth

Period	Standard Error	Oil prices	Oil output growth	Interest rates	Money supply growth	Inflation rates	Exchange rates	Manufacturing growth	GDP growth
3	0.218643	0.309415	2.190588	0.574823	0.273215	1.731715	0.239293	87.96335	6.717605
6	0.308444	0.234693	2.739144	1.727245	0.687814	7.235354	0.397010	60.73537	26.24337
9	0.428009	0.200103	4.183053	16.10652	2.426450	9.273727	0.736962	32.22488	34.84830
12	0.559992	0.119686	5.857290	28.02267	2.741843	7.731906	0.590879	19.13293	35.80279

### Summary and Conclusions

This study set out to investigate the relationship between monetary policy and growth of the manufacturing sector in Algeria taking into account the high level of oil production in the country. Employing a structural vector autoregressive model covering the period 1980Q1 to 2010Q4, the study finds no evidence that interest rates in the country adjust in response to oil output growth, oil prices, money supply growth or inflation rates. While GDP growth followed by manufacturing output growth account for the largest proportion of the variations in interest rates, their contribution to interest rate changes is very small. It is apparent, therefore, that interest rates are not an important operating tool of monetary policy in Algeria.

It is also observed that most of the fluctuations in the rate of inflation are due to interest rates fluctuations followed by GDP growth, growth of oil production and oil prices, respectively. It follows, therefore, that while monetary authorities in Algeria may not be using interest rates as the main operating tool of monetary policy to curb inflationary pressures, interest rate adjustments are very effective in driving inflation rates in a particular direction. This may present a lost opportunity to the Algerian authorities.

There is need, therefore, for the monetary authorities in Algeria to change their focus and prioritize interest rates as a primary operating tool of monetary policy in the fight against inflation. The study also finds evidence that inflation in Algeria is not necessarily driven by changes in money supply. The relatively small contribution of money supply growth to inflation variations confirms this. In addition, GDP growth is seen to affect inflation rates significantly, indicating that structural rigidities in the Algerian

economy play an important role in determining the country's inflation rates.

Furthermore, the study shows that money supply variations are largely explained by changes in interest rates. The results further suggest that to a great extent, monetary authorities respond to interest rate fluctuations by adjusting the growth of money supply. In addition, it is shown that oil prices play an important role in explaining money supply adjustments. This implies that monetary authorities respond to oil price changes by adjusting money supply, probably to control the resultant inflationary pressures.

Manufacturing output growth is observed to be largely driven by the overall GDP growth. This may be explained by strong forward and backward linkages between the manufacturing sector and other sectors of the economy. Interest rates also explain nearly a third of the variations in manufacturing output growth, suggesting that players in the manufacturing sector are sensitive to interest rates. A worrying element, however, is the earlier finding that monetary authorities do not influence the direction of interest rates to reinvigorate the manufacturing sector. Oil prices and exchange rates are observed to play a very minimal role in the determination of the direction of manufacturing output growth. Both variables account for less than one percent of the variations in manufacturing output growth in any period up to at least 12 quarters. The role of growth in oil production, the rate of inflation and money supply growth, albeit somewhat higher than that of exchange rates and oil prices, is still relatively low. Put together, they account for less than five percent of the variations in manufacturing output growth after three periods and an estimated fifteen percent after twelve periods.

A peek at the monetary transmission process shows that Algeria employs monetary aggregates as the

primary operating tool of monetary policy. The monetary authorities adjust monetary aggregates in response to any movements in the rate of interest, probably to keep the rate of interest within a certain target given other developments in the fundamentals. The interest rates, in turn, play an important role in determining variations in manufacturing sector growth. In addition, the interest rates significantly affect exchange rates, which have been observed to respond to changes in overall GDP growth. It is the overall GDP growth that is seen to exhibit the largest influence on manufacturing sector growth.

The study also finds that interest rates play an important role in explaining exchange rates in Algeria. This suggests that capital movements in Algeria are important in determining the value of the local currency on the foreign exchange market. It may also be that the Algerian central bank monitors the exchange rate and attempts to control it by making adjustments to the bank rate. We, however, find no evidence that oil prices and manufacturing output growth play an active role in the determination of exchange rate movements in the country.

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