



# Mathematical Model for Determining the Impact of Macroeconomic Policies on Standard of Living in Nigeria in the Fourth Republic

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**ABSTRACT:** This study examined the impact of macroeconomic policies on standard of living in Nigeria in the fourth republic. The study utilized mathematical model as a tool for analysis. Macroeconomic policy documents were reviewed from four administrations (Obasanjo's NEEDs document, Yar'adua/Goodluck's seven points agenda, Goodluck's transformation and the Buhari change and next level document). Twenty households were examined in the area of their income size, family size, expenditure level, social status and the general inflation rate. The model was validated in order to view the difference between the predictions of the model and the real-life data sourced for the study. The outcome of the comparison between the predictions of the model and the real-life data showed a higher correlation which thus recommends the model as an alternative modified model for measuring Nigeria's standard of living. Similarly, a variable sensitivity analysis of the model was verified in order to test the sensitivity and impacts of each variable in the model. The result showed that inflation ( $I_r$ ) of a nation has the highest negative impact on a citizen's standard of living followed by Expenditure level ( $E$ ) and finally the family size ( $F$ ) of an individual. The study recommended that since Inflation rate ( $I_r$ ) of a nation has the highest negative impact on a citizen's standard of living, favourable policies should be put in place to reduce national inflation rate which will in turn raise standard of living of the citizens.

**KEYWORDS:** Mathematical Model, Microeconomics, Inflation Rate, Standard of Living, Nigeria.

## INTRODUCTION

Over time, poverty, hunger, gender discrimination, lack of equal educational opportunities for women, high infant and maternal mortality rate, and other social problems has become prevalence in many countries of the world. While some countries are committed to solving some of these problems, others seem not to have woken up to the reality of the day. And these problems unattended to have rendered citizens extremely poor and nations crisis prone. In the

committee of countries, Nigeria is crawling when statistics are considered regarding the measures put on ground towards the achievement of economic comfort for its citizens as documented in the sustainable development goals (SDGs). In the light of the above problems, the issue of development has become pertinent and has called for the attention of scholars in the last few decades.

There is no doubt, there are different standpoint to development, however, there is a general consensus that development will lead to transformation evidenced in increased capacity of people to obtain basic necessities of life (food, clothing and shelter), employment, equal participation in government, political and economic independence, adequate education, gender equality, sustainable development and peace [1]. World statistics has shown that more than 1.2 billion people or about 20 percent of world population live or survive on less than US \$1 per day [2]. The UNDP in its 2021 report documented that the three richest people in the world have assets that exceed the combined Gross Domestic Product (GDP) of 48 developing countries. Similarly, the 1000 richest people in the world have personal wealth greater than 500 million people in developing countries. In Nigeria, about 95 percent of the total wealth is domicile in the hands of 5 percent population, while the other 5 percent wealth is domicile in the hands of 95 percent of the population. According to [3], life expectancy for Nigeria has been further reduced to an average of 52 years for men and 53 years for women respectively.

In attempt to bridge the gap above and improve standard of living for vast population, Nigeria has consistently updated her macroeconomic policies since the return of democracy in the fourth republic to accommodate changes created by the forces of demand and supply in the economy as part of the agenda of SDGs. For example, the Obasanjo led administration introduced the National Economic Empowerment Development Strategies (NEEDS) which was accepted to be one of the soundest economic policies ever in the country in 2003 with the sole objective of poverty alleviation. The policy did record some measure of successes in economic growth, however, as good as the policy document was, it was jettison as the administration ended [4].

The seven-point-agenda was introduced at the emergence of new administration in 2007 by the late president Yar'Adua led administration with the aim of improving the standard of living of the citizen and achievement of economic comfort. His policy focus was to improve power and energy, ensure food security, wealth creation, develop the transport sector, land reform, ensure security, and provide education for all. As fine and good as this policy was, it was truncated as the proponent was lost to the cold hands of death [5].

As Goodluck took over the mantle of leadership in 2011, he came with a vision to rapidly develop the economy, to achieve this, the vision was encoded in a policy document called 'transformation agenda' to turn the country around and give it a new sense of direction. The agenda draws its inspiration from vision 20:2020 and previous National Development Plans (NDPs) which had been in place before he took the mantle of leadership. Summarily, the transformation agenda include; a macroeconomic framework for economic direction, job creation, better power supply, justice and judicial autonomy, addressing governance challenges, human capital development, improving transportation through evolving a multi modal, integrated sustainable transportation system with more emphasis on rail and inland waterways transportation. It was obvious that this policy was achieved to a reasonable extent as life was becoming better for the citizens evidenced in reduction in unemployment, increase in literacy rate and per capita income, before the 2015 general election which led to a birth of new administration [6].

As the Buhari led administration took over the mantle of leadership in 2015, it has since then introduced several macroeconomic policies, such as the change document, next level policy document, Economic Recovery Growth Plan (2017-2020), and the recent sixth National Development Plan (2021-2025). The vision of the sixth NDP is consistent with the pursuit of socio-economic transformation of the country as envisioned in the long-term aspiration of Nigeria, encapsulated in the Nigeria Agenda 2050. The Plan also builds 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 5 percent on average during the plan period, increased 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 [7].

A question may be asked, to what extent has the macroeconomic policies introduced since the return to democracy been achieved, and to what extent has it improved the standard of living of the people? These questions indeed, form the crux of the focus of this paper which attempts to assess the connection between these policies since the fourth republic and how these are likely to affect the standard of living of Nigerians.

It is no doubt that government parameter as underscored by the work of [8] harshly affect the standard of living of every citizen of a particular nation. But unlike government parameter which is solely a manifestation of governmental policies and activities, inflation on the other hand is an economic variable that is jointly created by the citizens themselves and some failed governance perspectives and regulations. Inflation could be said to be stimulated by an economic set of variables that have both direct and indirect influence on the standard of living of the citizens. The work of [9] explicitly formulated a standard of living model for macroeconomic policies and standard of living in Nigeria, but the variables considered by their work are not all the main variables that could influence the standard of living of any citizen per time. Thus, the interest of this study is to incorporate inflation rate of Nigeria in their model and formulate a modified model from their work using their sourced data. However, their income data was modified by adding the minimum wage of 30,000 to reflect the present-day reality.

## LITERATURE REVIEW

[9] studied Nigerians' standard of living and the achievement of first item on the vision 20;2020, using mathematical model. Result showed that there is no specific standard of living value that can momentarily stop human existence but the snag indicated based on the work is that, those whose standard of living is critical (very close to zero percent) can take to negative ways of getting income in order to survive and thus, pose a challenge to the achievement of the overall vision 2020. This study is criticized on the ground that it does not include minimum wage to its income schedule, and inflation rate was not captured in their model.

National Bureau of Statistics (NBS) produced an individual Nigerian's Standard of Living result according to [11], the Statistician General of the federation in a press briefing classifying in their result Nigerian into (a) Food poverty (b) Absolute poverty and (c) Relative poverty categories using questionnaire and Voice-of-the- people approach. But the agency did not implore the use of mathematical modeling approach in their research.

[12] researched on the impact of Nigeria's fiscal policies on standard of living using data obtained from the Central Bank of Nigeria (CBN) and the Nigeria Bureau of Statistics from

1980 to 2016. The study adopted the Modified Least Square method, and result revealed that increase in employment had positive and significant impact on standard of living. However, the secondary data used in the work is criticized on the ground that the data might not be specific to the need of the researcher, he may not have control over the data quality, it may be bias and not timely. The gap noticed in the published literature reviewed is the reason and the uniqueness of this current study. However, the significant difference between this study and that of [9] is that this study introduced inflation rate of Nigeria and modified the income schedule by adding the minimum wage of 30,000 into their model to reflect the present-day reality.

## RESEARCH METHODOLOGY

In this section we considered the subheading below as they unfold.

### *Model Formulation*

Under this heading we shall make some basic assumptions needed to give us a model that conforms to reality.

Basic Assumptions:

Here, we highlighted the form of mathematical relationships that exist between standard of living and the set of parameters that influences it.

Standard of Living (S) versus a Nation's Inflation rate (Ir) on citizens:

A nation with a high Inflation rate (Ir) tends to have adverse effect on the individual citizen's economic purchasing power. Thus, we could remark that when the Standard of Living (S) of the citizen is low then it means the national Inflation rate (Ir) is high and vice-versa. Hence, Standard of Living is inversely proportional to Inflation rate as shown mathematically in equation (3.1) below.

$$\begin{aligned} S &\propto \frac{1}{Ir} \\ \Rightarrow S &= \frac{C}{Ir} \end{aligned} \tag{3.1}$$

Standard of Living (S) versus Family Size, Income, Expenditure Level and Social Status of citizens:

From the work of [9], all the Standard of living variables (such as: family size (F), Income (I), Expenditure Level (E), Social Status (T)) influenced or connected by income can be mathematically expressed as:

$$S = K \left( \frac{A}{F} + \frac{BT}{E} \right) I \tag{3.2}$$

And thus, substituting our relationship between Inflation rate and individual's Standard of living expressed in equation (3.1) into equation (3.2) gives:

$$S = K \left( \frac{A}{F} + \frac{BT}{E} + \frac{C}{Ir} \right) I \tag{3.3}$$

Now setting  $\alpha = KA$ ,  $\beta = KB$ ,  $\gamma = KC$  in equation (3.3) gives:

$$\therefore S = \frac{\alpha I}{F} + \frac{\beta TI}{E} + \frac{\gamma}{Ir} \quad (3.4)$$

Where: S = Standard of living

I = Income

Ir = Inflation rate

F = Family Size

E = Expenditure Level

T = Social Status and

$\alpha, \beta, \gamma$  are constants.

Hence, equation (3.4) is our modified model for determining the Standard of living of Nigerians.

#### *Data and Source of Data*

This study utilized a secondary set of data for its analysis. Also, the income values column of the work of [9], since it does not reflect the current day reality was modified by adding the current minimum wage of ₦30,000 across each data and inflation rate which is constant for all the family was introduced as shown in Table 1 below.

**Table 1: Sourced data on standard of living variables**

<b>2022 Salary/ Income (I) in ₦</b>	<b>Family size (F)</b>	<b>Expenditure level (E) per month in (%)</b>	<b>Social status/Societal Expectation (T) in (%)</b>	<b>Inflation rate (Ir) in (%)</b>	<b>Standard of living (S) in (%)</b>
37500	8	0.2	0.5	0.21	52
41000	3	0.6	0.6	0.21	48
37000	1	0.6	0.6	0.21	54
50500	9	0.4	0.6	0.21	50
37000	4	0.2	0.4	0.21	40
37700	5	0.6	0.6	0.21	52
41000	2	0.4	0.6	0.21	72
37300	7	0.2	0.4	0.21	41
45000	5	0.8	0.7	0.21	58
40000	7	0.8	0.7	0.21	55

43500	3	0.6	0.6	0.21	62
41500	8	0.6	0.8	0.21	55
34500	1	0.6	0.6	0.21	51
35000	1	0.4	0.5	0.21	53
55000	1	0.8	0.75	0.21	94
37000	3	0.4	0.4	0.21	52
51000	2	0.6	0.7	0.21	73
37800	2	0.8	0.6	0.21	52
40000	8	0.6	0.7	0.21	56
50000	1	0.9	0.6	0.21	74

**Source:** survey report from the work of [9] with the modified income values by adding the Nigeria's 2022 minimum wage to each of the respondent's monthly income/salary and inclusion of annual inflation rate.

The next step to take is to harmonize the data in table 1 in order to help in evaluating the model equation constants in equation (3.4). To achieve this, we employed the method of Least Squares Method to minimise the function in equation (3.4) using the functional below:

$$I_{\min} = \text{Min} \sum_{i=1}^{20} \left( S_i - \frac{\alpha I_i}{F_i} - \frac{\beta T_i I_i}{E_i} - \frac{\gamma I_i}{I_r} \right)^2 \tag{3.4}$$

Also, differentiating equation (3.4) partially with respect to each of the model constants gives:

$$\left. \begin{aligned} \frac{\partial I}{\partial \alpha} &= -2 \sum_{i=1}^{20} \left( S_i - \frac{\alpha I_i}{F_i} - \frac{\beta T_i I_i}{E_i} - \frac{\gamma I_i}{I_r} \right) \frac{I_i}{F_i} \\ \frac{\partial I}{\partial \beta} &= -2 \sum_{i=1}^{20} \left( S_i - \frac{\alpha I_i}{F_i} - \frac{\beta T_i I_i}{E_i} - \frac{\gamma I_i}{I_r} \right) \frac{T_i I_i}{E_i} \\ \frac{\partial I}{\partial \gamma} &= -2 \sum_{i=1}^{20} \left( S_i - \frac{\alpha I_i}{F_i} - \frac{\beta T_i I_i}{E_i} - \frac{\gamma I_i}{I_r} \right) \frac{I_i}{I_r} \end{aligned} \right\} \tag{3.5}$$

But at turning point/optimal point, we have a state of equilibrium where:

$$\frac{\partial I}{\partial \alpha} = \frac{\partial I}{\partial \beta} = \frac{\partial I}{\partial \gamma} = 0.$$

Thus, equation (3.5) becomes;

$$\left. \begin{aligned} -2 \sum_{i=1}^{20} \left( S_i - \frac{\alpha I_i}{F_i} - \frac{\beta T_i I_i}{E_i} - \frac{\gamma I_i}{I_r} \right) \frac{I_i}{F_i} &= 0 \\ -2 \sum_{i=1}^{20} \left( S_i - \frac{\alpha I_i}{F_i} - \frac{\beta T_i I_i}{E_i} - \frac{\gamma I_i}{I_r} \right) \frac{T_i I_i}{E_i} &= 0 \\ -2 \sum_{i=1}^{20} \left( S_i - \frac{\alpha I_i}{F_i} - \frac{\beta T_i I_i}{E_i} - \frac{\gamma I_i}{I_r} \right) \frac{I_i}{I_r} &= 0 \end{aligned} \right\} \quad (3.6)$$

Dividing both sides of equation (3.6) by -2 and opening the brackets gives:

$$\left. \begin{aligned} \sum_{i=1}^{20} \frac{S_i I_i}{F_i} &= \alpha \sum_{i=1}^{20} \left( \frac{I_i}{F_i} \right)^2 + \beta \sum_{i=1}^{20} \frac{T_i I_i^2}{E_i F_i} + \gamma \sum_{i=1}^{20} \frac{I_i^2}{I_r F_i} \\ \sum_{i=1}^{20} \frac{S_i T_i I_i}{E_i} &= \alpha \sum_{i=1}^{20} \frac{T_i I_i^2}{E_i F_i} + \beta \sum_{i=1}^{20} \left( \frac{T_i I_i}{E_i} \right)^2 + \gamma \sum_{i=1}^{20} \frac{T_i I_i^2}{I_r E_i} \\ \sum_{i=1}^{20} \frac{S_i I_i}{I_r} &= \alpha \sum_{i=1}^{20} \frac{I_i^2}{I_r F_i} + \beta \sum_{i=1}^{20} \frac{T_i I_i^2}{I_r E_i} + \gamma \sum_{i=1}^{20} \left( \frac{I_i}{I_r} \right)^2 \end{aligned} \right\} \quad (3.7)$$

Therefore, the equation (3.7) is going to be solved using the multiplication computation values from table 1. And to achieve that, we perform a new multiplication computation as obtained in the tables below.

**Table 2: Multiplication of the data in table**

	SI/F	(I/F) <sup>2</sup>	T*I <sup>2</sup> /E*F	I <sup>2</sup> /F*I <sub>r</sub>	STI/E	I <sup>2</sup> *T/I <sub>r</sub> *E	S*I/I <sub>r</sub>
	200000	25000000	2.33E+08	952380952	1866667	8888888889	7619048
	2900000	2.5E+09	1.67E+09	1.19E+10	1933333	7936507937	13809524
	243750	21972656	4.39E+08	837053571	4875000	1.6741E+10	9285714
	656000	1.87E+08	5.6E+08	2.668E+09	1968000	8004761905	9371429
	1961000	1.37E+09	1.37E+09	6.519E+09	1961000	6519047619	9338095
	370333.3	31484568	4.25E+08	1.349E+09	4999500	1.8216E+10	15871429
	370000	85562500	6.85E+08	1.63E+09	2960000	1.3038E+10	7047619
	271440	56851600	2.84E+08	1.354E+09	1357200	6768047619	6462857
	1476000	4.2E+08	1.26E+09	4.002E+09	4428000	1.2007E+10	14057143
	218471.4	28393673	3.98E+08	946455782	3058600	1.325E+10	7282381
	522000	81000000	3.54E+08	1.929E+09	2283750	8437500000	12428571
	314285.7	32653061	2E+08	1.088E+09	1925000	6666666667	10476190

	899000	2.1E+08	6.31E+08	3.004E+09	2697000	9010714286	12842857
	285312.5	26910156	2.87E+08	1.025E+09	3043333	1.0935E+10	10869048
	1725000	1.19E+09	1.19E+09	5.668E+09	1725000	5667857143	8214286
	1995000	1.23E+09	1.53E+09	5.833E+09	2493750	7291666667	9500000
	5170000	3.03E+09	2.84E+09	1.44E+10	4846875	1.3504E+10	24619048
	468666.7	1.52E+08	4.56E+08	2.173E+09	1406000	6519047619	6695238
	1657500	6.5E+08	1.52E+09	6.193E+09	3867500	1.445E+10	15785714
	661500	3.57E+08	5.36E+08	3.402E+09	992250	5103000000	6300000
<b>SUM</b>	<b>22365260</b>	<b>1.17E+10</b>	<b>1.69E+10</b>	<b>7.688E+10</b>	<b>54687758</b>	<b>1.9896E+11</b>	<b>2.18E+08</b>

**Table 3: Multiplication of the data in table continued**

	$(I/Ir)^2$	$(T*I/E)^2$	I/F	T/I/E	Ir*I
	36281179138	2.18E+09	2E+08	1.87E+09	3.36E+08
	56689342404	1.11E+09	2.5E+09	1.67E+09	5.25E+08
	31887755102	8.79E+09	1.76E+08	3.52E+09	2.95E+08
	38117913832	1.68E+09	5.6E+08	1.68E+09	3.53E+08
	31043083900	1.37E+09	1.37E+09	1.37E+09	2.87E+08
	57828798186	5.74E+09	2.83E+08	3.83E+09	5.36E+08
	31043083900	5.48E+09	3.42E+08	2.74E+09	2.87E+08
	32228798186	1.42E+09	2.84E+08	1.42E+09	2.98E+08
	38117913832	3.78E+09	8.41E+08	2.52E+09	3.53E+08
	31548526077	5.57E+09	1.99E+08	2.78E+09	2.92E+08
	45918367347	1.55E+09	4.05E+08	1.77E+09	4.25E+08
	36281179138	1.23E+09	2.29E+08	1.4E+09	3.36E+08
	42908163265	1.89E+09	6.31E+08	1.89E+09	3.97E+08
	39053287982	3.06E+09	2.15E+08	2.3E+09	3.62E+08
	26989795918	1.19E+09	1.19E+09	1.19E+09	2.5E+08
	27777777778	1.91E+09	1.23E+09	1.53E+09	2.57E+08
	68594104308	2.66E+09	3.03E+09	2.84E+09	6.35E+08
	31043083900	1.37E+09	4.56E+08	1.37E+09	2.87E+08
	58979591837	3.54E+09	1.3E+09	3.03E+09	5.46E+08
	32400000000	8.04E+08	7.14E+08	1.07E+09	3E+08



<b>SUM</b>	<b>7.94732E+11</b>	<b>5.63E+10</b>	<b>1.61E+10</b>	<b>4.18E+10</b>	<b>7.36E+09</b>
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Hence, from the summation of the data in Tables 2 and 3, we have that:

$$\left. \begin{aligned}
 \sum_{i=1}^{20} \frac{S_i I_i}{F_i} &= 22365260, \quad \sum_{i=1}^{20} \left( \frac{I_i}{F_i} \right)^2 = 1.17E + 10, \\
 \sum_{i=1}^{20} \frac{T_i I_i^2}{E_i F_i} &= 1.69E + 10, \quad \sum_{i=1}^{20} \frac{I_i^2}{I_r F_i} = 7.688E + 10 \\
 \sum_{i=1}^{20} \frac{S_i T_i I_i}{E_i} &= 54687758, \quad \sum_{i=1}^{20} \left( \frac{T_i I_i}{E_i} \right)^2 = 5.63E + 10, \\
 \sum_{i=1}^{20} \frac{T_i I_i^2}{I_r E_i} &= 1.9896E + 11, \quad \sum_{i=1}^{20} \frac{S_i I_i}{I_r} = 2.18E + 08, \quad \sum_{i=1}^{20} \left( \frac{I_i}{I_r} \right)^2 = 7.94732E + 11
 \end{aligned} \right\} \tag{3.8}$$

And by substituting the values in equation (3.8) into equation (3.7) and solving the resulting system of equations, showed that:

$$\left. \begin{aligned}
 \alpha &= 0.0003986706515 \\
 \beta &= 0.0001683234738; \\
 \gamma &= 0.0001934443187
 \end{aligned} \right\} \tag{3.9}$$

Hence, Putting the values of equation (3.9) into (3.4) gives:

$$\therefore S = \frac{0.0003986706515I}{F} + \frac{0.0001683234738TI}{E} + \frac{0.0001934443187I}{I_r} \tag{3.10}$$

Therefore, equation (3.10) is our modified formulated model for estimating Nigerians' standard of Living. And by mere substitution of every citizens values for F, E, T, I and Ir into our equation (3.10) will give the approximate standard of living of that citizen.

*Validation of the model*

In this section, the extent to which our formulated could be said to be valid was ascertained by comparing the sourced data and the model predictions. This could be found in the table below.

**Table 4: Validation and comparison between real-life data and our model predictions**

S/N	S	Model (Sm)
1	56	53.43939
2	74	76.10713
3	52	44.60484
4	48	56.80718
5	54	54.96395
6	50	65.5122

7	40	46.73666
8	52	51.48111
9	72	55.5791
10	41	46.51631
11	58	62.06774
12	55	54.82857
13	62	60.27103
14	55	54.68328
15	51	51.25017
16	53	51.03137
17	94	82.08092
18	52	51.26501
19	73	71.00314
20	52	54.35665

**Remarks:** From the table data shown above, since the difference between each of the data from both the real-life data and our model predicted standard of living values of Nigerians are minimal both values are approximately the same, the we can conclude that the model is suitable for use by the would-be users of this model.

### 3.4 Sensitivity Analysis of the Model

This section computes the sensitivity index of each of the standard of living variables. A mathematical software called MAPLE18 (with details as shown in the Appendix section of this work) was used for the variable sensitivity index computation.

**Table 5: Sensitivity index table**

S/N	Model Variables	Sensitivity Index
1	Income (I)	1.000000001
2	Family size (F)	- 0.08197541010
3	Expenditure level (E)	- 0.1509085921
4	Inflation rate (Ir)	- 0.7671159978
5	Social Status (T)	0.1509085921

**Remarks:** From the table data shown above, the variable that has the highest negative impact on the standard of living of Nigerians is the inflation rate. This tends to confirm the motivation for this study.

## CONCLUSION

In this study, an existing model on the standard of living of Nigerians was modified with the inclusion of National Inflation rate that bites on every individual's income, purchasing power

and his/her standard of living. The model was validated in order to view the differences between the predictions of the model and the real-life data sourced for the study. But the outcome of the comparison between the predictions of the model and the real-life data showed a higher correlation which thus recommends the model as an alternative modified model for measuring Nigerians' standard of living. Similarly, a variable sensitivity analysis of the model was verified in order to test the sensitivity and impacts of each of the model variables. The analysis from table 5, showed that Inflation rate (Ir) of a nation has the highest negative impact on a citizen's standard of living followed by Expenditure level (E) and finally the family size (F) of an individual. Thus, as a recommendation, since Inflation rate (Ir) of a nation has the highest negative impact on a citizen's standard of living, therefore, favourable policies and economic legislations that will reduce national Inflation rate which will in turn raise the standard of living of the citizens has to be prioritize.

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