Original Research Article

Dynamic Parameter State-Space Modelling for Assessing the Relationship between Money Supply and Economic Growth: A Study of Nigeria

ABSTRACT

Using data from 2008 to 2023, this study attempts to investigate the dynamic relationship between GDP growth and money supply growth (M2) using a state-space modelling approach. Both M2 and GDP exhibit significant volatility, with GDP displaying somewhat lower levels of this volatility, according to a close examination of the summary figures. When looking at the features of their distribution, we find that these variables have a flatter-than-usual distribution with a slight positive skew.

The link between M2 growth and GDP growth is well captured by the state-space model, highlighting the importance of M2 as an explanatory element. A modest and statistically significant standard deviation of the observation error is shown by the model. This implies that it explains differences in GDP quite effectively. Though some lack of statistical significance means caution is urged, the state transition equation does hint at a mostly predictable evolution of unobserved state variables.

Although the study points out that additional macroeconomic aspects and other models should be investigated further, the log-likelihood value indicates that this model fits fairly well. The findings demonstrate the critical role that the money supply plays in economic growth, which is in line with theoretical assumptions. This study also suggests that future research can examine more complex dynamics—such as non-linear relationships and potential implications of exogenous shocks—to better understand the relationship between M2 and GDP growth.

This study adds important insights to the body of knowledge by using a state-space modelling framework to present actual data about the relationship between money supply and economic output. These results may have a big impact on monetary policy and macroeconomic forecasting.

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

1. INTRODUCTION

The relationship between the money supply and economic growth has long been emphasised in macroeconomic theory and policy (Awwad, 2021). The significance of controlling this money supply to affect economic performance has long been emphasised by schools such as classical and monetarist. But contemporary perspectives, particularly in developing countries, indicate that this relationship is more nuanced and subject to alter over time (Choudhury, 2021).

An unusual setting for examining this relationship is Nigeria. The post-conflict economy is undergoing change. Nigeria's economy has changed significantly during the past 20 years. A number of factors have contributed, including changes in monetary policy, remittances, and foreign aid (Williams, 2020). However, despite these adjustments, there is a dearth of comprehensive empirical research on how changes in the money supply affect Nigeria's economic expansion. This dearth of study is particularly noticeable when viewed from the viewpoint of a dynamic system [4-6].

Although the relationship between money supply and economic growth has been the subject of numerous studies, there is a dearth of research that particularly addresses Nigeria. Furthermore, there hasn't been much work done with approaches that include relationships that change over time [7,8]. A fixed link throughout time is often assumed by conventional econometric models. Regretfully, this may not adequately convey the intricacies of a quickly changing economy. Consequently, a dynamic parameter state-space model was employed in this study [9,10]. This model aids in evaluating how the money supply's impact on Nigeria's economic growth changes over time.

1.2 Research Objectives

The purpose of this study is to:

1. Make a model that illustrates how Nigeria's money supply and growth are related. This will employ a state-space methodology.
2. Examine the relationship's stability throughout time and identify significant turning points.

1.3 Significance of the Study

The results of this study will contribute to a better knowledge of Nigerian financial systems. For individuals who create policies, this can provide insightful information. The research emphasises the necessity of flexible monetary policies by concentrating on how the money supply and economic development evolve over time. These regulations can more effectively address the particular difficulties that a transitioning economy faces.

2. MATERIAL AND METHODS

2.1 Data Collection

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.

2.2 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 (2.1) and (2.2) as follows:

$$y_t = \beta_t x_t + \epsilon_t \quad (2.1)$$

$$\beta_t = \beta_{t-1} + \eta_t \quad (2.2)$$

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.
2.3 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.

3. RESULTS AND DISCUSSION

3.1 Descriptive Statistics

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

The distribution and characteristics of both economic variables over the observed period are summarised in Table 1, which displays the Money Supply (M2) and GDP summary data from 2008 to 2023.
The average GDP for M2 over this time period is roughly 6.47 billion, while the average money supply is roughly 2.90 billion. The distribution for M2 appears to be slightly tilted to the right, as indicated by the median being marginally lower than the mean. The median for GDP is quite near to the mean, indicating a distribution that is reasonably symmetrical. While GDP has fluctuated between 4.58 billion and 8.53 billion, M2 has fluctuated between 1.39 billion and 5.49 billion. The range shows how much these variables have changed over time. M2 and GDP both exhibit comparable degrees of variability around their respective averages, with GDP displaying somewhat greater variance. M2's C.V. is higher. compared to GDP, indicating that M2 is more erratic in relation to its mean value. GDP has very low skewness, suggesting near symmetry, whereas M2 has substantial positive skewness, suggesting a right-skewed distribution. While both GDP and M2 show negative kurtosis, GDP's flatness is more noticeable. The central 50% of GDP data has a broader dispersion than M2, as evidenced by GDP's marginally bigger IQR than M2.
According to the data, GDP is less volatile than its mean (as shown by the C.V.) but has a larger average value than M2. Both M2 and GDP have reasonably symmetric distributions, with M2 exhibiting a little greater positive skewness. Particularly for GDP, the lower kurtosis values imply that both distributions are less peaked and have thinner tails than a normal distribution.

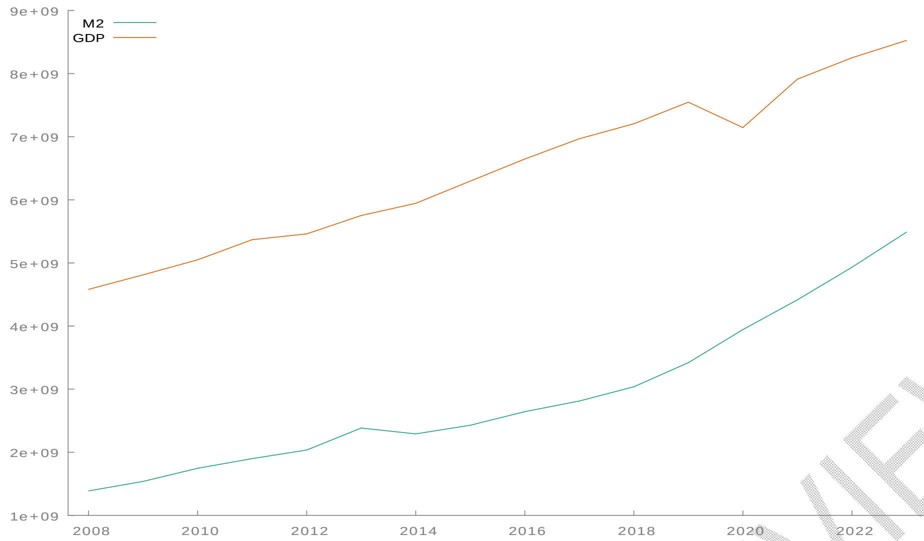

Fig. 1: Time plot for Money Supply and Gross Domestic Product, 2008-2023

Figure 1 illustrates the trend and connection between GDP (Gross Domestic Product), a more comprehensive indicator of the money supply, and M2 throughout time. Over time, M2 and GDP have both shown steady rising trends. This implies that the money supply and the economy have both been expanding. The relationship between M2 and GDP seems to be positive. GDP often rises in tandem with M2, and vice versa. This connection is frequently interpreted as an indication of economic expansion and advancement. Compared to the GDP growth rate, the M2 growth rate appears to have varied more. M2 increases more slowly than GDP during some times and more quickly during others.

4.2 State Space Modelling

Table 2: Observation equation

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

The results of the observation equation are displayed in Table 2. In a state-space model, observable data and unobserved state variables are connected by the observation equation. The calculated standard deviation of the error term in the observation equation is 0.0325691. This is the typical size of deviations from expected results caused by measurement error or noise. With a high z-statistic of 5.292 and an extraordinarily low p-value (1.21e-07), the standard deviation is clearly different from zero. The finding is highly significant at conventional levels (e.g., 1%, 5%, or even 0.1%) because to the low p-value. This demonstrates that the error term in the observation equation has a non-zero standard deviation and is highly precisely approximated.

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

The state transition equation's results are shown in Table 3. The table gives statistical details on the coefficients related to the state transition equation, which describes the evolution of the unobserved state variables.

A highly predictable process is indicated by the extremely small coefficient value (1.64459×10−9), which implies that the process noise is very near zero. The precision of the coefficient estimate is indicated by the standard error value of 0.00651196, which is 0.00651196. In this instance, the incredibly small coefficient value is accompanied by a comparatively significant standard error. This disparity suggests that there is a great deal of

uncertainty surrounding the calculated coefficient, even though it is extremely small. The z-statistic is incredibly small, which is indicative of the coefficient's close to zero value. The coefficient is not substantially different from zero, according to the modest z-statistic. A p-value of 1.0000 indicates that the coefficient is not statistically significant, meaning that the null hypothesis cannot be discarded. Although this number should be interpreted in relation to other models or benchmarks, the log-likelihood value of 21.1982 in this case indicates a reasonable fit of the state-space model to the data.
The error term of the state transition equation is calculated to have a standard deviation of 1.64459e-09, which is very near to zero. This implies that there is very little random noise and that the process controlling the evolution of the state variables is nearly totally deterministic.
This coefficient is not statistically significant, though, as the p-value is 1.0000 and the z-statistic is quite small (2.525e−072.525e-072.525e−07). The model implies that there is no significant random variation in the state transition process, and this lack of relevance raises the possibility that the estimate of the near-zero standard deviation is unreliable.
Although the model's overall fit is reflected in the log-likelihood value of 21.1982, it is difficult to assess the model's adequacy on its own without comparing it to other models. Although this conclusion is not statistically significant, the results show that the state transition process is nearly completely deterministic, with little to no random noise. This could suggest that the process is predictable or that the model needs to be updated to accurately capture the state variables' dynamics.

4. CONCLUSION

Using a state-space model, this study sought to investigate the dynamic link between GDP growth and the expansion of the money supply (M2) between 2008 and 2023. The results show a number of significant revelations.

Both M2 and GDP exhibit notable variability over the research period, according to summary statistics. However, the coefficient of variation (C.V.) indicates that GDP growth is less variable than M2 growth. These variables' distributions have a negative excess kurtosis and are somewhat skewed to the right. This implies that they are flatter than distributions in general. The observation equation emphasises how important money supply expansion is in explaining changes in GDP.

Additionally, this equation's error term is statistically significant and has a modest standard deviation. This suggests that there is little unexplained variability in the model, which well captures the relationship between M2 and GDP growth. According to the state transition equation, the evolution of unobserved state variables—which could be a sign of underlying shocks or economic conditions—is primarily predictable. Interestingly, the transition error term's standard deviation is extremely near to zero. However, we should use caution when drawing this conclusion because this coefficient lacks statistical significance. It implies that even though our model assumes a deterministic transition, more research or better modelling may be required to capture the actual dynamics.

The log-likelihood score is 21.1982, indicating that the state-space model provides a reasonably good fit to the data. However, comparisons with other models could be useful for a more thorough assessment of its suitability.

The findings support the idea that monetary issues can affect economic performance and highlight the money supply as a major predictor of GDP growth. However, the nearly deterministic character of state transition and the sparse statistical findings highlight the possibility that other elements or alternative models may be required to adequately represent the complex relationships between money supply and GDP growth.

By examining non-linear dynamics and adding more macroeconomic variables, future studies could expand on these conclusions. Understanding the mechanisms underlying these observed associations may also be improved by using various modelling tools. Furthermore, it could be helpful to examine sub-periods or carry out robustness tests to validate these results in light of possible exogenous shocks and structural alterations during this time.

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