INTERNATIONAL JOURNAL OF RESEARCH AND INNOVATION IN APPLIED SCIENCE (IJRIAS)
ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume IX Issue X October 2024

Dynamic Parameter Model for Assessing the Relationship between Money Supply and Economic Growth in Nigeria

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DOI: https://doi.org/10.51584/IJRIAS.2024.910016

Received: 27 September 2024; Accepted: 03 October 2024; Published: 07 November 2024

ABSTRACT

The research explores the dynamic relationship between money supply growth (M2) and GDP growth in Nigeria from 2008 to 2023 using a state-space modeling approach. The model effectively captures the relationship between M2 growth and GDP growth, highlighting the importance of M2 as an explanatory factor. The results show a low and statistically significant standard deviation of the observation error, suggesting the model explains GDP variations well. However, the state transition equation indicates a mostly deterministic evolution of unobserved state variables. While the model fits reasonably well according to the log-likelihood value, the study aims to address the limited empirical research on this relationship in Nigeria's transitional, post-conflict economy. By employing a dynamic parameter state-space model, the researchers seek to capture the potentially changing nature of this relationship over time, moving beyond traditional econometric models that assume fixed relationships. The study draws on various macroeconomic theories, including the quantity theory of money, endogenous growth theory, and state-space models. The log-likelihood value shows that this model fits reasonably well, yet the study notes that other models & more macroeconomic factors should be examined further. Consistent with theoretical predictions, the results highlight the money supply's vital role in economic growth. To deepen our grasp of how M2 relates to GDP growth, this study suggests that future research might explore more complex dynamics—such as non-linear associations and potential impacts of external shocks. These findings could significantly influence macroeconomic forecasting & monetary policy. The findings support theoretical predictions about the role of money supply in economic growth, but the study suggests future research should explore more complex dynamics, such as non-linear associations and potential impacts of external shocks.

Keywords: Money Supply, Economic Growth, State-Space Model, Time-Varying Parameters, Nigeria, Monetary Policy

INTRODUCTION

Background

Macroeconomic theory & policy have long emphasized how the money supply connects to economic growth (Awwad, 2021). Historically, schools like classical & monetarist have focused on the importance of managing this money supply to influence economic performance. However, modern views—especially in developing nations—suggest that this relationship is more complex and may change over time (Choudhury, 2021).

Nigeria presents a unique situation for examining this relationship. It's a post-conflict economy that is in transition. Over the last two decades, Nigeria's economy has seen significant changes. Factors like foreign aid, remittances, & shifts in monetary policies have all played a role (Williams, 2020). Yet, despite these changes, the effect of fluctuations in the money supply on Nigeria's economic growth lacks extensive empirical study. This lack of research stands out, especially when considering the perspective of a dynamic system.

While several studies have explored the link between money supply and economic growth, research specifically focusing on Nigeria is limited. Moreover, not much has been done using methods that take into account relationships that vary over time. Traditional econometric models tend to assume a fixed link over time. Unfortunately, this might not capture the complexities of an economy that's rapidly evolving. Therefore, this

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research used a dynamic parameter state-space model. This model helps assess how the influence of money supply on economic growth in Nigeria shifts over time.

The link between money supply and economic growth has been widely explored across macroeconomic theories. For this study, the quantity theory of money, endogenous growth theory and the state-space models were applied.

Fisher and Friedman's classical economic theory assumes that changes in the money supply have a direct and proportional effect on pricing and economic production (Backhouse, 2020). Monetarist policies promote strict control over the money supply to maintain stable economic growth.

According to Mengesha and Singh (2023), Romer and Lucas' endogenous growth models imply that the money supply can influence long-term economic growth via capital accumulation, technical innovation, and productivity. The models imply that the money supply has an indirect impact on economic development by influencing investments in human capital and technology.

The state-space approach provides a framework for representing time-varying relationships (Camarero, Sapena, & Tamarit, 2020). It was initially developed for engineering and later expanded to economics. Unlike traditional econometric models, which assume constant parameters, state-space models allow for dynamic parameters that can change over time. This makes them particularly valuable for analysing transitional economies, such as Nigeria's.

Zhang, et al. (2023) investigated the effects of Chinese monetary policy on capital flows and the offshore Renminbi market. Using state space models, they investigated the dynamic linkages between capital flows, the Renminbi market, and monetary policy. Strong correlations between capital flows and policy changes were found by the research, indicating the effectiveness and consistency of monetary policy in influencing conditions in offshore markets. The findings highlight how important it is to include both domestic and global factors when assessing monetary policy's effects.

The paper by Awe and Adepoju (2020) aimed to improve the estimation of time-varying parameters in dynamic state space models by using discounted evolution variance. They created a Bayesian framework that incorporates discounted evolution variance to enable more precise modelling of dynamic systems with growing uncertainty. The Bayesian estimating method yields consistent findings even with discounted evolution variance, which enhances state space model predictions and provides insights into time-varying systems.

Bhatta, et al. (2021) examined the policy implications of the impossible trinity, or trilemma, in a small open economy by simulating various policy scenarios using state space models. The authors used state space models to understand trade-offs and policy decisions within the framework of the trilemma. The outcomes of the simulation offer crucial perspectives for decision-makers regarding capital mobility, monetary policy, and exchange rate management. Additionally, they highlighted the challenges tiny open economies confront in balancing impractical trinity constraints with desired economic results.

Arsad, Baharudin, and Rahman (2021) evaluated the dynamic relationship between stock prices and macroeconomic factors using the Kalman filter technique. This approach captures time-varying relationships and allows for time-varying parameter estimation. The results showed significant variations in the relationship between stock prices and macroeconomic factors across time, providing insight into how macroeconomic changes impact the dynamic behaviour of the stock market.

Bhatta, Nepal, Harvie, and Jayanthakumaran (2022) investigated the uncovered interest parity (UIP) condition in a small open economy using state space models. The writers used state space models to account for time-varying factors and structural changes in the economy to understand how UIP may be applied in different economic circumstances. The findings highlighted the importance of time-varying economic factors and validated the UIP condition in the examined economy.

METHODOLOGY

For Nigeria, this analysis makes use of yearly data from 2000 to 2023. The information comprises:

Money Supply (M2): This refers to the total amount of money in circulation as well as different kinds of deposits.

GDP: The gross domestic product, adjusted for inflation, is calculated using constant prices.

Data was sourced from the Central Bank of Nigeria and the World Bank's World Development Indicators.

Model Specification

A state-space model with dynamic parameters is used to depict the relationship between money supply and economic growth over time. The model forms are presented in (3.1) and (3.2) as follows:

$$y_t = \beta_t x_t + \epsilon_t \quad (3.1)$$

$$\beta_t = \beta_{t-1} + \eta_t \quad (3.2)$$

where:

y_t is the GDP growth rate at time t,

x_t is the growth rate of money supply at time t,

β_t represents the time-varying parameter, and

ϵ_t and η_t are error terms.

The Kalman filter, a recursive technique that yields estimates of the unobserved time-varying parameter, β_t, is used to estimate the model.

Estimation Procedures

Maximum Likelihood Estimation (MLE) is used to estimate the state-space model's parameters. The statistical program R incorporates the Kalman filter, enabling effective estimate of the time-varying coefficients.

RESULTS

Table 1: Summary Statistics, using the observations 2008 – 2023

Variable	M2	GDP
Mean	2.90E+09	6.47E+09
Median	2.54E+09	6.47E+09
Minimum	1.39E+09	4.58E+09
Maximum	5.49E+09	8.53E+09
Std. Dev.	1.23E+09	1.25E+09
C.V.	0.42378	0.19278
Skewness	0.77215	0.092921
Ex. Kurtosis	-0.48503	-1.1906
5% Perc.	undefined	undefined
95% Perc.	undefined	undefined
IQ range	1.88E+09	2.07E+09

Table 1 shows the summary statistics on Money Supply (M2) and Gross Domestic Product (GDP) from 2008 to 2023, providing an overview of the distribution and features of both economic variables over the observed period.

For M2, the average money supply over this period is approximately 2.90 billion, while the average GDP is around 6.47 billion. For M2, the median is slightly lower than the mean, suggesting a distribution that is slightly skewed to the right. For GDP, the median is very close to the mean, suggesting a fairly symmetric distribution. M2 has varied between 1.39 billion and 5.49 billion, while GDP has ranged from 4.58 billion to 8.53 billion. The range indicates the extent of variation in these variables over the period. Both M2 and GDP have similar levels of variability around their respective means, with GDP showing slightly more variation. M2 has a higher C.V. than GDP, suggesting that M2 is more volatile relative to its average value than GDP is. M2 has moderate positive skewness, indicating a right-skewed distribution, while GDP has very low skewness, indicating near symmetry. Both M2 and GDP exhibit negative kurtosis, with GDP having a more pronounced flatness. GDP has a slightly larger IQR than M2, indicating that the central 50% of GDP data has a wider spread than M2.

The data shows that GDP has a higher average value than M2 but is less volatile relative to its mean (as indicated by the C.V.). The distributions of both M2 and GDP are fairly symmetric, with M2 showing slightly more positive skewness. The lower kurtosis values suggest that both distributions are less peaked and have thinner tails compared to a normal distribution, particularly for GDP.

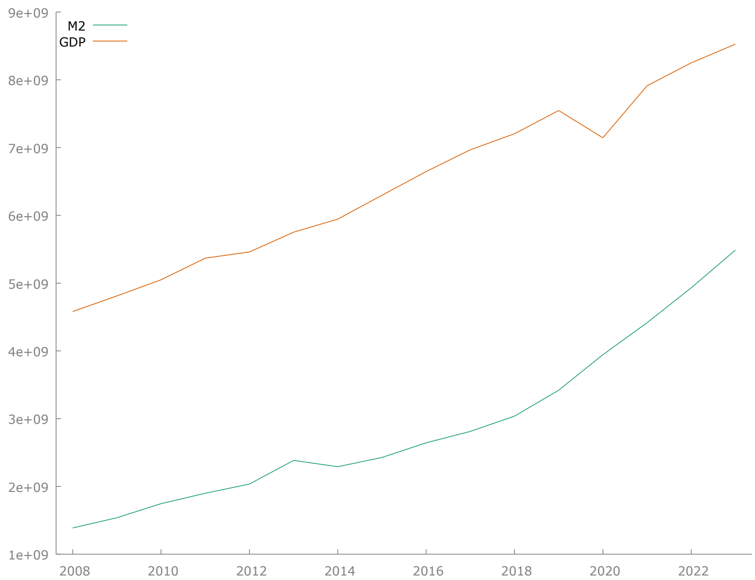

Fig. 1: Time plot for Money Supply and Gross Domestic Product, 2008-2023

Figure 1 shows the pattern and the relationship between **M2** (a broader measure of money supply) and **GDP** (Gross Domestic Product) over time.

Both M2 and GDP have exhibited consistent upward trends over the years. This suggests that both the economy and the money supply have been growing. There appears to be a positive correlation between M2 and GDP. As M2 increases, GDP tends to increase as well, and vice versa. This relationship is often seen as a sign of economic growth and development. The rate of growth of M2 seems to have fluctuated more than the rate of growth of GDP. There are periods where M2 grows more rapidly than GDP, and others where it grows more slowly.

State Space Modelling

Table 2: Observation equation

	Coefficient	std. error	z	p-value
stdev[1]	0.0325691	0.00615485	5.292	1.21e-07 ***

Table 2 shows the outcomes of the observation equation. The observation equation in a state-space model connects observed data to unobserved state variables.

The error term in the observation equation has an estimated standard deviation of 0.0325691. This represents the usual magnitude of variations from projected values owing to noise or measurement error. The z-statistic of 5.292 is high, and the p-value is exceptionally low (1.21e-07), indicating that the standard deviation is considerably distinct from zero. Given the low p-value, the finding is highly significant at conventional levels (e.g., 1%, 5%, or even 0.1%). This shows that the observation equation's error term has a non-zero standard deviation, which is approximated with high precision.

Table 3: State transition equation

	Coefficient	std. error	z	p-value
stdev[1]	1.64459e-09	0.00651196	2.525e-07	1.0000

Log-likelihood = 21.1982

Table 3 presents the results of the **state transition equation**. The state transition equation models how the unobserved state variables evolve, and the table provides statistical information about the coefficients associated with this equation.

The coefficient value ($1.64459\times10-9$) is extremely small, suggesting that the process noise is very close to zero, indicating a highly deterministic process. The standard error value of 0.00651196 is a measure of the precision of the coefficient estimate. In this case, the standard error is relatively large compared to the extremely small coefficient value. This discrepancy indicates that while the estimated coefficient is very small, there is considerable uncertainty around this estimate. The z-statistic is extremely small, reflecting the near-zero value of the coefficient. The small z-statistic suggests that the coefficient is not significantly different from zero. A p-value of 1.0000 suggests that the null hypothesis cannot be rejected; in other words, the coefficient is not statistically significant. In this context, the log-likelihood value of 21.1982 suggests a reasonable fit of the state-space model to the data, though this value should be interpreted relative to other models or benchmarks.

The standard deviation of the state transition equation's error term is estimated to be 1.64459e-09, which is extremely close to zero. This suggests that the process governing the evolution of the state variables is almost entirely deterministic, with negligible random noise.

However, the z-statistic is extremely small (2.525e−072.525e-072.525e−07), and the p-value is 1.0000, indicating that this coefficient is not statistically significant. This lack of significance means that the near-zero standard deviation estimate may not be reliable, and the model suggests that there is no meaningful random variation in the state transition process.

The log-likelihood value of 21.1982 reflects the overall fit of the model, but without comparison to alternative models, it's challenging to judge the adequacy of this fit in isolation.

The results indicate that the state transition mechanism is almost entirely deterministic, with little to no random noise, however, this conclusion is not statistically significant. This might indicate that the process is predictable, or that the model requires revision to properly reflect the dynamics of the state variables.

CONCLUSION

This study aimed to explore the dynamic relationship between the increase in money supply (M2) and GDP growth between 2008 & 2023 using a state-space model. The findings reveal several important insights.

Looking at summary statistics, it's clear that both M2 and GDP show significant variability over the study period. However, GDP growth has lower variability compared to M2 growth, as shown by the coefficient of variation (C.V.). The distributions of these variables are somewhat skewed to the right, with a negative excess kurtosis.

This suggests they are flatter than typical distributions. The observation equation highlights the crucial role of money supply growth in explaining GDP fluctuations.

Furthermore, the error term in this equation displays a low standard deviation and is statistically significant. This indicates that the model accurately reflects the connection between M2 & GDP growth, leaving minimal unexplained variability. The state transition equation suggests that the development of unobserved state variables—perhaps indicating underlying economic conditions or shocks—is largely deterministic. Notably, the standard deviation of the transition error term is very close to zero. Yet, because this coefficient lacks statistical significance, we should be cautious with this conclusion. It suggests that although we assume a deterministic transition in our model, actual dynamics might need further examination or improved modeling.

The log-likelihood value stands at 21.1982, which shows the state-space model fits the data fairly well. Still, a more comprehensive evaluation of its appropriateness could benefit from comparisons with other models.

The results underscore money supply as a key predictor of GDP growth, aligning with theoretical views that monetary factors can influence economic performance. Nevertheless, the almost deterministic nature of state transition & limited statistical results point out that additional components or different models might be necessary to fully capture the intricate dynamics between money supply & GDP growth.

Future research could build on these findings by including more macroeconomic variables and exploring non-linear dynamics. Utilizing different modeling tools could also enhance understanding of what drives these observed relationships. Additionally, given potential exogenous shocks & structural changes during this period, it may be useful to analyze sub-periods or conduct robustness tests to confirm these findings.

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APPENDICES

Appendix A: Stata Code

import excel "C:\Users\Olugbenga\Downloads\NigeriaData.xlsx") first row clear tsset Year gen log GDP = log (GDP) gen log M2 = log(M2)

* Calculate growth rates (percentage change) gen GDP growth = (log GDP – log GDP[n-1]) / log GDP[n-1] gen M2 growth = (log M2 – log M2[n-1]) / log M2[n-1]

*Drop missing values generated by the differencing drop if missing (GDP growth) | missing (M2 growth)

* Define the state-space model sspace (GDP eq: GDP growth = {alpha}*M2 growth, state(beta)) /// (state eq: beta = L. beta, state no constant)

* Set constraints constraint 1 [GDP eq] alpha = 1, constraint 2 [state eq] L.beta = 1

* Run the model with the constraints sspace (GDP eq: GDP growth = {alpha}*M2 growth, state(beta)) /// (state eq: beta = L.beta, state noconstant), constraints(1/2) estimate display b[beta] predict beta t, state list Date betat twoway (line betat Date), title("Time-Varying Relationship Between M2 and GDP Growth") predict resids, resid tsline resids, title ("Residuals from State-Space Model")