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MODELLING SECTORAL SENSITIVITY TO MACROECONOMIC SHOCKS: EVIDENCE FROM NIGERIA

Joshua Adeyemi Afolabi[1], Blessing Ufuoma Olanrewaju[1*] and Wasiu Adekunle[2]

[1]*Nigeria Institute of Social and Economic Research, Ibadan, Nigeria*
[2]*Nigeria Economic Summit Group, Lagos, Nigeria*

The Nigerian economy has been repeatedly hit by macroeconomic shocks, primarily owing to its over-reliance on crude oil and poor resource management. Given the limited resilience capacity of Nigeria's economic sectors, this study examined the sensitivity of these sectors to macroeconomic shocks using the Vector Autoregression (VAR) and the Vector Error Correction (VEC) models in whose frameworks the study was carried out for the period between 2010Q1 and 2021Q4. The findings revealed the high responsiveness of the services and agricultural sectors to fiscal shocks, as well as the high sensitivity of the industrial sector to interest rate shocks. Also, the services sector was found to be more resilient to oil price shocks than the other sectors. Therefore, this study advocates for developing strategies to boost sectoral productivity and skillfully blend the fiscal and monetary policies so as to cushion the effects of macroeconomic shocks. Overall, this study provides the evidence of the sectoral effects of macroeconomic shocks in Nigeria.

Keywords: macroeconomic shocks, vector autoregression, vector error correction, industrial sector, agricultural sector, service sector

JEL Classification: C22, E23, E52, E62

INTRODUCTION

Macroeconomic shocks are inevitable given the rising pace of globalization and economic interrelations among countries. These shocks may engender erratic fluctuations in aggregate supply or demand and thus calls for immediate policy responses (Gajic, 2012). The effects of shocks on macroeconomic stability largely depend on the nature of the shock (positive or negative), the degree of vulnerability to external shocks and the efficiency level of the economy (Bodunrin, 2016). The Nigerian economy has witnessed various macroeconomic shocks over the years. Oil price shocks, however, remain the most dominant given the over-reliance of the economy on oil revenue and the exogenously determined oil price, which is subject to the dynamics of the market forces in the global oil market (Ogunjimi, 2020a; 2020b). The effect of these shocks is evident in the macroeconomic

* *Correspondence to:* B. U. Olanrewaju, Nigeria Institute of Social and Economic Research, Ibadan, Nigeria; e-mail: blessed.ufuoma@gmail.com

instability characterized by a rising inflation, exchange rate fluctuations, a rising unemployment rate, income inequality, dwindling government revenue and persistent poverty. Consequently, in a bid to ameliorate the adverse effects of oil price shocks on the economy, the Nigerian government has embarked on various policy responses, but the problems still linger.

According to the Central Bank of Nigeria (2021), Nigeria has had to grapple with the two episodes of economic recession in five years (namely those in 2016 and 2020). While the 2016 economic recession was partly a result of the oil price slump in the international market, the 2020 episode was due to both the Russia-Saudi Arabia oil price war and the COVID-19 pandemic (Adeoti & Gbadebo-Smith, 2020). The twin shock to the Nigerian economy was so severe that the price of crude oil, Nigeria's main source of foreign exchange, nosedived to US$30/barrel as against the benchmark of US$57/barrel proposed in the 2020 Nigerian budget. This led to a downward revision of the crude oil benchmark to US$28/barrel in order to make the budget implementation more effective, even though it limited the government's capacity to perform its fiscal responsibilities (Ozili, 2020). It seems as though Nigeria's economic fortune and fiscal policy are determined by the dynamics of the oil price in the international market as changes in oil prices lead to the execution of either a contractionary or expansionary fiscal policy (Aminu & Ogunjimi, 2019; Afolabi & Ogunjimi, 2020).

Moreover, the twin shocks of 2020 had a multifaceted impact on the Nigerian economy, affecting almost every sector of the Nigerian economy. Specifically, the agricultural, industrial, manufacturing, education, transportation, arts, entertainment and recreation sectors were badly hit, with only a few services sectors, such as the information technology sector, thriving (Afolabi & Oji, 2021; Olanrewaju & Afolabi, 2022). These adverse effects may be linked to the economy's weak resilience to shocks, weak institutions and a poor productive base coupled with poor resource management. The persistence of these problems could further weaken Nigeria's capability of effectively absorbing future shocks and addressing macroeconomic instability. However, with the right policy framework and the right implementation strategy, Nigeria can build a bulwark against future macroeconomic and health shocks.

Based on the foregoing, it is imperative to examine the sensitivity of the various sectors of the Nigerian economy to macroeconomic shocks relating to oil price fluctuations and policy shifts, with a view to suggesting measures to become resilient against future shocks. Previous studies focused on the effects of shocks on one or two sectors only (Oyelami & Olomola, 2016; Obi, Awujola & Ogwuche, 2016; Onyimadu, 2019), simultaneously ignoring the inter-linkages among the sectors. Evidence abounds that oil price shocks have far-reaching effects on more than one economic sector (Aminu & Ogunjimi, 2019). To this end, the primary objective of the study implies the investigation of the degree of the sensitivity of all the sectors of the Nigerian economy to various macroeconomic shocks so as to arm policymakers with the requisite tools required to boost the resilience of Nigeria's economic sectors against subsequent shocks.

Taking into consideration the objective of this study, the impulse response function and variance decomposition mechanisms of the Vector Autoregression (VAR) and Vector Error Correction (VEC) models are used to test the following hypotheses:

H1: The Nigerian agricultural, industrial and service sectors are unresponsive to fiscal shocks.

H2: The Nigerian agricultural, industrial and service sectors are insensitive to monetary shocks.

H3: The Nigerian agricultural, industrial and service sectors are unresponsive to external shocks.

The remaining part of this paper is sectioned as follows: Section 2 reviews the empirical literature, while Section 3 describes the sectoral and export structures of the Nigerian economy; Section 4 discusses the methodology adopted in this study and Section 5 contains the results and discussion;

Section 6 presents the conclusion and the policy recommendations based on the findings of the study.

LITERATURE REVIEW

A number of the empirical pieces of evidence of the effect of macroeconomic shocks are documented in the literature. However, there is a lack of consensus on the magnitude, direction and effect of macroeconomic shocks on the economy as the empirical evidence is mixed. G. Bäurle and E. Steiner (2015) assessed the resilience of the Swiss productive sectors to monetary and external shocks using the structural dynamic factor model. Their result showed that monetary and external shocks had partial transmission to the productive sectors and their effects varied across those sectors. On the other hand, R. M. Campos-Vazquez (2010) examined the labor market effects of macroeconomic shocks in Mexico. The result showed that the macroeconomic shocks aggravated youth unemployment, rendered unskilled labor jobless, lowered the labor force participation and reduced employment in the informal sector. The findings also revealed the fact that the formal sector was more adversely affected by the macroeconomic shocks than the informal sector.

C. L. Nguena and R. T. Nanfosso (2014) investigated the degree to which the financial sectors of the countries in the Central African Economic and Monetary Community (CEMAC) region were resilient to macroeconomic shocks. The results showed that the banking sectors in the region were less resilient to the macroeconomic shocks as bank provisions plummeted in the face of the declining GDP *per capita*, the real exchange rate and financial credits, as well as a rising interest rate. Overall, the result suggests the need to account for macroeconomic shocks in the formulation and implementation of financial policies. On the other hand, C. Higson, S. Holly, P. Kattuman and S. Platis (2004) evaluated the growth effects of shocks among firms in the United Kingdom. The results revealed the fact that firms in the mid-range of growth were more affected by the shocks than other firms. K. Bruckmeier, A. Peichl, M. Popp, J. Wiemers and T. Wollmershäuser (2020) used multiple economic models to evaluate the impact of the macroeconomic shocks occasioned by the COVID-19 pandemic and the policy responses on the German economy. The findings revealed the fact that the pandemic had lowered gross labor income but made disposable household income progressive as discretionary policies had proven helpful in stabilizing income during the period.

K. Andam, H. Edeha, V. Oboh, K. Pauw and J. Thurlow (2020) adopted the Social Accounting Matrix (SAM) model to quantify the impact of the shocks arising from the COVID-19 pandemic on the Nigerian economy. It was found that Nigeria's economy slowed down, with the services sector being mostly hit by the pandemic. Nonetheless, the output of the agricultural sector also declined despite its exclusion from the list of the sectors under the compulsory lockdown. The sector was indirectly affected due to its connection with the other economic sectors. In the same vein, P. K. Ozili (2020) assessed the effect of the COVID-19 pandemic on the Nigerian economy. The results showed that the interplay between the oil price crash and the COVID-19 outbreak had led to economic recession in Nigeria, with the COVID-19 pandemic halting economic activities globally and lowering demand for crude oil in the international market. Further results revealed the fact that the pandemic had adversely affected the labor market outcomes and sectoral performance.

With the help of the Vector Autoregression (VAR) model, B. T. Ewing, S. M. Forbes and J. E. Payne (2003) analyzed the impact of monetary, real output and market risk premium shocks on specific stock market variables. The findings accounted for the fact that the effect of a shock on the stock market variables depended on the nature (anticipated or unanticipated) of the shock itself. Specifically, a positive anticipated shock to the market risk premium and the real output has positive impacts on each stock market index, with the monetary shock exerting more influence on capital and financial goods than the other shocks. In a similar fashion, I. Babouček and M. Jančar (2005) adopted the VAR model to analyze the effects of macroeconomic shocks from various channels on the Czech economy.

According to their findings, the performance of the Czech banking sector was impressive and had a profound capacity to withstand credit risk shocks as it was less responsive to such shocks.

In a recent study, M. Murach and H. Wagner (2021) also used the VAR model to evaluate the extent to which external shocks affected the business cycle in the Chinese agricultural, industrial and services sectors between 1996 and 2014. The findings revealed the fact that, as the most dominant economic sector in China, the Chinese industrial sector sharply responded to the shocks arising from the financial, trade and confidence channels. The high vulnerability of the industrial sector to external shocks is attributed to the predominant export- and investment-driven outlook of the country. However, S. S. Abere and T. O. Akinbobola (2020) used a variant of the VAR model, namely the Structural Vector Autoregressive (SVAR) model, to assess the effects of external shocks and institutional quality on Nigeria's macroeconomic performance. The findings of that study revealed the fact that external shocks affected Nigeria's macroeconomic performance more than institutional quality, with an increased foreign aid and the terms of trade having a more positive impact on macroeconomic performance.

Adopting another variant of the VAR model, i.e. the Bayesian Vector Auto Regression (BVAR) model, N. Mupunga and P. Le Roux (2015) examined the way how macroeconomic shocks determined the volume of the public debt in Zimbabwe. It was found that the public debt was highly sensitive to shocks to the exchange rate, the trade balance, the interest rate and economic growth. However, with the help of the Computable General Equilibrium (CGE) framework, E. B. Sennoga and J. M. Matovu (2016) evaluated the growth and welfare effects of shocks to the terms of trade, foreign aid and the global oil price in Uganda between 2010 and 2017. The findings revealed that the three channels of shock had positive effects on the agricultural and services sectors but they had a negative effect on the industrial sector; the positive effect was large enough to offset the negative effect so that the real GDP growth had slightly deviated. On the other hand, the three shocks lowered the household welfare and worsened the poverty incidence in the country.

The foregoing suggests a lack of unanimous agreement on the nature of the effect of macroeconomic shocks on various sectors of an economy, which could be attributed to the methodology employed, the study scope, the economic structure and the timeframe of each study. Moreover, there is a dearth of studies on the subject for the Nigerian case and those few available studies on Nigeria did not consider the effects of macroeconomic (fiscal and monetary) policies on sectoral performance in Nigeria. This study fills this gap in the literature by evaluating the sensitivity of each economic sector (i.e. the agricultural, industrial and services sectors) in Nigeria to fiscal, monetary and external shocks using the Vector Autoregression (VAR) and Vector Error Correction (VEC) model frameworks, with a particular emphasis on their inherent impulse response function and variance decomposition mechanisms.

NIGERIA'S SECTORAL STRUCTURE

Typically, the Nigerian economy has three key sectors: agriculture, industry and services, each of them having different respective subsectors (CBN, 2021). The performance of these sectors in terms of their contribution to the GDP is shown in Figure 1. It shows that the service sector makes the highest contribution to the GDP throughout the period of observation. Specifically, the contribution the services sector makes to the total GDP averaged 52.3 percent between 2010Q1 and 2021Q4, while the average shares of the industrial and agricultural sectors stood at 23.5 percent and 24.2 percent, respectively, over the same period (Figure 1). However, it is noteworthy that the services sector played a significant role in mitigating the impact of COVID-19 on the aggregate output as its contribution rose during 2020Q1 and 2020Q2 when the lockdown orders were imposed by the government, with the trade, information and communication technology, and financial and insurance subsectors leading the impressive contribution. Despite the lockdown orders and the other containment measures introduced so

as to flatten the COVID-19 curve, the feat of these subsectors was possible because the activities in these subsectors do not necessarily require physical human interactions. The sector also played a significant role in lifting the Nigerian economy from the 2016 recession given its huge share in the total GDP.

Similarly, the contribution of the agricultural sector to the total GDP experienced a significant growth in the third quarters of 2016 to 2021, with a substantial contribution from the crop production subsector. However, these contributions were insufficient to save the economy from slipping into the episodes of recession witnessed in Nigeria in 2016 and 2020 - the two recessions that occurred in five years. On the other hand, the industrial sector was badly hit by the 2016 recession and the 2020 pandemic as its contribution to the GDP plummeted for the most part of the period after 2016, which is because the sector largely depends on the agricultural and transportation sectors for raw materials and the distribution of finished goods, which were halted during the lockdown. The falling contribution of the industrial sector vis-à-vis the positive contribution of the agricultural sector to the GDP since the 2016 recession shows that the Nigerian agricultural sector produces more food crops than cash crops, which could serve as raw materials (the input factors) for industries. Hence, a large proportion of the raw materials used in the industrial sector are sourced from abroad.

The dismal performance of the industrial sector is evidenced by the low non-oil export during the periods under consideration (Figure 2). Figure 2 shows Nigeria's export profile, revealing the dominance of oil export in Nigeria's export basket, as well as the high reliance of the country to oil export as its major source of foreign exchange. The successive government in Nigeria has made numerous efforts with respect to the balancing of this skewed trend through the formulation and adoption of various diversification policies. However, this export trend reveals the fact that the diversification efforts of the government are yet to yield the desired outcomes, which on its part suggests the possibility of having some lacunas in the existing diversification policies that need to be urgently addressed in order to ensure a successful transition to economic and export diversification.

METHODOLOGY

The Vector Autoregression (VAR) and Vector Error Correction (VEC) model frameworks are used as the analytical technique for this study given their ability to treat all variables in the system of equations as endogenous. They are used to assess the sensitivity of

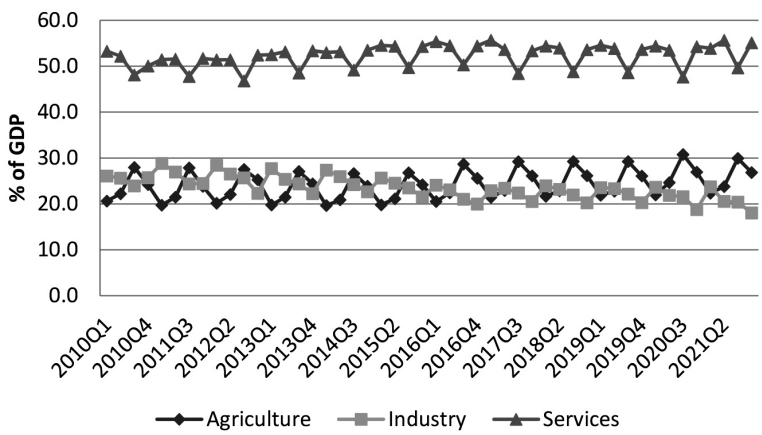

Figure 1 The Sectoral Share in Nigeria's Total GDP (%)

Source: Authors, based on CBN, 2021

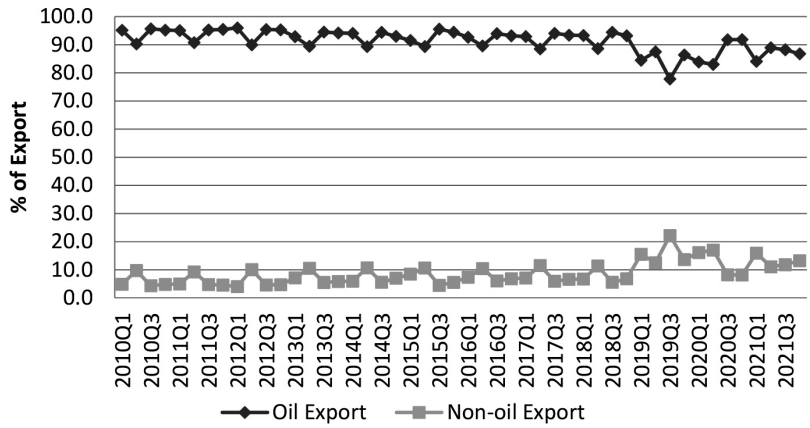

Figure 2 The Share of Oil and Non-Oil Export in Nigeria's Total Export (%)

Source: Authors, based on CBN, 2021

the productive sectors to shocks from macroeconomic indicators. The VAR and VEC models adopted in this study consist of the four variables that include the sectoral output (comprising the agricultural, industrial and services outputs), the oil price (used to proxy external shocks), the government expenditure (used to proxy the fiscal policy shocks) and the interest rate (used to proxy the monetary policy shocks). The general VAR framework is specified as follows:

$$X_t = \beta_0 + \sum_{t=1}^{k} \beta_i X_{t-1} + \varepsilon_t \quad (1)$$

where X_t is the 4x1 vector of the variables including the sectoral output (the agricultural, industrial and services outputs), the oil price, the government expenditure and the interest rate; β_i represents the identity matrix; β_i denotes the 4x4 coefficient matrices; and εt denotes the one-step ahead prediction error. For ease of the interpretation of the results, all the variables are expressed in a natural logarithm, except for the interest rate already expressed in percentage. However, the short- and long-term estimates of the VAR and VEC models, as well as the causality tests, are not presented given the fact that the study is primarily focused on the investigation of sectoral responses to macroeconomic shocks. The Variance Decomposition (VD) and Impulse Response Function (IRF) are usually the focus of empirical discussions in a study of this nature (Ewing *et al*, 2003; Bäurle & Steiner, 2015; Sennoga & Matovu, 2016; Murach & Wagner, 2021).

The matrix form of the equation (1) is written as follows:

$$\begin{pmatrix} AGR_t \\ GOV_t \\ MPR_t \\ OILP_t \end{pmatrix} = \begin{pmatrix} \alpha_{1t} \\ \alpha_{2t} \\ \alpha_{3t} \\ \alpha_{4t} \end{pmatrix} + \begin{pmatrix} \alpha_{11}(L) & \alpha_{12}(L) & \alpha_{13}(L) & \alpha_{14}(L) \\ \alpha_{21}(L) & \alpha_{22}(L) & \alpha_{23}(L) & \alpha_{24}(L) \\ \alpha_{31}(L) & \alpha_{32}(L) & \alpha_{33}(L) & \alpha_{34}(L) \\ \alpha_{41}(L) & \alpha_{42}(L) & \alpha_{43}(L) & \alpha_{44}(L) \end{pmatrix} * \begin{pmatrix} AGR_{t-1} \\ GOV_{t-1} \\ MPR_{t-1} \\ OILP_{t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \end{pmatrix}$$

$$\begin{pmatrix} IND_t \\ GOV_t \\ MPR_t \\ OILP_t \end{pmatrix} = \begin{pmatrix} \beta_{1t} \\ \beta_{2t} \\ \beta_{3t} \\ \beta_{4t} \end{pmatrix} + \begin{pmatrix} \beta_{11}(L) & \beta_{12}(L) & \beta_{13}(L) & \beta_{14}(L) \\ \beta_{21}(L) & \beta_{22}(L) & \beta_{23}(L) & \beta_{24}(L) \\ \beta_{31}(L) & \beta_{32}(L) & \beta_{33}(L) & \beta_{34}(L) \\ \beta_{41}(L) & \beta_{42}(L) & \beta_{43}(L) & \beta_{44}(L) \end{pmatrix} * \begin{pmatrix} IND_{t-1} \\ GOV_{t-1} \\ MPR_{t-1} \\ OILP_{t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{5t} \\ \varepsilon_{6t} \\ \varepsilon_{7t} \\ \varepsilon_{8t} \end{pmatrix}$$

$$\begin{pmatrix} SERV_t \\ GOV_t \\ MPR_t \\ OILP_t \end{pmatrix} = \begin{pmatrix} \delta_{1t} \\ \delta_{2t} \\ \delta_{3t} \\ \delta_{4t} \end{pmatrix} + \begin{pmatrix} \delta_{11}(L) & \delta_{12}(L) & \delta_{13}(L) & \delta_{14}(L) \\ \delta_{21}(L) & \delta_{22}(L) & \delta_{23}(L) & \delta_{24}(L) \\ \delta_{31}(L) & \delta_{32}(L) & \delta_{33}(L) & \delta_{34}(L) \\ \delta_{41}(L) & \delta_{42}(L) & \delta_{43}(L) & \delta_{44}(L) \end{pmatrix} * \begin{pmatrix} SERV_{t-1} \\ GOV_{t-1} \\ MPR_{t-1} \\ OILP_{t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{9t} \\ \varepsilon_{10t} \\ \varepsilon_{11t} \\ \varepsilon_{12t} \end{pmatrix}$$

where α_{ij}, β_{ij} and δ_{ij} are parameters in the MxN matrix forms denoting the effect of the j^{th} endogenous (dependent) variables on the i^{th} endogenous variable, whereas ε_{it} denotes the error terms of the models.

The VAR approach has the following estimation procedures:

Step I: Estimate the VAR model with all the variables specified as endogenous variables.

Step II: Generate the Variance Decomposition and the corresponding Impulse Response Function (IRF) from the estimated VAR.

Step III: Interpret the results accordingly.

Variance Decomposition (VD) and the Impulse Response Function (IRF) for the sectoral indices are presented by showing graphically and in the tabular form the sensitivity of each sector to its own shock and shocks to the other sectors under consideration. Specifically, the IRF is computed in order to show the response of the sectoral output to macroeconomic shocks, whereas the VD is used to quantify the proportion of the sectoral output that is explained by its own shock and shocks from the other macroeconomic variables. Preliminary tests, such as the unit root and correlation tests, however, were conducted so as to determine the stationarity properties of each variable and the relationship among the variables. The optimum lag length selection test was also done. The post-estimation tests were carried out, too, so as to determine the reliability of the estimates. The quarterly data on the variables of interest were sourced from the Central Bank of Nigeria's (CBN) database for the period from 2011Q1 to 2021Q4. The source and description of each variable are presented in Table 1.

RESULTS AND DISCUSSION

Descriptive statistics

The statistical properties of the variables of interest in this study are given in Table 2. It shows that the service sector dominates the other economic sectors in Nigeria as its mean value was about N8.6 trillion for the review period while the average values of the agricultural and industrial sectors are ₦4.02 trillion and N3.8 trillion, respectively, which gives further credence to the earlier assertion that the service sector contributes the highest share to the aggregate output in Nigeria. While the oil price reached the trough of US$27.5 during the period under consideration, it

Table 1 The Data description and sources

Variable	Description	Source
Agricultural Output (AGR)	Agricultural sector GDP (₦' million)	CBN (2021)
Government Expenditure (GOV)	Government expenditure (₦' million)	CBN (2021)
Industrial Output (IND)	Industrial sector GDP (₦' million)	CBN (2021)
Monetary Policy Rate (MPR)	Monetary Policy Rate (%)	CBN (2021)
Oil Price (OILP)	Bonny light spot oil price (US$ per barrel)	CBN (2021)
Service Output (SERV)	Services sector GDP (₦' million)	CBN (2021)

Source: Authors

peaked at US$121.2, raising the government revenue and facilitating domestic resource mobilization. Given the fact that crude oil export is the mainstay of the Nigerian economy, any change in the oil price directly affects the government revenue and expenditure, which reflects in huge gaps between the minimum and maximum government expenditure, as well as the range of the oil prices for the period under consideration. The monetary policy rate ranged between 6 percent and 14 percent, averaging 11.85 percent during the review period. However, the standard deviation of each variable is relatively large, with all the variables, except for the monetary policy rate, being platykurtic. In addition, all the variables, except for the industrial output and the monetary policy rate, are positively skewed.

The correlation result

Correlation analysis is important in empirical studies for two reasons: first, to determine the direction and strength of the relationship between two variables and second, to detect the possibility of encountering multicollinearity problems. With regards to the direction and strength of the relationship, the correlation results reported in Table 3 show that the government expenditure establishes a positive and moderate relationship with both the agricultural and services outputs but a weak negative association with the industrial output, which signals that the industrial sector is neglected by the government. Hence its dismal performance in relation to the other productive sectors. On the other hand, the oil price demonstrates a weak positive relationship with productivity in the industrial sector, a relatively weak negative relationship with the agricultural sector productivity and a moderate negative association with the services sector output. However, the monetary policy rate establishes a positive relationship with all the productive sectors, even though the relationship is somewhat moderate for the agricultural and industrial sectors but quite strong for the services sector. On the matter of multicollinearity, a correlation statistic of more than 80% signals the possibility of an exact linear relationship among the explanatory variables, the situation which makes the variance of the estimates extremely large, thus undermining the reliability of the estimated model. Interestingly, the correlation result reveals the absence of multicollinearity as the highest magnitude of the relationship between all the variables is 69 percent. Thus, the estimated model could be adjudged as reliable.

The unit root test result

Unit root tests are often conducted in time-series and panel studies so as to determine the appropriate estimation technique which is to be adopted in a bid to circumvent spurious results. This study conducts

Table 2 The descriptive statistics

Variables	Mean	Maximum	Minimum	Standard deviation	Skewness	Kurtosis
AGR	4026401	5550941	2594760	850596.6	0.23	1.96
GOV	1618449	3195926	743654.3	694781.7	0.65	2.10
IND	3840718	4230768	3284291	227758.2	-0.48	2.94
MPR	11.85	14.00	6.00	2.31	-1.49	4.33
OILP	76.63486	121.2267	27.49333	27.06	0.22	1.76
SERV	8621769	11203610	6704428	1060974	0.06	2.72

Note: AGR, GOV, IND, MPR, OILP and SERV imply the agricultural output, the government expenditure, the industrial output, the monetary policy rate, the oil price and the services output, respectively.

Source: Authors

Table 3 The correlation matrix

	LAGR	LIND	LSERV	LGOV	LOILP	MPR
LAGR	1					
LIND	0.15	1				
LSERV	0.65	0.26	1			
LGOV	0.63	-0.03	0.69	1		
LOILP	-0.33	0.12	-0.51	-0.48	1	
MPR	0.44	0.48	0.68	0.47	-0.35	1

Note: LAGR, LIND, LSERV, LGOV, LOILP and MPR imply the log of the agricultural output, the log of the industrial output, the log of services output, the log of the government expenditure, the log of the oil price and the monetary policy rate, respectively.

Source: Authors

unit roots tests on the variables of interest using the Augmented Dickey-Fuller (ADF) approach and the result is presented in Table 4. The null hypothesis of the ADF approach reads "The variable contains a unit root", which should be rejected if the probability value is less than 10 percent or accepted if it is otherwise. Accordingly, the result showed that the null hypothesis was accepted when the unit root test was conducted at the level for all the variables but the same was rejected when the variables were differenced in the first place, which is indicative of the fact that all the variables are stationary at the first difference (I(1)), which is a prerequisite for running the Johansen cointegration test.

Optimal lag selection

It is important to determine the optimal lag length before conducting a cointegration test as the result will be incorporated in subsequent estimations. Determining the optimal lag length helps circumvent the problem of an estimation bias and a loss of the degree of freedom that arises from under- and over-parameterized models, respectively (Afolabi, 2022). There are different criteria used in selecting the optimal lag and the lag length most selected by the various criteria will be opted for. Accordingly, the results of the optimal lag selection presented in Table 5 show that the optimal lag for all the three models (the agricultural, industrial and services output models) is 2. Thus, the optimal lag used in subsequent estimation is VAR(2).

Table 4 The augmented Dickey-Fuller unit test results

Variables	Level	First difference	Status
LAGR	-0.91b	-6.08*b	I(1)
LIND	-2.34a	-6.81*b	I(1)
LSERV	-2.07b	-2.65***a	I(1)
LGOV	0.95a	-8.89a	I(1)
LOILP	-1.61a	-6.58b	I(1)
MPR	-2.20b	-4.67*b	I(1)

Note: * and *** represent statistical significance at the 1% and 10% levels, respectively; 'a' and 'b' represent the model with the constant and the model with the constant and the trend, respectively; I(1) implies stationarity at the first difference.

Source: Authors

The cointegration test result

The unit root test results meet the requirement for conducting the cointegration test using the Johansen approach. The test is conducted on all the three models and the results are presented in Table 6. Basically, the Johansen cointegration approach tests the hypothesis reading "There is no long-term relationship among the variables." and the decision rule is that the null hypothesis will be rejected if the trace statistic exceeds the 5% critical value and will be accepted if it is otherwise. The Johansen approach has two inherent likelihood ratio test statistics (the trace and the maximum eigenvalue tests) that influence the decision to reject or to accept the null hypothesis and determines the number of the cointegrating vectors. Accordingly, the trace cointegration rank test results show the absence of the cointegrating vector among the variables in the agricultural and services output models; thus the null hypothesis is accepted, whereas it is rejected in the case of the industrial output that has three cointegrating vectors. Similarly, the maximum eigenvalue cointegration rank test results show the absence of a long-term relationship among the variables in the agricultural and services output models but the converse in the industrial output model. For the models with no cointegrating vectors, the Vector Autoregression (VAR) model is the appropriate model to run, whereas the Vector Error Correction (VEC) model is the appropriate model to run when a model has at least one cointegrating vector. Thus, while the VAR model is run for the agricultural and services output models, the VEC model is run for the industrial output model.

VAR estimation results

This study is primarily focused on the examination of the sectoral responses to fiscal, monetary and external shocks. The VAR and VEC models are estimated using the VAR(2) optimal lag length for all the three models and the corresponding results of the impulse response functions and the variance decomposition of each model are presented in Figure 3, Figure 4 and Figure 5, and in Table 7.

Table 5 The VAR lag length selection criteria

The agricultural output model						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-110.49	NA	0.002	4.98	5.14	5.04
1	7.42	210.18	2.04E-05	0.55	1.34	0.84
2	81.36	118.96*	1.67e-06*	-1.97*	-0.54*	-1.44*
The industrial output model						
Lag	LogL	LR	FPE	AIC	SC	HQ
1	52.79	NA	2.38E-06	-1.60	-0.96*	-1.36
2	75.72	37.89*	1.78e-06*	-1.90*	-0.63	-1.42*
The services output model						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-74.22	NA	0.0004	3.40	3.56	3.46
1	41.87	206.95	4.56E-06	-0.95	-0.16*	-0.65*
2	60.00	29.17*	4.22e-06*	-1.04*	0.39	-0.51

Note: * indicates the lag order selected by the criterion, LR = the sequential modified LR test statistic (each test at the 5% level), FPE = the Final Prediction Error, AIC = the Akaike Information Criterion, SC = the Schwarz Information Criterion; and HQ = the Hannan-Quinn Information Criterion.

Source: Authors

Sectoral responses to the fiscal shock

The government expenditure is an anchor fiscal tool the Nigerian government uses to ensure the fiscal stability of the country. Government expenditure shocks in Nigeria mainly arise from volatility in crude oil prices in the international market as crude oil is the main source of the Nigerian government revenue (Aminu & Ogunjimi, 2019). Thus, a shock to the government expenditure has implications for the sectoral output in the country. The IRF results show that a shock to the government expenditure has a positive contemporaneous effect on the agricultural output in Nigeria, indicating that an expansionary fiscal policy (an increase in the government expenditure in this case) spurs the agricultural output. However, the positive effect turned negative after the four quarters (one year), implying that the positive effect of the government expenditure on the agricultural output in Nigeria is a short-term phenomenon. This corroborates the finding of P. K. Ozili (2020), who argued that the government expenditure stifled the sectoral output. Similarly, the government expenditure shock has a positive contemporaneous impact on the services sector output although the impact is more lasting in the services sector than in the agricultural sector. Tacitly, an increase in the government expenditure boosts the services output more than it does the agricultural output.

Conversely, the government expenditure shock has a long-term negative contemporaneous effect on the industrial output which is such that a sudden increase in the government expenditure will stifle the industrial output in the long run, at a lower magnitude though compared to the agricultural and services sectors' outputs. This partly explains the high-flying performance of the services and agricultural sectors and somewhat dismal performance of the industrial sector in the country (Ogunjimi, 2020b). In addition, the results of the Variance Decomposition in Table 7 show that the government expenditure shocks account for a peak of 25% variation in the agricultural output in the third quarter, 1.2% of the industrial output in the tenth quarter and 2.7% variation in the services output in the fourth quarter. Overall, the services and agricultural sectors are the most responsive to

Table 6 The Johansen cointegration test result

The trace cointegration rank test result							
		Agricultural output model		Industrial output model		Services output model	
Hypothesized no. of CE(s)	5% critical value	Eigenvalue	Trace statistic	Eigenvalue	Trace statistic	Eigenvalue	Trace statistic
None	47.86	0.33	42.00	0.55*	67.55	0.37	45.98
At most 1	29.80	0.27	24.28	0.31*	33.64	0.27	24.94
At most 2	15.49	0.17	10.11	0.29*	17.61	0.17	11.03
At most 3	3.84	0.04	1.87	0.07	3.07	0.06	2.61
The maximum eigenvalue cointegration rank test result							
		Agricultural output model		Industrial output model		Services output model	
Hypothesized no. of CE(s)	5% critical value	Eigenvalue	Trace statistic	Eigenvalue	Trace statistic	Eigenvalue	Trace statistic
None	27.58	0.33	17.72	0.55*	33.91	0.37	21.04
At most 1	21.13	0.27	14.17	0.31	16.03	0.27	13.91
At most 2	14.26	0.17	8.24	0.29*	14.53	0.17	8.42
At most 3	3.84	0.04	1.87	0.07	3.07	0.06	2.61

Note: *denotes significance at the 5% level.

Source: Authors

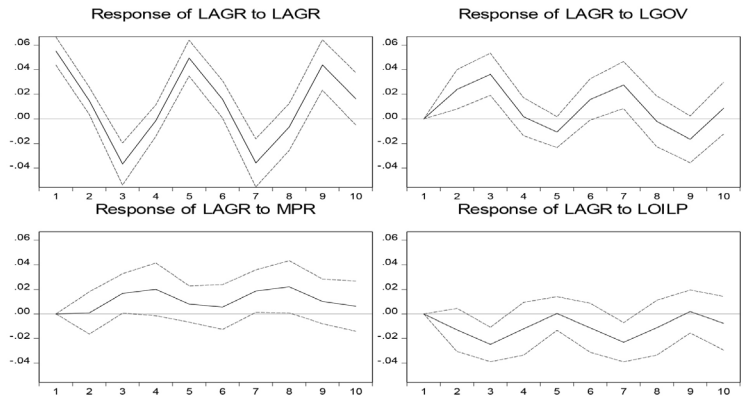

Figure 3 The impulse response function of the agricultural sector to macroeconomic shocks

Source: Authors

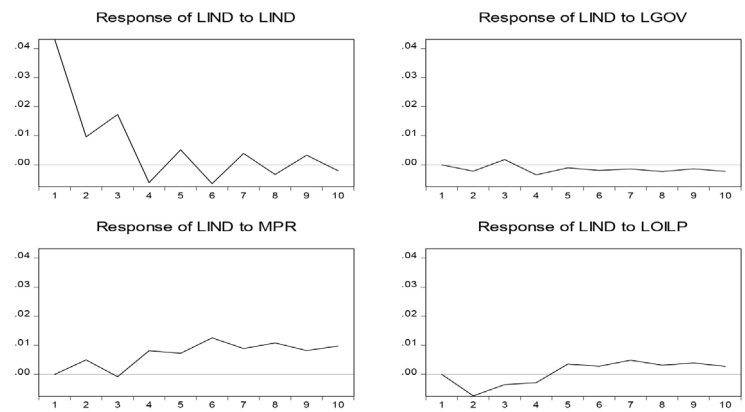

Figure 4 Th impulse response function of the industrial sector to macroeconomic shocks

Source: Authors

the government expenditure shocks relative to the industrial sector. The government expends more on the services sector than on the other two economic sectors due to the dominance of the services sector, as well as its huge contribution to the Nigerian GDP. It also explains the unimpressive contribution of the industrial and agricultural sectors to the GDP, which is primarily caused by limited financial resources. Nonetheless, the agricultural and industrial sectors have equally benefitted from the recurring government intervention directed towards the achievement of industrialization and self-sufficiency in food production such as the Anchor Borrowers' Scheme and Small and Medium Enterprises Credit Guarantee Scheme (SMECGS), among others.

Sectoral responses to the monetary shock

The monetary policy rate (MPR) (the interest rate) is determined by the Central Bank of Nigeria (CBN), the apex monetary authority in Nigeria. The CBN uses the MPR to moderate monetary policy in the country. The

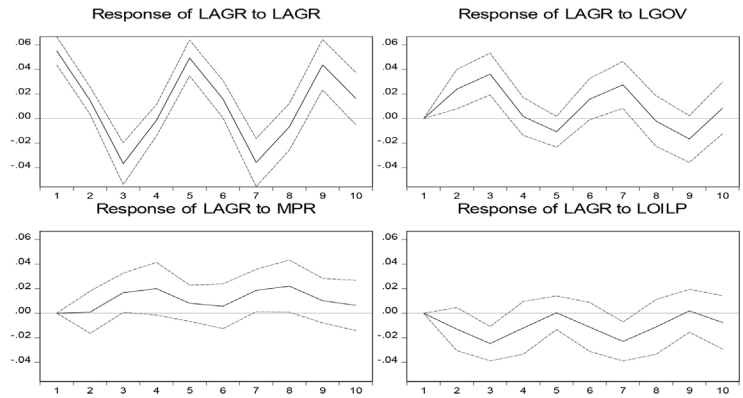

Figure 5 The impulse response function of the services sector to macroeconomic shocks

Source: Authors

IRF result shows that a shock to the monetary policy rate, the proxy for the monetary shock, has a long-term positive contemporaneous effect on the agricultural output in Nigeria, implying that a positive shock to the MPR leads to an increase in the agricultural output in the long run. In a similar fashion, the MPR shock has a positive contemporaneous effect on the industrial output in Nigeria, especially for the first two quarters, after which it turns negative in the third quarter and subsequently becomes positive with a higher magnitude. This implies that a sudden increase in the MPR will spur industrial production in the short run and that it will eventually have a higher magnitude of the impact on the industrial output in subsequent periods. On the other hand, the interest rate shock has a contemporaneous positive impact on the services sector output in the first two quarters following the shock to the MPR, but a negative impact afterwards. This shows that the interest rate shock hurts the services sector output in the long run. These findings are in line with the finding of L. O. Oyelami and P. A. Olomola (2016), as well as the postulation of traditional Keynesian economists that an increase in the real interest rate deters investment and ultimately stifles the sectoral and aggregate outputs.

Moreover, the results of the Variance Decomposition show that the interest rate (MPR) shocks explain an about 10.7% variation in the agricultural output in the eighth quarter, 20.2% in the industrial output in the tenth quarter, and a 0.5% variation in the services output in the tenth quarter. In sum, the industrial sector is the most responsive to the interest rate shock, whereas the services sector is the least responsive among the three key economic sectors in Nigeria. This suggests the resilience of the industrial and agricultural sectors relative to the services sector in the face of interest rate shocks. The agricultural and industrial sectors are not too exposed to the interest rate shocks as the services sector is, which could be explained by the CBN's restrictions with regards to interbank rates on a number of food items and other basic manufactured products (dairy products included).

Sectoral responses to the external shock

Given the fact that the oil price is denominated in a foreign currency and determined by the market forces in the international market, oil price shocks are regarded as external shocks in Nigeria. According to the IRF results, the oil price shock has a negative contemporaneous effect on the agricultural output in Nigeria, so that a positive oil price shock leads to a decline in the agricultural output, which on its part indicates that oil price shocks adversely affect the agricultural output in Nigeria in the long run. However, the negative contemporaneous effect of oil price shocks on the industrial output seems to be short-

Table 7 The variance decomposition of Nigeria's productive sectors

Period	Variance decomposition of LAGR					Variance decomposition of LIND					Variance decomposition of LSERV				
	S.E.	LAGR	LGOV	MPR	LOILP	S.E.	LIND	LGOV	MPR	LOILP	S.E.	LSERV	LGOV	MPR	LOILP
1	0.055	100.00	0.00	0.00	0.00	0.043	100.00	0.00	0.00	0.00	0.084	100.00	0.00	0.00	0.00
2	0.063	81.41	14.32	0.01	4.26	0.04	95.84	0.24	1.20	2.72	0.097	93.73	2.56	0.06	3.66
3	0.087	60.92	24.96	3.67	10.44	0.049	95.69	0.35	1.07	2.89	0.117	95.05	1.91	0.04	3.00
4	0.090	56.83	23.31	8.33	11.52	0.050	92.43	0.82	3.67	3.08	0.130	93.18	2.72	0.03	4.07
5	0.104	65.67	18.73	6.90	8.71	0.051	90.14	0.83	5.59	3.45	0.144	93.72	2.22	0.07	3.00
6	0.107	64.07	19.82	6.77	9.33	0.053	84.82	0.91	10.81	3.47	0.155	92.99	2.43	0.09	4.49
7	0.120	60.01	21.05	7.79	11.16	0.054	81.83	0.94	13.08	4.15	0.167	93.14	2.13	0.17	4.55
8	0.122	57.66	20.15	10.69	11.50	0.055	78.35	1.07	16.30	4.28	0.177	92.72	2.20	0.25	4.83
9	0.131	61.07	19.09	9.86	9.99	0.056	76.33	1.10	17.93	4.64	0.188	92.67	2.04	0.38	4.91
10	0.133	61.07	19.02	9.84	10.07	0.057	73.85	1.22	20.22	4.71	0.197	92.35	2.08	0.50	5.07

Source: Authors

lived as the effect turned positive in the fifth quarter, implying that the oil price shock can only negatively affect the industrial output for one year, after which the sector would adjust well enough to turn the negative impact to a positive one. The narrative is different for the services sector as the result shows the presence of a positive contemporaneous effect of the oil price shock on the services sector output. The result suggests that the positive effect of oil price shocks on the services sector output is a long-term phenomenon in Nigeria. These results support the findings of A. Aminu and J. A. Ogunjimi (2019); C. Onyimadu (2019) and J. A. Ogunjimi (2020a), who showed that the oil price was the key determinant of the sectoral output in Nigeria.

The Variance Decomposition results also show that, in the tenth quarter, the oil price shock accounts for 10.1% in the agricultural output, 4.7% in the industrial output and 5.1% in the services output. The peculiarity of Nigeria as an oil-dependent economy reflects in the vulnerability of almost all the sectors to oil price shocks most especially on the downside. At the aggregate level, the agricultural and industrial sectors are more exposed to negative oil price shocks compared to the services sector, which to some extent implies that a decline in receipts from crude oil sales would exert a negative impact on the performance of the key activities carried out by the agricultural and industrial sectors. With the magnifying negative impact of COVID-19 on global oil prices, the performances of the agricultural and industrial sectors remain vulnerable to the oil price volatility, indicating that they are less resilient and fragile. In brief, the services sector is more resilient to oil price shocks than the industrial and agricultural sectors are.

CONCLUSION

The quest for sustainable growth and competitiveness of the Nigerian economy has been pursued by successive governments in the country. However, Nigeria's susceptibility to various macroeconomic shocks (such as fiscal, monetary and external shocks) due to its fragility continues to dampen the possibility of achieving this quest. Given this, the study examined the sectoral responses to macroeconomic shocks in Nigeria using the VAR and VEC model frameworks. The quarterly data on the key variables of interest for the period spanning 2010Q1 and 2021Q4 were sourced from the Central Bank of Nigeria's database. The findings revealed the fact that the services and agricultural sectors were more responsive to the government expenditure shocks than the industrial sector. In addition, the industrial sector was found to be the most responsive to interest rate shocks, whereas the service sector was the least

responsive to interest rate shocks. With regards to oil price shocks, the services sector was found to be more resilient to oil price shocks than the industrial and agricultural sectors. Regarding the results of the tested hypotheses, the following conclusions are made:

- The agricultural, industrial and services sectors are responsive to fiscal shocks although with different levels of responsiveness.
- The agricultural, industrial and services sectors are sensitive to monetary shocks, albeit at different sensitivity levels.
- The agricultural, industrial and services sectors are responsive to external shocks, albeit at varying degrees.

These findings have scientific and practical implications. For the scientific implications, the varying degrees of the responsiveness of each economic sector to the policy changes suggest the need to consider both domestic and external shocks in the determination of the macroeconomic stability of the domestic economy. For the practical implications, however, the sensitivity of the agricultural sector to the government expenditure shocks indicates the need to prioritize investment in the technologies and machinery that would aid improved productivity in the agricultural sector and in the other economic sectors. Given the adverse effects of interest rate shocks on the sectoral output, the monetary authorities need to prioritize stabilizing interest rates, which will incentivize both domestic and foreign investors to invest in the various sectors of the Nigerian economy, thereby advancing the diversification quest of the country and providing the necessary support to the less resilient sectors. Finally, to maximize positive macroeconomic shocks, the Nigerian government and other stakeholders need to ensure that national accounts are opened and effectively managed in order to store surpluses during the periods of boom, which would be useful at a later period, especially during downturns.

The scope of this study is delimited to only one indicator for the fiscal, monetary and external shocks and is focused on only the Nigerian key economic sectors. Future studies could consider using different indicators of fiscal, monetary and external shocks in their evaluation of the sectoral response to shocks. In addition, future investigations should focus on the subsectors in the agricultural, industrial and services sectors so as to effectively delineate the subsector with the highest response and the lowest response to each form of the macroeconomic shock. Moreover, since this study was only based on the Nigerian economy, future studies could be conducted for other countries for the purpose of plausible comparisons and in order to check if country-specific characteristics influence the sectoral responses to macroeconomic shocks. Finally, a panel study on the subject matter is also a good direction for future research.

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Joshua Adeyemi Afolabi is a Research Fellow at the Innovation and Technology Policy Department, Nigerian Institute of Social and Economic Research. His research interests include development and macroeconomic issues.

Blessing Ufuoma Olanrewaju is a Research Fellow at the Economic and Business Policy Department, Nigerian Institute of Social and Economic Research. Her research interests include long-run economic growth, energy economics, public policy and development economics.

Wasiu Adekunle is a Research Associate at the Nigerian Economic Summit Group, Lagos, Nigeria. He is highly skilled in economic and econometric research.

MODELIRANJE OSETLJIVOSTI SEKTORA NA MAKROEKONOMSKE ŠOKOVE - DOKAZ IZ NIGERIJE

Joshua Adeyemi Afolabi[1], Blessing Ufuoma Olanrewaju[1] i Wasiu Adekunle[2]

[1]*Nigeria Institute of Social and Economic Research, Ibadan, Nigeria*
[2]*Nigeria Economic Summit Group, Lagos, Nigeria*

Privreda Nigerije se uvek iznova nalazi na udaru makroekonomskih šokova prevashodno zbog toga što se preterano oslanja na sirovu naftu i loše upravljanje resursima. S obzirom na ograničeni kapacitet otpornosti privrednih sektora u Nigeriji, ova studija ima za cilj da ispita osetljivost tih sektora na makroekonomske šokove. U studiji se koriste vektorski autoregresioni model (VAR) i vektorski model sa korekcijom ravnotežne greške (VEC) za period od prvog kvartala 2010. godine do četvrtog kvartala 2021, a sprovodi se u okvirima tih modela. Saznanja do kojih se došlo izvođenjem ove studije ukazuju na činjenicu da su uslužni i poljoprivredni sektor veoma osetljivi na fiskalne šokove, kao i na činjenicu da je industrijski sektor veoma osetljiv na šokove kamatnih stopa. Takođe, došlo se do saznanja da je uslužni sektor otporniji na šokove cena nafte u odnosu na druge sektore. Stoga se u ovoj studiji zauzima stav da je potrebno razvijati strategije koje će podsticati sektorsku produktivnost i koje će vešto objediniti fiskalnu i monetarnu politiku kako bi se prigušili učinci makroekonomskih šokova. Ova studija pruža dokaze o posledicama makroekonomskih šokova na sektorskom nivou u Nigeriji.

Ključne reči: makroekonomski šokovi, vektorski autoregresioni model, vektorski model sa korekcijom ravnotežne greške, industrijski sektor, poljoprivredni sektor, uslužni sektor

JEL Classification: C22, E23, E52, E62