Asian Journal of Economics, Finance and Management

Volume 6, Issue 1, Page 74-87, 2024; Article no.AJEFM.1486

Application of Optimal Control Modelling Procedure for Determining the Impact of the Nigerian Monetary and Fiscal Policies on its Economic Growth

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.globalpresshub.com/review-history/1486

Original Research Article

Received: 13/12/2023
Accepted: 15/02/2024
Published: 22/02/2024

ABSTRACT

This study determined the impact of monetary and fiscal policy on economic growth in Nigeria. The study applied the optimal control theory as a method of analysis to check which of the policies 'either monetary or fiscal' exert more impact on the economy during the National Development Plan

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of 2021-2025. The first stage of the analysis showed that the fiscal policies can sustain an economic growth even if some monetary policies are failing. In the second stage of the work, the variables were subjected to optimal control modelling in order to know the actual level/magnitude of the policy-making effort needed for a continuous economic boost in Nigeria. The result revealed that monetary policy may be said to be very weak in Nigeria, which has led to the exchange rate in the parallel market to be as high as $1=N1200, with a very high inflation rate of 22.41%, hence, fiscal policy exerts more impact on the economy during the implementation of the NDP of 2021. The study concluded that in order to enjoy tangible and multiplicity of both F_n and F_s on the Nigeria economy, major control variables such as strengthened legislation and adequate value reorientation, reward for dignity and labor has to be sustained. From extant literature, it was observed that previous studies adopted econometric method for analysis, none has attempted to use optimal control theory using Nigeria data, this study intend to fill this gap by adopting Optimal Control Modeling as method of analysis.

Keywords: Economy; major control variables; monetary policies.

1. INTRODUCTION

Economic growth is the total increase in the production or output of goods and services within an economy over a specific period of time. It is typically measured by assessing the change in a country's gross domestic product (GDP), which is the total value of final goods and services produced within a country in a given year. Economic growth is a key indicator of the health and development of an economy. It is usually associated with a higher standard of living for the population, as it creates job opportunities, increase incomes, and improves living conditions. Additionally, economic growth allows governments to generate more tax revenue, which can be invested in public infrastructure, social programs, and other initiatives that support further development. There are various factors that can contribute to economic growth, such as increases in opportunity, technological advancements, capital investments, access to credit, trade liberalization, political stability, and efficient institutions. Governments often implement policies, including monetary and fiscal measures, to stimulate economic growth and manage its impact on inflation, employment, and other macroeconomic variables.

According to World Bank (2023), Nigeria is the largest economy in Africa with a GDP of 440.8 billion USD in 2021, which increased to 477.39 billion USD in 2022. Nigeria is seen as one of the fastest developing countries in Africa, with a GDP growth rate of 2.65 percent in 2015, and -1.62 percent in 2016 which indicates negative growth, this is perhaps as a result of fall in crude oil price at the international market. But growth rate was strengthened to 0.81 percent in 2017 as economic activities began to pick up. The growth rate rose to 1.92 percent in 2018, and increased further to 2.21 percent in 2019, but declined to -1.79 percent as a result of the Covid 19 pandemic that brought the world economy to a standstill. However, the growth rate increased after the lockdown to 3.65 percent in 2021 and 3.25 percent in 2022 respectively (International Monetary Fund, 2023). But despite all the 'paper-economic' growth recorded, since commodities' hike in prices were not controlled, no citizens' happiness and family's welfare were of priority to the government of the day, it was quite obvious that no tangible contribution to the economic growth was observed [1,2,3].

"Fiscal and monetary policies are equally used to stabilize the macroeconomic situations of a country" [4]. "Monetary policy denotes the actions taken by a nation's central bank to control the supply of money and credit in the economy, with the aim of achieving macroeconomic objectives such as price stability, output growth, and full employment" [5]. "On the other hand, fiscal policy is the use of government expenditure, taxation, and borrowing to regulate the economic activities of a country in order to achieve macroeconomic objectives such as full employment, price stability, and output growth" [6].

"Monetary policy is mainly implemented by the central bank, while fiscal policy is implemented by the Ministry of Finance or Treasury. Although monetary and fiscal policies have the same objective of ensuring stable, and sustainable economic growth, they use different mechanisms to achieve this objective. However, both policies can complement themselves in achieving macroeconomic stability" [7]. "In many countries, monetary policy has generally played a supporting role to fiscal policy, and central banks have often been required to finance public sector

deficits. This is often because fiscal policy is typically more responsive and flexible than monetary policy, making it more effective in addressing short-term economic challenges" [8]. "Although, in recent years there has been a development towards increasing central bank independence, which has created more opportunities for monetary policy and fiscal policy to complement each other. This has involved giving central banks more autonomy to set their own policy goals and instruments, to reduce the level to which central banks are required to finance public sector deficits. Fiscal policy can influence the efficiency of monetary policy in many ways. For example, fiscal policy actions can impact the general price level, which can cast doubts on the efficacy of monetary policy. Fiscal policy can also impact aggregate demand in the short run, which can affect the efficacy of monetary policy in achieving macroeconomic stability" [9].

"The relative importance of fiscal and monetary policies is a matter of debate, with some economists arguing that monetary policy has a greater impact on economic activity, while others argue that fiscal policy is more effective. Keynes and his followers believe that fiscal policy is more potent in stimulating aggregate demand and reducing unemployment, while monetarists maintain that monetary policy is more potent in promoting economic growth" [10]. "Real wealth effect is described as changes in the price level, and how it affects consumer spending, as assets gain or lose purchasing power. Arthur Cecil Pigou contended that Keynes' General Theory did not sufficiently account for the role of the "wealth effect" on consumption, which would make the economy more "self-correcting" to drops in aggregate demand" [11].

"Nigeria like all other developing countries faces challenges of economic growth and development which has not been addressed by monetary and fiscal policies. And this is often due to vulnerability to external shocks and internal disruptions, resulting in high levels of unemployment, low income, inequality, and poverty. The Nigerian economy has fluctuated in the recent times due to the volatility of the oil price at the international market, resulting in volatility through rising inflation, huge unemployment, low productivity, and dwindling foreign reserves, leading to unstable exchange rates" [12]. "Particularly, between 2015 and 2022, Nigeria has experienced two major recessions. The first in 2015 was due to the fall in oil price, and the second in 2020 was due to covid-19 pandemic. During these periods, Nigeria implemented several monetary and fiscal policies aimed at reducing inflation and stabilizing the economy. For example, The Central Bank of Nigeria (CBN) adopted an inflation targeting framework, which aimed to maintain inflation within a target range of 6-9%. The government also implemented fiscal policies to support economic growth, such as increased public spending on infrastructure and social services" [9]. Others includes conditional cash transfer, N-power, Covid-19 loan among others.

"The National Development Plan (2021-2025) was introduced with the vision of socio-economic transformation of the country as envisioned in the long-term aspiration of Nigeria, encapsulated in the Nigeria Agenda 2050. The Plan was built on the achievements and lessons learned during the implementation of the ERGP. The objective of this plan is to achieve; a broad-based real GDP growth rate of about five percent on average during the plan period, increase employment generation of about 21 million jobs, and through an inclusive growth lift 35 million people out of poverty over the plan period. This will set the stage for achieving the government's target of lifting 100 million Nigerians out of poverty in 10 years under the National Poverty Reduction and Growth Strategy" (NDP, 2020). Also, the recent removal of the fuel subsidy and the foreign exchange management reforms are critical steps to address long-standing macroeconomic imbalances and have the potential to establish a solid foundation for sustainable and inclusive growth.

"However, Nigeria continues to face several harsh economic challenges, such as the recent cash-crunch, unimaginable exchange rate, high cost of living, low productivity, and high unemployment amongst others. The government and the CBN have employed various policies to address these challenges, such as the implementation of a fixed exchange rate regime, the introduction of a loan-to-deposit ratio (LDR) policy to boost lending to the real sector, and the establishment of an infrastructure development fund to finance critical infrastructure projects" [13]. A question may be asked, if the monetary and fiscal policies in the NDP of 2021-2025 will exert impact on economic growth within the stipulated period, and to know which of the policies can sustain economic growth in Nigeria. Against this background, this study seeks to examine the impact of

monetary and fiscal policy on economic growth in Nigeria.

1.1 Objectives of the Study

Specifically, the study intend:

i. To examine the impact of monetary and fiscal policies on economic growth in Nigeria as documented in the NDP of 2021-2025
ii. To investigate which of the policy exerts more impact on the economic growth.

1.2 Conceptual Clarification

1.2.1 Concept of monetary policy

"Monetary policy is the actions and measures implemented by a central bank or monetary authority to control and regulate the money supply, interest rates, and credit available in the economy. The main purpose of introducing monetary policy is to maintain price stability and promote economic growth. Central banks adopt various tools to implement monetary policy. The most common tool is open market operations, where the central bank buys or sells government securities to influence the money supply. When the central bank buys securities, it injects money into the economy, increasing the money supply, and vice versa" [14].

"Another tool used is the adjustment of interest rates. The central bank can raise or lower interest rates to influence borrowing and spending levels. By raising interest rates, the central bank reduces borrowing and spending, which can help control inflation. Conversely, lowering interest rates can stimulate borrowing and spending, which can encourage economic growth. Monetary policy also involves setting reserve requirements, which are the amount of funds that banks must hold in reserve against their deposits" [15].

"The effectiveness of monetary policy depends on various factors, including the state of the economy, the level of inflation, and other macroeconomic conditions. It is a crucial tool in managing and stabilizing economies, allowing policymakers to respond to economic challenges and promote sustainable growth" [8].

1.2.2 The concept of fiscal policy

"Fiscal policy refers to the use of government spending and taxation to influence the overall economic activity and achieve specific macroeconomic objectives. It is an essential tool for policymakers to manage the economy and promote economic growth, stability and welfare. There are two main components of fiscal policy: government spending and taxation. By adjusting these parameters, governments can influence the overall level of aggregate demand, which in turn affects economic output, employment and inflation" [16].

"Expansionary fiscal policy involves increasing government spending and/or reducing taxes to stimulate aggregate demand and boost economic activity. This can be useful during times of recession or slow economic growth when there is a need to spur consumer and business spending. On the other hand, contractionary fiscal policy involves decreasing government spending and/or increasing taxes to reduce aggregate demand and constrain economic activity. This is typically implemented during periods of high inflation or excessive aggregate demand to cool down the economy and control inflationary pressures. Fiscal policy can also be used to achieve specific socioeconomic objectives, such as redistributing income, reducing poverty, promoting infrastructural development or addressing environmental concerns. Government can allocate resources through targeted spending programs and tax policies to achieve these goals. It worth nothing that the effectiveness of fiscal policy depends on various factors, including the size of the fiscal multiplier, structural constraints, the credibility of the government, and the overall economic environment. Therefore, policy makers need to carefully design and implement fiscal measures to achieve the desired outcomes while considering the short-term and long-term implications" [17].

1.3 The Concept of Optimal Control Theory

Optimal control theory is a mathematical framework that deals with finding the optimal control strategy for a dynamic system. It is used to determine the sequence of control inputs over time that minimizes or maximizes a certain performance measure, also known as the objective function. The objective function is typically defined based on the system's states and control inputs, and it can capture different criteria such as energy consumption, time efficiency, stability, or cost. The goal is to find the control inputs that optimize this objective function while satisfying the system's dynamic constraints. Optimal control theory relies on mathematical optimization techniques to find the optimal control strategy. It considers the

dynamics of the system, the objective function, and the constraints to calculate the control signals that lead to the desired system behaviour.

2. LITERATURE REVIEW

Over time, there have been several debates regarding the effectiveness of fiscal and monetary policy stances across countries and how the differ from each other. Several studies have been conducted in this study area. For example, the work of Abata et al. [4] examined "the impact of fiscal and monetary policies on economic growth and development in Nigeria. The study revealed that fiscal indiscipline is one of the major challenges to achieving sustainable economic growth in Nigeria. It was concluded that the effectiveness of fiscal and monetary policies on economic growth in Nigeria can only be achieved through proper coordination and implementation of these policies, as well as the political willingness to address the issue of fiscal indiscipline in Nigeria".

Ogar et al. [18] conducted "a study that investigated the connection between fiscal and monetary policies and economic growth in Nigeria between 1986 and 2010. The study revealed that both government revenue and money supply had positive impact on gross domestic product, and are statistically significant at 0.5 percent level of significance". While Noman and Khudri [19] carried out "a study on the effects of fiscal and monetary policies on economic growth in Bangladesh between 1980 and 2013. The study concluded that there is a positive relationship between narrow money, broad money, exchange rate, government revenue, and expenditure with real gross domestic product. This implies that an increase in these variables will result in a corresponding increase in the real gross domestic product in Bangladesh ceteris paribus".

More so, Bodunrin [20] studied "the effect of fiscal and monetary policies on economic growth in Nigeria from 1981 to 2015. The main purpose of the study was to determine which of the policies between fiscal and monetary had a robust impact on the economic growth in Nigeria and to investigate how GDP growth reacted to the shocks caused by monetary and fiscal policies. The Study employed VAR method of analysis, and the result showed that fiscal policy had a short-term impact on real GDP growth, which, however, faded away after one year period. On the other hand, the study found that monetary policy had no significant effect on the growth of real GDP in Nigeria within the period under study".

Ogunbiyi and Okoye [21] in their study considered "the relationship between fiscal policy and economic growth in Nigeria between 1970 and 2014. The study concluded that government expenditure on economic service and fiscal deficit had a positive but insignificant relationship with gross domestic product, while government expenditure on social and community service and tax revenue had a positive and significant relationship with gross domestic product. while, government expenditure on administration and transfer had a negative and insignificant relationship with economic growth. The study revealed that government expenditure on social and community service and tax revenue are more effective in promoting economic growth than government expenditure on economic services and fiscal deficit, while government expenditure on administration and transfer may hinder economic growth".

While, Nwoko et al. [22] studied "the efficiency of the CBN's monetary policies in promoting economic growth in Nigeria between 1990 and 2011. The study revealed that average price and the labour force had a significant impact on GDP, signifying that inflation and employment are important factors in determining economic growth in Nigeria. However, the study did not show the impact of money supply on economic growth. This implies that the effectiveness of monetary policy in Nigeria may depend on factors other than the amount of money in circulation, suggesting that the Central Bank of Nigeria may need to consider alternative strategies in promoting economic growth".

In the same vein, Okorie et al. [10] led "a study to determine the effectiveness of monetary and fiscal policies in Nigeria using quarterly time-series from 1981Q1-2012Q4. The study revealed that both monetary and fiscal policies have significant and positive impact on income. The findings suggested that both policies are important tools for stimulating economic growth and development in Nigeria". While Idris and Bakar [23] evaluate "the effects of fiscal operations on macroeconomic growth in Nigeria. Findings showed that fiscal operations were ineffective in providing the necessary macroeconomic environment for sustainable growth in Nigeria. They submitted that government's fiscal policy failed to stimulate economic growth due to a lack of fiscal discipline and ineffectiveness in the management revenues. The study recommended that there

was a need for more effective fiscal policy measures to promote sustainable economic growth and development in Nigeria".

Also, Ayodeji and Oluwole [24] investigated "the impact of monetary policy on economic growth in Nigeria. The study used money supply and exchange rate as targeted variables. It was found that both variables had a positive and significant impact on economic growth. This implies that the effectiveness of monetary policy in Nigeria is unlimited in promoting economic growth, although the study suggested that additional policies may be necessary to support sustained economic growth in the country".

The work of Adeniyi et al. [6] showed "the relationship between monetary policy and economic growth in Nigeria. The study concluded that monetary policy had a positive impact on economic growth in Nigeria in both the short and long run. Specifically, the study found that an increase in money supply had a positive impact on economic growth, while an increase in interest rates had a negative impact on economic growth within the period under investigation".

More so, Alabi and Olarinde [9] examined "the relationship between fiscal policy and economic growth in Nigeria. It was found that government spending and taxation had a significant impact on economic growth in Nigeria. Government spending has a positive impact on economic growth, while taxation has a negative impact on economic growth. The study also revealed that the impact of fiscal policy on economic growth varied sector to sector with government spending having a higher positive impact on the service sector compared to other sectors".

Umar and Murtala [25] studied "the impact of fiscal policy on economic growth in Nigeria. The study adopted the the Autoregressive Distributed Lag (ARDL) as method of analysis using annual data from 1981 to 2017. It was found that government expenditure and taxation have significant impacts on economic growth in Nigeria in the short run and the long run. The study further showed that government expenditure has a higher positive impact on economic growth than taxation. It was concluded that the Nigerian government should focus on using fiscal policy to stimulate the economy, particularly through increased government spending on sectors that have a higher multiplier effect on economic growth, such as infrastructure development".

3. METHODOLOGY

3.1 Model's Assumptions

- We assumed that μ stands for the death of an economy of a nation, and that an economy of a nation dies when μ =1.
  Thus for this study, μ = [0, 1].
  But, μ = 1: means total death and extinguishment of the economy's fortunes and prosperity. Also, when μ is greater than 0 and very close to 1, it implies that some parts of the Economy are still working, but the economy needs urgent attention in order not to lead to total death of the economy. Also, when μ = 0 means no death or partial death of the Economy.
- The impact of the interaction between the Fiscal Policies on an Economy, $F_S(t)$ and the monetary Policies on an Economy $F_n(t)$ cannot be obviously noticed except through some model simulations. This therefore accounted for the dotted-interaction-line in the models flow chart below.

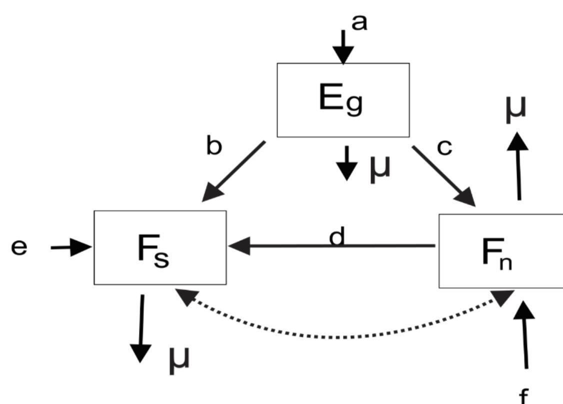

Fig. 1. The model equations from the flow chart above

List 1. Model variables and parameters descriptions

S/N	Variables	Descriptions
1	E(t)	The entire Economy of a nation
2	$F_S(t)$	Fiscal Policies on an Economy
3	$E_g(t)$	Economic growth
4	$F_n(t)$	Monetary Policies on an Economy
5	a	External contribution to Eg
6	b	impact of Fs on Eg
7	c	impact of Fn on Eg
8	D	impact of Fs on Fn
9	e	External contribution to Fs
10	f	External forces contribution to Fn
11	μ	death or partial death of the Economy

3.2 Flow Chart of the Model's Variable Interaction

The major components of an economy is subdivided into three compartments: The Economic growth compartment, $E_g(t)$ (which is a visible compartment), the Fiscal Policies on an Economy, $F_S(t)$ (non-visible compartment), and the Monetary Policies on an Economy $F_n(t)$ (non-visible compartment),

3.3 Stage 1 of the Study (The Model Without the introduction of optimal control variable)

Thus from the model's flowchart, the model's Differential equation is given as;

$$\left.\begin{aligned}\frac{dE_g}{dt} &= a + bF_S E_g + cE_g F_n - \mu E_g \\ \frac{dF_n}{dt} &= f - cE_g F_n - \mu F_n - dF_n F_S \\ \frac{dF_S}{dt} &= e - bF_S E_g - \mu F_S + dF_n F_S\end{aligned}\right\} \qquad (0)$$

$$Where:\ E = F_S + F_n + E_g \text{ and } \frac{dE}{dt} = \frac{F_S}{dt} + \frac{F_n}{dt} + \frac{E_g}{dt}$$

3.4 Determination of the Positivity of the Model's Solution

From equation (0) above, we have that, when

$$\frac{dE}{dt} = \frac{F_S}{dt} + \frac{F_n}{dt} + \frac{E_g}{dt}$$

$$\Rightarrow \frac{dE}{dt} = a - \mu E_g + f - \mu F_n + e - \mu F_S = (a + f + e) - \mu(E_g - F_n + F_S)$$

$$\therefore \frac{dE}{dt} = (a + f + e) - \mu(E_g - F_n + F_S) = (a + f + e) - \mu E$$

$$\therefore \frac{dE}{dt} = (a + f + e) - \mu E \geq -\mu E$$

$$\therefore \frac{dE}{dt} \geq -\mu E$$

Integrating both sides

$$\int \frac{dE}{dt} = -\int \mu E \qquad (1)$$

Using integration by separation of variable to find the solution to (1)

$$\int \frac{dE}{E} = -\int \mu dt$$
$$\ln E = -\mu t + c$$

Taking the exponential of both side

$$\ell^{\ln E} = e^{-\mu t + c}$$
$$E(t) = Be^{-\mu t} \qquad (2)$$
$$where \;\; B = e^{c}$$
$$at\, t = 0$$
$$E(0) = B$$

Putting the values of B into (2)

$$E(t) = E(0)e^{-\mu t} \geq 0 \qquad (3)$$

Which verifies that the solution to the model entire model for E(t) and all compartments exist and is positive.

3.5 Stage II of the Study (The model with the introduction of optimal control variable)

3.5.1 The Model Problem with the inclusion of control variable u(t)

In this segment of the study, we let the control variable u(t) to be the minimizing efforts needed to control the adverse effect of some faulty monetary and fiscal policies on an economy or economic growth. And the u(t) stands for some economic variables such as minimal inflation rate, employment generation and other contending control variables like strengthened governmental legislation and adequate value reorientation, reward for dignity of labour, fair prices/taxes, welfare and basic amenities for citizens.

Thus, the model in equation (1) could be re-written with the inclusion of the optimal control variable u(t) as below:

$$\left.\begin{aligned}
\frac{dE_g}{dt} &= a + bF_S E_g(1-u) + cE_g F_n(1-u) - \mu E_g \\
\frac{dF_n}{dt} &= f - cE_g F_n(1-u) - \mu F_n - dF_n F_S \\
\frac{dF_S}{dt} &= e - bF_S E_g(1-u) - \mu F_S + dF_n F_S
\end{aligned}\right\} \qquad (4)$$

Thus the optimal control problem for the model is a minimization problem since the study is interested in minimising the adverse effect of some fauty monetary and fiscal policies on the Nigerian economy. And in a standard optimal control form, the problem could be written as below:

$$\left.\begin{aligned}
&\underset{u}{Minimise} \int_0^{T_{end}} (E_g(t) + \frac{1}{2}Au^2(t))dt \\
&Subject\ to: \\
&\frac{dE_g}{dt} = a + bF_S E_g(1-u) + cE_g F_n(1-u) - \mu E_g \\
&\frac{dF_n}{dt} = f - cE_g F_n(1-u) - \mu F_n - dF_n F_S \\
&\frac{dF_S}{dt} = e - bF_S E_g(1-u) - \mu F_S + dF_n F_S
\end{aligned}\right\} \quad (5)$$

Where from equation (5), A also means a rate measure of the relative or total impact of control management of the entire national economy from crashing or dying as related to u(t).

After the optimal control model was ready, we perfomed the following procedures

i. Compute the optimal control numerically .
ii. Investigate how the optimal control process depends on various parameters and variables of the model.

4. RESULTS AND DISCUSSION

In this section, the model represented in equation (5) is the general model for the entire interaction dynamics between the components of the economy studied in this research. But in the first stage of our analysis, we analyzed for the impacts of only the fiscal and monetary policies on the Nigerian Economic growth. This was achieved by setting u(t)=0 in equation (5). However, in the second stage of the model's analysis, we varied the impacts of u(t) on the economy's models at u(t)=25%, 50%. 75% and 95% respectively.

4.1 The solution to the First Stage of the Model's Analysis (When u(t)=0)

At this point, both fiscal and monetary policy exerts impact on economic growth.

4.2 Remarks/Discussion of the first Stage of the Model's Analysis

From the Table 1 and Fig. 2, it could be observed that the model was simulated with the data such that in the first month, the economy has 40.7% growth, where the contribution of the monetary and fiscal policies were at the rates of 28.6% and 26.36% respectively. But midway into the year, it was observed that the economy has recorded 63.39% growth, where the contribution of the monetary and fiscal policies were at the rates of 57.55% and 81.6% respectively as well. However, at the last month of the year, it was observed that the economy has recorded a remarkable growth rate of 91.7%, where the contribution of the monetary and fiscal policies were at the rates of 59.4% and 162.4% respectively. The implication of the model analysis showed clearly that initially, at the beginning of a year, when a higher amount or so much of monetary policies and promises are being made with lesser effort on fiscal policies, it could be assumed that the greater monetary policies is what gives rise to higher economic growth. But midway into the year, it was observed that for a continuous and increasing economic growth, higher and concerted efforts must be channeled towards fiscal policies. The same trend continued for the remaining parts of the year where it was observed that for a maximum economic growth, the efforts channeled towards fiscal policies must even double the efforts ascribed to its monetary counterpart.

This also showed that the fiscal policies can sustain an economic growth even if some few monetary policies are failing. This study therefore recommends that the government has to be deliberate about maintaining her fiscal policies even in the midst of failing monetary policies for a stable economic boost.

4.3 The solution to the Second Stage of the Model's Analysis (When values of u(t) were varied)

As mentioned in section 4.0, in this subsection, we varied values of the optimal control variable in order to see the actual level/amount of the general policy making effort is needed for a continuous economic boost in Nigeria.

4.3.1 Solution to the model problem with the control variable, u(t)= 0.25

At this point there is no significant impact of monetary policy on economic growth.

4.3.2 Solution to the model problem with the control variable, u(t) = 0.5

At this point, there is a noticeable impact between monetary policy and economic growth.

4.3.3 Solution to the model problem with the control variable, u(t) = 0.75

At this point, there is a more noticeable impact of monetary policy on economic growth.

4.3.4 Solution to The Model Problem with the control variable, u(t) = 0.95

At this point, both monetary and fiscal policy have continuous impact on economic growth.

4.4 Remarks/Discussion of the Second Stage of the Model's Analysis

Just as the case of the current day Nigeria at 2023, the monetary policies may be said to be very weak which has led [the exchange rate in the parallel market to be one dollar = ₦1200 with a very high inflation rate of 22.41%]; but this does not mean that the Nigeria economy will crash (or Eg = 0). This is attributed to the control measures: the present and continuous strength of fiscal policy (Fs) from the optimal control graphs.

As at n = 0 (E_g, F_n and F_s); there is meeting point (noticeable impact) of F_s on E_g but that of F_n and E_g (was not noticeable).

As at when u = 0.25, there was continuous meeting point (noticeable impact of F_s and E_g just as it was when n = 0 but no significant impact of F_n on E_g

As at when U= 0.5, In this case there is noticeable impact between F_g on E_g but there is a very near impact of F_n on E_g; although it is too glaring.

As at when U = 0.75, this time, there was a none negligible impact of F_n on E_g. this impact is so close that E_g almost began to assume the slope of the F_n or the nation where F_s and F_n continue to impact on each other

As at when U is = 0.95, this stage is when the control is at optimal such that both the F_n and the F_s have continuous and several impact on E_g of a nation.

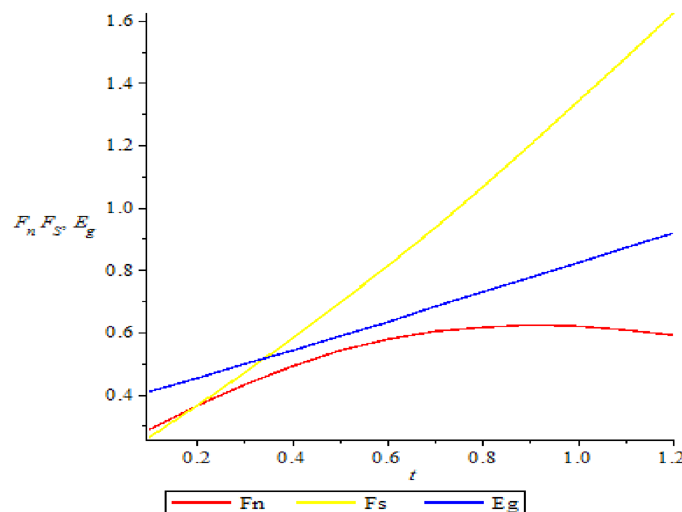

Fig. 2. Graphical profile Solution to The Model Problem when control variable, u(t) = 0

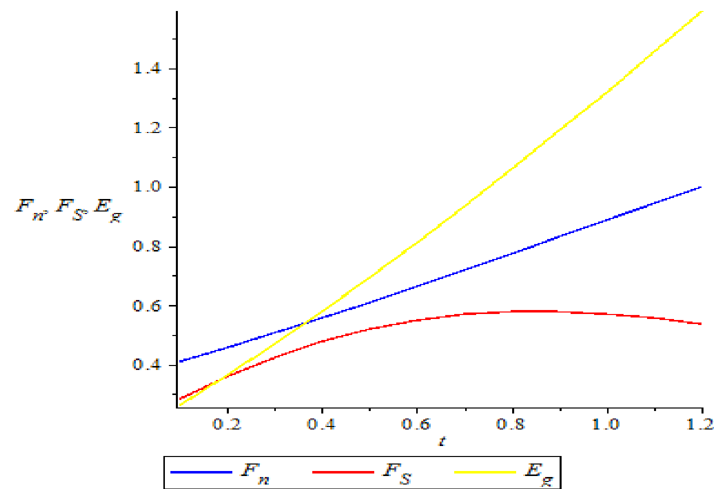

Fig. 3a. Graphical profile Solution to The Model Problem when control variable, u(t) = 0.25

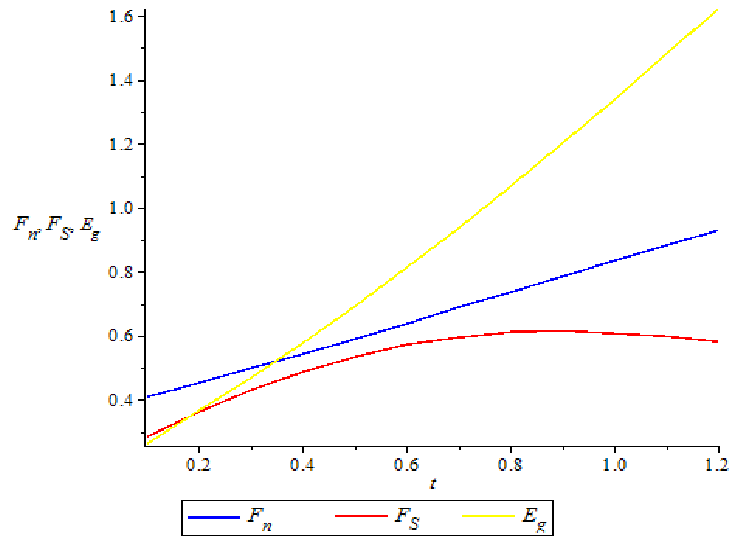

Fig. 3b. Graphical profile Solution to the model problem when control variable, u(t) = 0.5

Table 1. the solution to the model's system of equations when the control variable, u =0

T	Eg	Fn	Fs
0.1	0.408	0.286	0.264
0.2	0.452	0.364	0.365
0.3	0.496	0.433	0.469
0.4	0.542	0.491	0.578
0.5	0.587	0.539	0.692
0.6	0.634	0.576	0.811
0.7	0.681	0.601	0.935
0.8	0.728	0.617	1.065
0.9	0.776	0.622	1.199
1.0	0.823	0.618	1.338
1.1	0.870	0.608	1.479
1.2	0.917	0.590	1.624

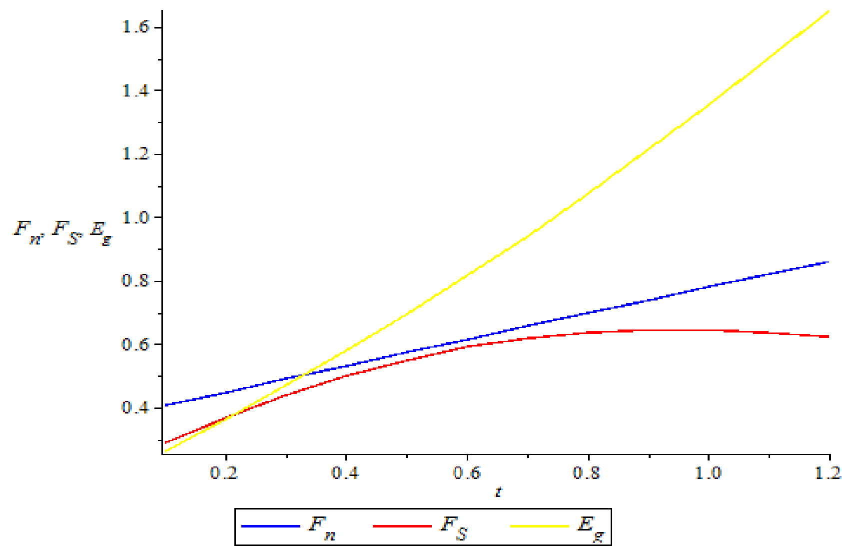

Fig. 4. Graphical profile Solution to The Model Problem when control variable, u(t) = 0.75

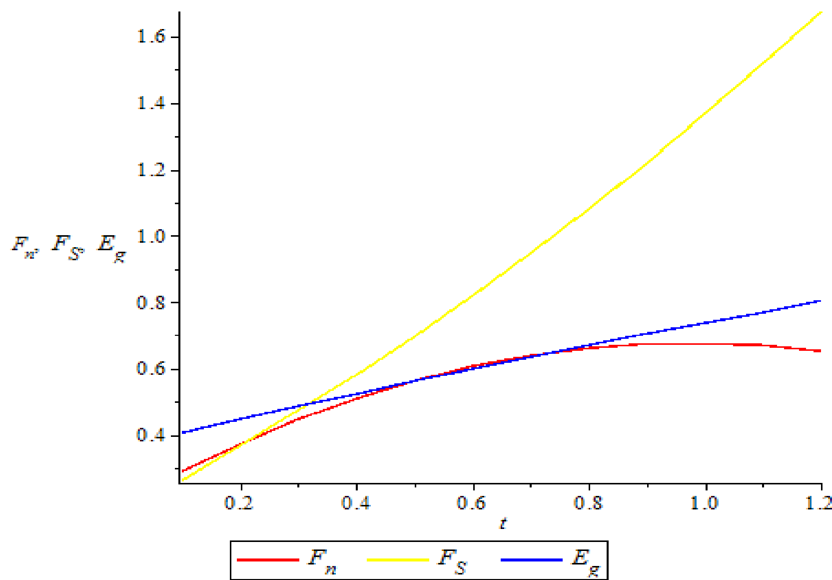

Fig. 5. Graphical profile Solution to The Model Problem when control variable, u(t) = 0.95

5. CONCLUSION

This study examined the application of optimal control modelling procedure for determining the impact of the Nigerian monetary and fiscal policies on its economic growth, using data from the sixth National Development Plan. The study was divided into two stages; the first stage of the analysis showed that the fiscal policy (F_s) can sustain economic growth (E_g) even if some monetary policies (F_n) are failing. In the second stage of the study, the variables were subjected to Optimal Control Modelling in order to know the level/magnitude of the policy making effort needed for a continuous economic boost in Nigeria. Result revealed that monetary policy (F_n) is weak, that fiscal policy (F_s) exerts more impact on the economy during the implementation of the sixth NDP. This result is in line with the studies of Umar and Murtala [25], and Bodunrin [20]. Hence from the findings of this study, in order to enjoy tangible and multiplicity of both F_n and F_s on the Nigerian economy, some macroeconomic variables such as inflation, employment, and other control variables such as strengthened legislation and adequate value reorientation,

reward for dignity and labour has to be strengthened and sustained.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://prh.globalpresshub.com/review-history/1486