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TESTING ENDOGENEITY OF MONEY SUPPLY: AN APPLICATION TO RWANDAN DATA.

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ABSTRACT

Purpose: The study aims to study the endogeneity of the money supply in Rwanda. The objective is to identify the empirical evidence regarding the extent and characteristics of this endogeneity specifically concerning variables such as monetary base, credit, demand deposit, and industrial production index.

Design/ Methodology/ Approach: The study utilizes Rwandan data from January 2012 to December 2022, the study used data provided by the National Bank of Rwanda and the National Institute of Statistics of Rwanda. The study employs descriptive analysis which involves examining descriptive statistics for each variable to understand the data's characteristics and assess the dispersion of the data points from their mean, time series analysis, cointegration testing, Vector Autoregressive (VAR) modelling, and Vector error correction model (VECM), were also be used in the research.

Findings: This research reveals that in Rwanda, the monetary base and overall monetary aggregates are primarily influenced by the extent of lending by commercial banks and demand deposits. It identifies a short-term causal relationship wherein the monetary base affects bank loans and the money supply. However, in the short term, the quantity of deposits, money supply, and the monetary base appear to have no direct impact on the volume of loans extended by commercial banks. The models validate that monetary indicators are chiefly influenced by the industrial production index, bank deposits, and the volume of loans issued by commercial banks

Research Limitation/Implications: Establishing clear causality between money supply and economic variables such as output and inflation is challenging due to the potential for bidirectional causality. The money supply can influence these variables, and vice versa, making it difficult to identify the direction and magnitude of causal relationships.

Practical Implications: The study's emphasis on the pivotal role played by commercial banks and their lending activities in the creation of money in Rwanda provides valuable insights into the country's banking sector dynamics.

Social Implications: This knowledge can be used to design policies that promote financial inclusion, ensuring banks' activities contribute to wider economic goals.

Originality/ Value: The use of a range of analytical techniques, including descriptive analysis, time series analysis, cointegration testing, Vector Autoregressive (VAR) modelling, and Vector error correction model (VECM), adds rigour to the analysis and enhances the robustness of the findings.

Keywords: *Commercial banks. endogeneity. monetary policy. money supply. Rwanda*

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INTRODUCTION

Throughout history, economists have been engaged in discussions about the essence of the money supply, specifically debating whether it is exogenously or endogenously determined. Money supply is viewed as exogenous by monetarists, meaning it is indicated that it is shaped by the monetary policies enforced by the central bank. One school of thought, championed by Friedman (1963), emphasizes controlling the money supply's growth to ensure price stability and a robust economy. Conversely, post-Keynesian economists, as exemplified by Moore (1979), argue that money supply responds to internal factors like deposits and economic activity. They prioritize managing overall demand and recommend using fiscal policy, such as government spending, to promote economic stability**.**

The composition of monetary supply originates from sophisticated dynamics involving financial institutions, banking systems, and the conduct of economic actors. Post-Keynesian economists highlight the crucial function of monetary policy measures and the influence of government rules in regulating the creation and flow of money. According to Dedeoglu & Ogut (2018), bank loans are a determining factor in shaping the size of the currency in circulation. This study is supported by the findings of various scholars, including Nell (2000), Howells (2007), and Nayan et al. (2013).

Several theories are originating from the post-Keynesian school of thought. One prominent theory is the accommodations view, as presented by (Moore, 1989), which asserts that the banking industry generates money in response to consumer and commercial credit demand. This theory holds that bank lending decisions, which are impacted by borrowers' creditworthiness and want to apply for loans for both personal and business purposes, ultimately determine the amount of money in circulation. From this perspective, the central bank's main duty is not solely focused on controlling the amount of money in circulation but rather on meeting the reserves required by the banking sector. The literature strongly supports the accommodationists' viewpoint regarding an internally determined money supply (Arestis & Howells, 1999 and Palley, 1991). However, critics of the accommodationist view point out that it assumes there is never an excess of money and overlooks the presence of an independent money-demand function. However, critics contend that it disregards the potential for an excessive money supply, disregards independent functions for the demand of money, exposes the financial system to instability from uncontrolled expansion of credit, and fails to address the effects on distribution, which could potentially worsen inequality. As a result, although the theory offers valuable insights, it does not take into account these essential factors, thereby restricting its usefulness in developing comprehensive frameworks for monetary policy.

The reconciliation mechanism for aligning newly created deposits from lending with demand is a contentious issue, with Kaldor and Trevithick (1981) proposing automatic loan repayment and Moore (1991) emphasizing the willingness of new deposit holders to hold loan-created deposits. According to the liquidity preference theory, there exists a causal link between bank loans and the money supply when the money supply (M3) is internally determined within the system. On the other hand, causation from M3 to credit can be anticipated if money and loan demand are independent, suggesting that money demand limits the development of deposits through loans.

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Another perspective within the post-Keynesian school is the Structuralist view, as proposed by Palley (1994). This view emphasizes the role of financial institutions and market structure in determining the availability of money. According to this theory, banks function as intermediaries linking savers and borrowers, creating money through the process of financial intermediation. Minsky (1992), additionally contended that alterations within the financial system, such as the introduction of new financial instruments or the implementation of new regulations, can exert a considerable influence on the amount of money in circulation and the overall stability of the economy.

The deficiency in the Structuralist theory lies in its failure to comprehensively consider the intricate interconnections and reciprocal influences present within the financial system. Although the theory acknowledges the significance of alterations in the financial system, it may overly simplify the dynamics and fall short of encompassing the complete magnitude of how these alterations can impact the economy. Furthermore, the theory may not sufficiently tackle the significance of expectations, uncertainty, and behavioural factors in shaping economic outcomes.

Table 1. Endogenous nature of the money supply

Accomodationist (Moore, 1989)	**Structuralist (Palley, 1994)**	**Liquidity preference (Howells and Hussein, 1998)**
M3 → MB Credit→ M3 GDP→ M3	Credit ⇔ M3, MB GDP⇔ M3	Credit ⇔M3

Note that:
M3: Money Supply
MB: Monetary Base
GDP: Gross Domestic Product

Currently, money is being produced through the mechanism of credit generation by commercial banks and financial entities, thus influencing the overall monetary stock (Rahman, 2017). The majority of the circulating money is a product of commercial banks rather than Central or Federal Banks. These banks generate currency each time they extend loans to borrowers or receive deposits from lenders. Consequently, this process affects the pricing, measured in interest rates, and the scale, measured in the quantity of loans extended, of financial transactions within an economy.
According to research by McLeay and Radia (2014), it was discovered that the majority of available currency is primarily generated by private entities rather than originating from the Central Bank's printing presses. Banks generate money by extending loans to their customers or borrowers. The lending procedure directly impacts the total money supply in the economy. Correspondingly, according to Sigurjonsson's 2015 research, the monetary base typically constitutes less than 5% of the broader money supply, suggesting that commercial banks effectively generate over 95% of the money currently circulating.

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The ongoing discussion regarding endogenous and exogenous money theories revolves around the degree of influence wielded by commercial banks in the process of money creation. Thus, it is not governmental actions but rather the choices made by commercial banks and borrowers that dictate the amount of money circulating in the economy. The relationship between money supply and key economic indicators like inflation, GDP, and interest rates is a critical focus in monetary economics. However, accurately gauging this correlation presents challenges, particularly in the context of Rwanda—an emerging economy in Sub-Saharan Africa— in situations where the endogenous nature of the money supply is a significant consideration. This potential endogeneity can significantly influence the precision and reliability of monetary policy decisions, given the dynamic nature of financial markets, exchange rates, and government policies. Notably, the existing literature lacks empirical evidence regarding the extent and characteristics of endogeneity, specifically about variables such as monetary base and bank deposits. This research seeks to narrow this gap by conducting a thorough analysis of the innate nature of the money supply in Rwanda, with the ultimate aim of providing policy recommendations based on empirical evidence.

LITERATURE REVIEW

The inherent nature of the money supply in monetary economics continues to be a subject of significant debate. Empirical research has employed diverse methodologies to evaluate the influence of factors such as money demand and bank credit creation on the money supply. This ongoing discourse holds substantial implications for monetary policy and our comprehension of its impacts on the actual economy. When the money supply is determined endogenously, variations in money demand or banking activities can affect key economic indicators such as interest rates, output, and inflation.

This undermines the traditional notion that central banks exclusively regulate the money supply via mechanisms such as open market operations. Empirical investigations have employed econometric methodologies such as VAR models, cointegration analysis, SVAR models, and Vector Error Correction Models to scrutinize the inherent nature of the money supply. Results have varied, with certain studies backing the concept of endogeneity while others uncovering indications of exogeneity.

Bernanke and Blinder (1988) and Deleidi and Levrero (2019a) employed VAR and VECM models to investigate the inherent nature of the money supply in the United States. Their findings indicated that variations in the money supply were predominantly attributed to shifts in money demand, affirming its endogenous nature. Conversely, Sims (1982) contended that alterations in the money supply were primarily exogenous and influenced economic variables via interest rate adjustments.

The exploration of the intrinsic nature of the money supply has also broadened within the framework of monetary policy strategies such as inflation targeting and monetary aggregates targeting. Romer and Romer (2000) challenged the conventional view of targeting monetary aggregates by examining the internal dynamics of the money supply during the Great Depression. Their research revealed that the money supply was determined internally and adapted to changing economic conditions.

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The following text reviews various empirical investigations exploring the endogeneity of money supply across diverse nations. Starting with Rwanda, Nyalihama (2011) confirms the endogenous money theory by demonstrating the favourable effects of net domestic credits to banks, net foreign assets, and domestic credit to the government on the money supply. Nevertheless, outcomes over the long term remained inconclusive, indicating the necessity for additional research. In G-7 economies, Badarudin et al. (2013) concluded that bank lending significantly affected the money supply, emphasizing the importance of considering different monetary regimes.

A study on Zimbabwe's unique system of using multiple currencies, Sunge (2018) revealed an interesting characteristic of its money supply. Unlike some economies, Zimbabwe's money supply appears to be interconnected with factors like bank lending (bank credit), the amount of money deposited in banks (bank deposits), and the central bank's reserves (monetary base). This interconnectedness is referred to as endogeneity**.** In the United States, Deleidi and Levrero, (2019a) found that bank loans had a determining effect on bank deposits, influencing the monetary base, and underscoring the significance of economic activity and lending activities of commercial banks in shaping the money supply. Likewise, within the Eurozone, Deleidi and Fontana (2019) found that bank loans affected bank deposits, thereby influencing the monetary base, which is consistent with post-Keynesian theory and lends support to the endogenous viewpoint. Lastly, a recent investigation in Japan by Ongan and Gocer (2023) employing nonlinear models demonstrated that internal factors significantly impact Japan's money supply, enriching our understanding of the endogenous nature of money supply and providing tailored insights into Japan's circumstances.

As stated by the National Bank of Rwanda, its primary objective is to ensure price stability, which contributes to macroeconomic stability. In the previous two decades, the central bank has utilized a monetary targeting approach to curb inflation by overseeing the money supply in the economy, this framework helped to maintain low and stable inflation rates.

A quantity-based monetary policy framework was transitioned to a price-based framework by the National Bank of Rwanda (NBR) in January 2019. Inflation and monetary aggregates are impacted by evolving economic dynamics, and interest rates are increasingly important to economic decision-making, which has contributed to this change. The new approach offers advantages such as using interest rates as a primary operational target, enhancing transparency, and ensuring accountability in policy implementation (National Bank of Rwanda, 2022).

Analysing the data from 2011-2022, sourced from the National Bank of Rwanda, reveals a consistent growth in Rwanda's money supply, driven by economic expansion and increased demand. Broad money (M3) surged from RWF 1.3 trillion in December 2010 to RWF 4.5 trillion in December 2020, with a compound annual growth rate of 13.7% (National Bank of Rwanda, 2021). Fluctuations were observed in the growth rate of M3 over the study period. For instance, it slowed to 6.1% in 2015 from its peak of 19.5% in 2013, attributed partly to tightened monetary policy amid inflationary pressures. However, M3's growth rate rebounded, reaching 18.2% in 2017

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and 15.9% in 2019. In 2020, the growth rate of M3 decreased to 10.4% due to the impact of the COVID-19 pandemic on economic activities and the financial sector. In response, the BNR took action by implementing measures such as reducing the reserve requirement ratio and launching a credit guarantee program for small and medium-sized enterprises, aiming to stimulate economic growth and maintain financial stability.

Changes in money demand and actions taken by financial institutions have affected the growth and composition of the money supply. The National Bank of Rwanda (BNR) employed several monetary policy instruments to regulate the money supply by economic developments and inflationary pressures. Nevertheless, the efficacy of these measures relied on the reactions of market stakeholders, encompassing banks, households, and businesses.

METHODS AND MATERIALS

The strategy of this research is to do a combination of empirical analysis and theoretical assessment. The study analyzes the impact of macroeconomic variables and the money-creation process in Rwanda through a mix of quantitative data analysis and theoretical frameworks and the adoption of a research strategy that combines empirical analysis with theoretical assessment in research allows this study to provide a robust analysis of the impact of macroeconomic variables and the money-creation process in Rwanda, leading to valuable insights for both academia and policy formulation.

Data Source

To achieve the main objective of this study, the secondary data from January 2012 to December 2022 were used to investigate how the money supply in Rwanda responds to internal factors (endogeneity). The data, obtained from Rwanda's central bank (National Bank of Rwanda) and national statistics agency (National Institute of Statistics), includes various financial indicators: Broader Money Supply (M3), Monetary Base (MB), Domestic Credit, Demand Deposits, and the Industrial Production Index (IPI). Software called STATA is used to analyze these relationships.

Model specification

The descriptive analysis (Table 2) primarily emphasizes the examination of descriptive statistics for each variable, aiming to assess the dispersion of data points from their respective means and to understand the nature of the data. Furthermore, the analysis of the data encompassed time series analysis, cointegration testing, Vector Autoregressive (VAR) modelling, Vector Error Correction Model (VECM), and Granger causality testing, aiding in the examination of causal connections from both short and long-term perspectives. Three distinct models were employed to evaluate the causal relationships among various crucial variables.

Model1: IPI-M3- MB
Model2: MB- Credit- Deposit
Model3: MB- M3- Credit

The first model delves into how economic activity influences the creation of money. It accomplishes this by investigating the association between money supply and the Industrial

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Production Index (IPI), which serves as a barometer of economic growth, instead of opting for the more intricate Gross Domestic Product (GDP).

The second model evaluates the relationship between the monetary base and financial activities, including both deposits and lending. The third model estimated the existing relationship between monetary aggregate and the level of loan provided by commercial banks. The research adopts a systematic method to effectively organize the data. Initially, the stationary nature of the variables is evaluated using the Augmented Dickey-Fuller (ADF) unit root test (Table 3), which is a widely recognized technique in the literature and considered appropriate for this study. The second step involves determining the optimal lag (Table 4) for the model through lag length selection techniques, which are employed to evaluate various lag orders. Afterwards, the Johnsen cointegration test (Table 5) is employed to detect potential long-term cointegration among the variables. Then, the VAR and VECM econometric methodologies assist in estimating both short and long-term cointegration among the variables examined in this study. The Granger causality test is subsequently administered to assess any causal connections. This thorough methodology guarantees a rigorous examination of the dataset.

The outcome of the unit root test together with the lag selection and cointegration test prompted us to employ alternative econometric approaches in examining causality in both short and long-run perspectives, The methods developed by Fuller (1979), Engle and Granger (1987), Johansen (1988), Toda and Yamamoto (1995) and Christiano (2012).

Vector autoregression (VAR) statistics, as outlined by Lütkepohl (2001), enable the analysis of multiple time series variables to ascertain their mutual reliance. Within a Vector Autoregressive (VAR) model, each variable is represented as a linear amalgamation of its preceding instances and those of other variables present in the system.

$$y_t = \beta_1 y_t + \sum_{i=1}^{P} \beta_i y_{t-i} + \varepsilon_t \qquad (1)$$

Where y_t is a vector of observation, β is a matrix of parameters ε_t is a vector disturbance and p is the length of lag.

To employ the VAR model, every variable contained in the, $y_t\ the$ vector must be stationary. As long as there are one or more cointegration relationships among the key variables, the Vector Error Correction Model (VECM) will be applied in place of the non-stationary variables. To analyse non-stationary data with established cointegration relationships, the VECM is a restricted VAR that was created for that purpose.

$$\Delta Yt = \beta_0 + \sum_{i=1}^{P} \beta_{1i}\ \Delta Y_{\text{t-i}} + \sum_{i=1}^{P} \beta_{2i}\, \Delta X_{t-i} + \beta_3\, EC_{t-1} + \varepsilon_t \qquad (2)$$

Where Δ is the differencing operator where $\Delta Y_t = Y_t - Y_{t-1}$, $\Delta Y_{\text{t-i}}$ is vector variables endogenous with lags I, p is the lag of endogenous variables, ε_t is the $K \times 1$ vector residuals, β_3 is the error correction, EC_{t-1} is called Error correction, β represents the short-term dynamic coefficient of the

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model's adjustment towards long-term equilibrium, and ε_t is the impulses. X_t is the independent variable and Yt characterises the dependent variable, given that VECM models consider all variables as endogenous, determining causality involves alternately choosing the dependent and independent variables for estimation.

FINDING AND DISCUSSION

Table 2: Descriptive statistics for the variables (2012M1-2022M12)

Variable	Obs	Mean	Std. Dev.	Min	Max
IPI	144	100.0771	33.00453	45.8	173.6
M3	144	1802.863	888.1794	610.3	4000.4
Deposit	144	1638.535	829.1847	525.5	3686.6
credit	144	1799.397	1087.988	446.1	4419.8
MB	144	340.1319	162.3849	126.3	919.8

This table displays essential statistics for five variables: Industrial Production Index (IPI) measured in percentage, Money Supply (M3), Deposits, Credit, and Monetary Base (MB) which are measured in billion Rwandan Francs (Frw), with 144 observations per variable.

Table 3: Stationarity of the Data

Variables	ADF Statistics	Probability	Decision
dlnPIP	-16.153 ***	0.0000	I (1) Stationary
dlnM3	-13.347 ***	0.0000	I (1) Stationary
dlnMB	-13.817 ***	0.0000	I (1) Stationary
dlnDeposit	-13.884 ***	0.0000	I (1) Stationary
dlnCredit	-12.463 ***	0.0000	I (1) Stationary

Critical Values

At 1%	At 5%	At 10%
-2.353	-1.656	-1.288

The analysis of the variables' stationarity at the first difference, coupled with the outcomes of the Dickey-Fuller tests, presents strong evidence suggesting the absence of a unit root (no stationarity) in the time series data pertaining to the specified variable.

Table4: Selection-order criteria

lag	LL	LR	df	p	AIC	HQIC	SBIC
0	951.084				-13.5155	-13.4728	-13.4104
1	1703.27	1504.4	25	0.000	-23.9038	-23.6477*	-23.2735*
2	1733.46	60.384	25	0.000	-23.978*	-23.5084	-22.8223
3	1745.75	24.591	25	0.485	-23.7965	-23.1134	-22.1156
4	1776.2	60.887	25	0.000	-23.8743	-22.9777	-21.668

**Indicate the Best optimal lag*

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The model dramatically improves with a lag order of 1, as seen by greater LL and LR values, a low p-value, and noticeably lower AIC, HQIC, and SBIC values. According to these findings, a lag order of 1 seems to be the best choice because it significantly improves model fit while preventing overfitting.

The Granger Representation Theorem asserts that an error-correcting representation effectively captures the relationship between variables that exhibit cointegration (Engle & Granger, 1987). The importance of the Vector Error Correction Model (VECM) lies in its capability to illustrate the short-term dynamics within a persistent relationship and how adjustments towards long-term equilibrium occur. By examining the error correction components within these VECMs, it becomes possible to ascertain whether ongoing adjustments in one variable towards long-term equilibrium are influenced by simultaneous alterations in other variables. Since all variables have long-run cointegration (see Table 5), in estimating the VECM, we have decided to divide the variable into three parts as discussed in the methodology part and form three different models to make the interpretation simpler and more understandable.

Table 5: Johnsen cointegration test for cointegration

Maximum rank	parms	LL	eigenvalue	Trace statistics	5% critical value
0	30	1700.8916		106.7549	68.52
1	39	1729.6537	0.33309	49.2307	47.21
2	46	1742.392	0.16424	23.7541*	29.68
3	51	1749.9394	0.10085	8.6592	15.41
4	54	1754.169	0.05783	0.2001	3.76
5	55	1754.269	0.00141		

Maximum rank	parms	LL	eigenvalue	Max statistics	5% critical value
0	30	1700.8916		57.5241	68.52
1	39	1729.6537	0.33309	25.4766	47.21
2	46	1742.392	0.16424	15.0949	29.68
3	51	1749.9394	0.10085	8.4591	15.41
4	54	1754.169	0.05783	0.2001	3.76
5	55	1754.269	0.00141		

The variables lnMB, lnIPI, lnDeposit, lnCredit, and lnM3 were tested for long-term relationships using the Johansen cointegration approach. Results indicate the presence of at least two

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cointegrating vectors at the 5% significance level. Based on the trace statistic, the first set of findings suggests two long-term associations if the highest rank, 2, meets the significance level.

The second set of findings, based on the maximum eigenvalue statistic, also supports the presence of at least two cointegrating vectors. The highest rank that meets the significance level, 2, confirms two long-term associations between the variables. These conclusions imply significant long-term linkages between the variables. Over time, these elements: money supply, bank lending (bank credit), the amount deposited in banks (bank deposits), industrial output (industrial production), and the central bank's reserves (monetary base) become intricately connected, reciprocally influencing each other. The existence of cointegrating vectors indicates a steady equilibrium relationship among these variables over the long term, leading us to proceed with the next stage of estimation.

To evaluate the consistency and reliability of the empirical findings of these models, the study performed the structural break test using sub single command. a command that tests structural breaks with an unknown date, and observed that only Model 1 has a significant structural break found in April 2020. Now, to avoid the effect of the break found in April 2020, the study decided to run the model in two different periods: the first period starts from 2011:M1 to 2020:M3, and the second period covers the period from 2020:M5 to 2022:M12.

First, Model 1 was estimated, the main objective is to elucidate the connection between monetary variables (MB and M3) and the industrial production index (IPI). Through this examination, we will the alterations in monetary aggregates is determine if it directly influenced by production or if the relationship functions in the opposite direction. The relationship between lnMB, lnM3, and lnIPI will be demonstrated as a means of achieving this goal.

Johnsen's cointegration test revealed two cointegrated equations because the variables under consideration were cointegrated during the study period (see Table 5). In the initial period covering from 2011M1 to 2020M3, the findings are presented regarding long-run causality. The results, outlined in Table 6, indicate the existence of long-run causality from lnM3 and lnMB to lnIPI, as well as from lnM3 and lnIPI to lnMB. This is supported by the significant coefficients, with one $\beta 3$ value of -0.3709065 (with the 0.000 P- Value) and the other being -0.1501493 (with the 0.00 P-value) respectively. However, no further long-term causality has been observed between the natural logarithm of the Industrial Production Index (lnIPI) and Monetary Base (MB) leading to the natural logarithm of M3 money supply (lnM3). This is evident from the coefficient (-0.0397816) associated with the cointegrating equation of lnIPI and lnMB, which is statistically insignificant at the 5% level with a probability of 0.069.

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Table 6: Outcome of the error correction model (long-term causality model 1)

Dependent variables	Independent variables	B3	P-Value	lag	Conclusion
IPI	M3&MB	-0.37070	0.000	1	M3&MB→IPI
MB	M3&IPI	-0.15014	0.000	1	M3&IPI→MB
M3	MB&IPI	-0.39781	0.069	1	

Furthermore, to explore how these factors influence each other in the short term, the study employed a Granger causality test. This test strengthens the evidence for a long-term co-integration (interconnectedness) between variables like industrial production (IPI), the monetary base (MB), and the broader money supply (M3).

Table 7: Findings from the error-correction model (Short-term Causality: Wald Test, Model 1)

Equation	Ch2	P-value>ch2
Ln IPI does not demonstrate a Granger-causal influence on Ln MB	1.1045	0.293
Ln IPI demonstrate a Granger-causal influence on Ln M3	14.246	0.000***
Ln IPI demonstrate a Granger-causal influence on All	54.781	0.000***
Ln MB does not demonstrate a Granger-causal influence on Ln IPI	1.7628	0.148
Ln MB demonstrate a Granger-causal influence onM3	46.672	0.000***
Ln MB demonstrate a Granger-causal influence on All	47.003	0.000***
Ln M3 does not exert a Granger-causal influence on Ln IPI	3.7265	0.054
Ln M3 does not have a Granger-causal influence on Ln MB	0.13302	0.715
Ln M3 does not have a Granger-causal influence on All	4.O288	0.133

Note: **p < 0.05, ***p < 0.01, *p < 0.10.

The granger causality test outcome (see table 7) shows that there exists unidirectional causation between IPI and M3 in Rwanda, where the direction run from IPI to M3. Another direction run from MB to M3, but there is no bidirectional causation find in this part.

The research not only focused on causality analysis but also extended to estimating long-run elasticities. The overall findings of the Vector Error Correction Model (VECM) analysis on the Industrial Production Index (IPI), Money Supply (M3), and Monetary Base (MB) indicate that in the long run, MB hurts IPI, whereas M3 has a positive impact on IPI, with coefficients demonstrating significance at the 1% level. The outcomes obtained from Model 1 for the first period (2012M1-2020:M3) affirm the endogenous perspective, demonstrating that the industrial production index acts as a determining factor and positively impacts the Money supply. In the second period (2020:M5–2022:M12), since there is no cointegration among the variables, a VAR model and Wald test are employed to examine the causal relationships in the short run. In particular, lnIPI affects lnM3, and in turn, lnM3 determines lnMB.

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Secondly, the study runs Model 2, which is about the Monetary Base and financial activities (Deposit and domestic credit), the estimation of the VECM can follow, the model that provides short- and long-run causality. In this model, the whole study period is estimated, as a structural break was found but was not significant for 201201–2022:12.

Over the long term, there is an indication of causality from the natural logarithms of credit (lncredit) and natural logarithms of deposits (lnDeposit) to the natural logarithms of the monetary base (lnMB), as shown in Table 5. This is supported by a negative and statistically significant coefficient (β3 = -0.241809) at the 0.05 P-value as a result, the null hypothesis in this case is rejected, suggesting that the coefficient deviates from zero. This implies the presence of a statistically significant long-term causal relationship between credit and deposits to the monetary base.

On the contrary, no evidence supports long-term causality in the opposite direction. To be specific, the coefficient β3, which stands at 0.0600, is both positive and statistically significant at the 0.05 P-value. As a result, the null hypothesis is upheld, confirming the lack of long-term causality from the monetary base (MB) and deposits to credit. Furthermore, the coefficient β3, which stands at 0.0336118, lacks statistical significance and is positive. This reinforces the conclusion that there is no persistent association between the monetary base (MB) and credit to deposits. Given that β3 fails to meet the requirements of being negative and statistically significant, the study ultimately concludes that the monetary base (MB) and deposits do not exert a lasting influence on the volume of loans granted by commercial banks.

Table 8: Outcome of the error correction model (long-term causality model 2)

Dependent variables	**Independent variables**	***β3***	**P-Value**	**lag**	**Conclusion**
MB Credit Deposit	Credit & Deposit MB & deposit MB & credit	-0.2418094 0.0600 0.336118	0.003 0.014 0.268	1 1 1	Credit & Deposit→MB

Notes: The directional causation is illustrated by the arrows: single arrows denote unidirectional causality, while double arrows signify bidirectional causality.

After examining long-term relationships using a Vector Error Correction Model (VECM), the study investigated short-term causal dynamics through a Granger causality test. This test was performed to strengthen the evidence of long-term interconnectedness (cointegration) among variables such as the monetary base (MB), bank lending (credit), and deposits.

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Table 9: Findings from the error-correction models (Short-term Causality: Wald Test, Model 2)

Equation	**Ch2**	**P-value>ch2**
Ln MB does not have a Granger-causal impact on Ln credit	0.84103	0.359
Ln MB has a Granger-causal impact on Ln Deposit	4.5514	0.033**
Ln MB has a Granger-causal impact on All	27.366	0.000***
Ln credit does have a Granger-causal impact on ln MB	0.82688	0.363
Ln credit has a Granger-causal impact on ln Deposit	21.083	0.000***
Ln credit has a Granger-causal impact on All	28.55	0.000***
Ln Deposit does not have a Granger-causal impact on Ln MB	2.4471	0.118
Ln Deposit does have a Granger-causal impact on ln MB	1.2498	0.264
Ln Deposit does not have a Granger-causal impact on All	4.7187	0.094*

Note: **p < 0.05, ***p < 0.01, *p < 0.10.

According to the results of the Granger causality test (see Table 9), there is unidirectional causality in Rwanda between MB and Deposit, with the direction of causation running from MB to Deposit. There is no bidirectional causality found in this section, however there is another route that runs from credit to deposit.

The results of the long-term elasticities for Model 2 during the period from January 2011 to December 2022 are provided. Over the long term, it is observed that credit has a positive impact on MB. Specifically, a 1% increase in lncredit leads to a 0.84% rise in the Monetary base. On the contrary, in the long term, the influence of Deposits on MB is negative, although not statistically significant. This implies that a change in deposit does not bring about a notable alteration in MB. The outcomes of this section align with the post-Keynesian perspective of endogenous money. Consequently, the monetary base was identified as an endogenous variable, shaped in the long run by domestic credit and bank deposits. This finding is consistent with the findings of Deleidi and Levrero (2019).

Thirdly We run Model 3 with the objective of finding the influence of Bnk'Loans on Monetary Variables (MB and M3). The study confirms the presence of a sustained causal relationship in the period crossing from Jan 2011 to Dec. 2022. A concise summary of the findings is available in (Table 10). By assessing the coefficients associated with the cointegrating vectors, it is possible to discern ongoing causality from the natural logarithm of credit (lncredit) and the natural logarithm of M3 (lnM3) to the natural logarithm of the monetary base (lnMB). Since one of these coefficients ($\beta 3$) is computed as -0.2961484 (significantly significant at the 0.01 probability level), the null hypothesis is rejected, indicating the presence of a long-term causal link from lncredit and lnM3 to lnMB. Given that the estimated coefficients are characterized by positive values or lack statistical significance, there is an absence of long-term causality in the opposite direction. Consequently, it can be inferred that both M3 and commercial bank credit volumes show an integrated role in determining the monetary base.

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Table 10. Result of the error correction model (long run causality Model 3)

Dependent variables	Independent variables	$\beta 3$	P-Value	lag	Conclusion
MB	Credit & M3	-0.296148	0.001	1	Credit & M3→MB
M3	Reserve & credit	0.016362	0.630	1	-
Credit	MB & M3	0.04883	0.070	1	-

Notes: The arrows indicate the direction of causation: single arrows denote one-way causality, while double arrows signify two-way causality.

A Granger causality test followed the VECM analysis to examine short-term causality between MB, credit, and M3, solidifying evidence for long-run co-integration.

Table 11: Findings from the error-correction models (Short-term Causality: Wald Test, Model 3)

Equation	Ch2	P-value>ch2
Ln MB exert a Granger-causal influence on Ln M3	6.077	0.048**
Ln MB does not exert Granger-causal influence on Ln credit	0.25006	0.882
Ln MB does not exert a Granger-causal influence on All	16.198	0.003***
Ln M3 does not exert a Granger-causal influence on Ln MB	0.265113	0.876
Ln M3 does not exert Granger-causal influence on Ln credit	1.86	0.395
Ln M3 does not exert a Granger-causal influence on All	2.1461	0.709
Ln credit does not have a Granger-causal effect on Ln MB	1.9639	0.375
Ln credit has a Granger-causal effect on Ln M3	11.019	0.004***
Ln credit have a Granger-causal effect on All	17.931	0.001***

Note: **p < 0.05, ***p < 0.01, *p < 0.10.

Granger causality test findings (see Table 11) indicate that there is unidirectional causality in Rwanda between MB and M3, with MB leading the way in the direction of the cause. Although there isn't any bidirectional causation in this segment, credit can still go through M3.

In Model 3, according to the long-term estimate from the Johnsen normalization, a positive relationship is observed between MB and credit. Specifically, a 1% increase in lnCredit leads to a 0.58% rise in lnMB. However, an increase in lnM3 doesn't significantly impact lnMB. These long-term causal findings support the endogenous money perspective, suggesting that the monetary base is an endogenous variable in the long run. Additionally, MB is positively influenced by a broad measure of money (M3) and both the loan volume and M3 over an extended period.

In the long run, the analysis reveals significant and positive effects between various variables. Both money supply (M3) and monetary base (MB) have a lasting impact on the industrial production index (IPI), indicating that changes in money supply and monetary base can contribute to changes in industrial production over an extended period. Moreover, there exists a noteworthy and

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favourable correlation between both the money supply (M3) and the industrial production index (IPI) with the monetary base (MB). This indicates that alterations in both money supply and industrial production can mold the monetary base over an extended period. Additionally, credit and deposits collectively demonstrate a substantial and beneficial influence on the monetary base (MB) in the long term, suggesting that variations in both credit and deposit levels contribute to alterations in the monetary base over time. Lastly, both the money supply (M3) and credit display a significant and beneficial effect on the monetary base (MB) over the long haul, underscoring their pivotal roles in shaping the monetary base.

Discussion

A key question in economics concerns who control the money supply: internal forces or the central bank? Post-Keynesians argue it's internal, influenced by economic activity. Monetarists disagree, seeing central bank control. In practice, it is commercial banks rather than the central bank that predominantly create the majority of the money in circulation today.

In this paper, this research aims to enhance the current body of literature by examining these theories in Rwanda, utilizing time series data spanning from January 2012 to December 2022. To ensure all objectives are met, and to analyze the connections between the variables we're studying, this research utilizes Vector Autoregressive (VAR) and Vector Error Correction (VECM) models, the Industrial Production Index, Broader Money Supply (M3), Monetary Base, demand deposits, and Domestic credit. To streamline estimation and facilitate interpretation, the study divides and estimates the variables into three distinct models.

In general, the study reveals that in Rwanda, the monetary base (MB) and overall monetary aggregates (M3) are primarily influenced by the extent of lending by commercial banks and demand deposits. It identifies a short-term causal relationship wherein the monetary base (MB) affects bank loans and the money supply (M3). However, in the short term, the quantity of deposits (M3), money supply (M3), and the monetary base (MB) appear to have no direct impact on the volume of loans extended by commercial banks. These findings are consistent with those of Deleidi and Levrero (2019), who observed similar short-term dynamics.

Banks can only grant loans if there is enough demand from borrowers. It is vital to ensure that the money supply generated by monetary policies effectively reaches the real economy and doesn't get trapped within the banking system.

The models validate that monetary indicators are chiefly influenced by the industrial production index, bank deposits, and the volume of loans issued by commercial banks. This corresponds with findings from Deleidi and Fontana (2019), Deleidi and Levrero (2019b), Nayan et al. (2013b), and McLeay and Radia (2014), indicating that the influence of monetary policy on monetary indicators is mainly transmitted through interest rates, thereby impacting money demand. Moreover, the examination not only affirms the causality direction but also quantifies and confirms the anticipated long-term associations. In Model 1, the industrial production index demonstrates a favourable impact on the monetary base (MB). Model 2 suggests that the volume of loans provided

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by Rwandan commercial banks and the demand for deposits both have a considerable positive long-term impact on the level of the monetary base (MB), while domestic credit does not significantly affect the demand for deposits. On the other hand, Model 3 reveals that the loan volume exerts a positive and statistically significant long-term influence on both the monetary base (MB) and money supply (M3), with money supply (M3) directly influencing the level of the monetary base (MB). Research conducted by Deleidi and Levrero (2019) corroborates these findings, with both accommodationist and structuralist theories supporting the study's results.

CONCLUSION

Overall, this study provides empirical evidence supporting the endogenous money theory, showing that in Rwanda, commercial banks and their lending activities play a crucial role in the creation of money. The empirical findings of the study contradict the viewpoint of monetarists who argue that the money supply is determined externally. It also highlights the importance of understanding the interactions between domestic credit, bank deposits, and monetary aggregates when formulating monetary policies aimed at stimulating the real economy.

In summary, these findings offer valuable insights into the relationships and causality observed among money supply, the industrial production index, credit, demand deposits, and the monetary base, both in the short run and the long run. These connections underscore the interdependency of these variables within the Rwandan economic context and provide a deeper understanding of the dynamics of the monetary system and its impact on industrial production and credit. This research conducted in Rwanda provides empirical evidence to support the endogenous money theory, highlighting the pivotal role of commercial banks in the creation of money and challenging conventional monetarist perspectives.

The findings offer valuable insights for policymakers in formulating more effective monetary policies that take into account the interplay of key economic variables, thereby contributing to both economic stability and financial inclusion. By emphasizing the causal relationships between the money supply, industrial production, and credit, this study advances the theoretical discourse in the field of monetary economics and presents unique perspectives on the economic framework of Rwanda, thereby offering practical implications for sustainable growth and financial stability. The study recommends that future researchers extend this investigation by exploring the relationship between interest rates and the volume of loans extended by commercial banks in Rwanda. Examining these areas will offer a more comprehensive understanding of the factors influencing the dynamics of credit and deposits in the Rwandan banking system.

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