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Article

Financial development, interest rate pass-through and interest rate channel of monetary policy

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FINANCIAL ECONOMICS | RESEARCH ARTICLE

Financial development, interest rate pass-through and interest rate channel of monetary policy

Olajide Oyadeyi^{1*}

Abstract: The paper examined the interest rate operations and processes in Nigeria and examined the role of financial development in incentivizing central bank monetary policies from the monetary policy rate to the money market rates, lending rates, and deposit rates. The analysis covered the period from 1981 to 2021 with sub-samples for 1981 to 2011 and 1991 to 2021 to test the consistency of the findings. The findings confirmed that interest rate pass-through is incomplete for Nigeria, albeit to a lower degree in the short run compared to the long run. The reasons for this may be due to interest rate stickiness, problems of asymmetric information, and bank switching costs. Also, the findings confirmed that financial development weakens the impact of monetary policy on the interest rate pass-through process, while the analysis of the asymmetric mean adjustment lags confirmed that changes in the policy rate are transmitted to the deposit and lending rates within the year it was announced. The analysis confirmed that the results



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Olajide Oyadeyi is a professional economist and currently working as a researcher and development consultant. He received his Ph.D. from Obafemi Awolowo University and works mainly in the areas of macroeconomics, monetary economics, international economics, financial economics, public sector economics, and development economics. He has published several articles in highly reputable journals on topics such as financial development, monetary transmission mechanisms, monetary policies, the current account, banking development, capital market development, exchange rate management, interest rate management, the economics of crime, etc. His current research includes analyzing the role of financial development on the interest rate channel of monetary policy and its wider implications for the banking industry and the macroeconomy of Nigeria. This paper is part of other papers which seek to connect the link between financial development and monetary transmission mechanisms as well as their implications on the macroeconomic environment for Nigeria.

PUBLIC INTEREST STATEMENT

This research aims to test the individual and joint effects of financial development and monetary policy on the interest rate pass-through process in Nigeria. The goal is to determine whether financial development weakens or strengthens the process of interest rate transmission in Nigeria. In doing this, the paper accounts for the speed and the size of the transmission, the potential symmetric and asymmetric adjustments, and how long it will take for the banking sector lending and deposit rates to adjust to a change in the monetary policy rate. The findings showed that financial development weakens the interest rate channel, while banks adjust their interest rates in line with a shift in the policy rate within the year the change was announced. Therefore, understanding the role of financial development within the interest rate transmission is important for designing the appropriate monetary policy processes and operations for Nigeria.

across each sub-sample and the robustness tests are consistent with the main analysis. Therefore, it is imperative that policymakers should account for financial development when designing monetary policy effectiveness since it can hinder or strengthen the interest rate monetary policy channel.

Subjects: Economics and Development; Economics; Finance

Keywords: Financial development; monetary policy rate; monetary policy effectiveness; interest rate pass-through; interest rate channel of monetary policy

JEL classification: E4; E5; G1; G2

1. Introduction

The objective of the paper is to examine the role of financial development within the interest rate mechanism of monetary policy. This is because the financial sector serves as an important channel through which interest rate operations affect economic activities at the macro level and the banking sector at the micro level. One of the oldest and most well-studied channels of money transmission is the interest rate channel. It gives a description of how a policy-induced monetary policy interest rate change affects the level of prices and output in an economy, vis-à-vis the transmission of a monetary policy rate change to the lending and deposit interest rates and their impacts on general economic activities. Therefore, understanding monetary transmission via the interest rate channel, the mechanism by which central bank policy decisions are communicated to the economy and through which the central bank can steer the economy in the desired direction, is a fundamental part of modern monetary policymaking. The strength, speed, and transmission channels all affect how well a monetary policy works.

The mechanism, however, is intricate and can take many different forms depending on a wide range of variables, such as the macroeconomic circumstances, the structure and development of the financial markets, and the regulatory environment. By implication, understanding how, by how much, and over what time policy interest rate changes induce changes in the market interest rates is crucial for a central bank due to the wider implications of such policy actions on economic activities. The effect of the central bank interest rate on the money market rates and retail bank interest rates has significant and intriguing ramifications in macro and microeconomics. On the macro side, this includes the monetary transmission mechanism and the best way to implement monetary policy, while on the micro side, it includes the structure and competitiveness of the banking industry. Since a central bank's short-term interest rate policy can affect and control the money market and retail interest rates, these rates can be thought of as variables that the central bank seeks to control to maintain a steady level of inflation and economic output (Karagiannis et al., 2014; Oyadeyi, 2022b). Therefore, it is anticipated that setting a target for the policy rate will affect the money market rate through open market operations and the retail lending and deposit rates through the banking system.

An essential component of interest rate processes and operations is the adjustment of retail bank interest rates (deposit and lending rates) and the money market rates in response to changes in the policy rates. To be effective, monetary policy must ensure that any shift in the policy rate must be transmitted to changes in retail interest rates and money market rates. For this to happen, the financial system needs to be able to transmit these changes to achieve the intended outcomes. The efficacy of this transmission will depend on the level of developments within the financial system. As a result, domestic demand and output will be affected. In other words, if interest rate signals are not effectively communicated to the economy, the central bank will need to take more drastic measures to achieve the same result. For this reason, it is crucial to implement and evaluate monetary policy through consistent monitoring and evaluation of the pass-through within the financial system.

Economists have argued at length about how interest rates affect the economy at large (for example, Bernanke & Gertler, 1995; DiMaggio et al., 2017). In fact, several studies have shown that an economy's level of financial development affects the effectiveness of monetary policy (Cottarelli & Kourelis, 1994; Fiador et al., 2022; Krause & Rioja, 2006; Oyadeyi, 2022a; Singh et al., 2008). It then follows that improving the efficacy of monetary policy would be greatly aided by a better understanding of the factors that affect market reactions and bank lending behaviour in response to central bank actions. This information could also be used to pinpoint areas for improvements within the selected monetary framework, such as intermediate targets and policy instruments (Fiador et al., 2022; Gigineishvili, 2011).

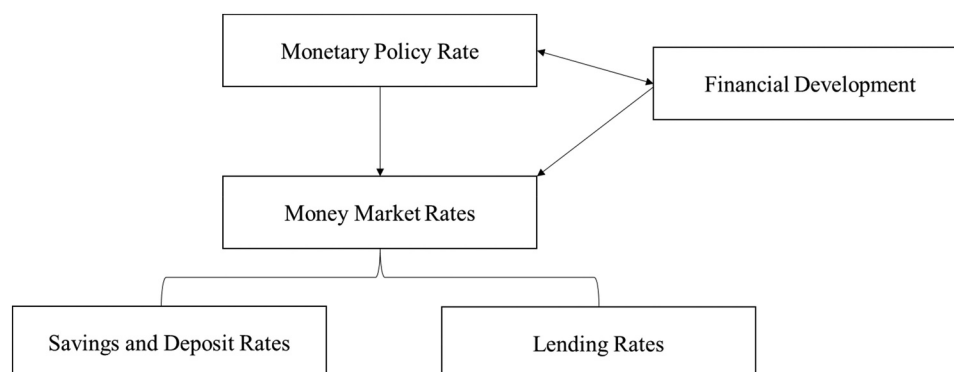
The developments of the financial system play an essential role in the transmission of monetary policy, especially in Africa which has mainly developing and emerging market countries, where most firms and external funding of households comes through bank loans. As a result, lending terms are crucial for central banks that aim to control overall demand in an economy (Altavilla et al., 2020). The interest rate pass-through process is a vital component of the money transmission decisions within the financial system. However, the 2007–2008 global financial crisis deteriorated the balance sheet of many banks, non-financial corporations, and sovereigns and hampered money transmission vis-à-vis the interest rate channel (Blot & Labondance, 2021; Ciccarelli et al., 2013). The important question yet to be answered is how much of a role financial development play in the interest rate pass-through process in a developing economy, such as Nigeria.

Several studies have investigated the role of the transmission channels of monetary policy in an economy (Dabla-Norris & Floerkemeier, 2006; Davoodi et al., 2013; Mishkin, 1995; Mishra et al., 2012; Oyadeyi & Akinbobola, 2020; Oyadeyi, 2022b). While several other studies have examined the speed and efficiency of interest rate decisions and processes in an economy (Blot & Labondance, 2021; Gigineishvili, 2011; Maravalle & Pandiella, 2022; Munir et al., 2022; Oyadeyi, 2022a). However, the uniqueness of this paper is that it highlights the critical role of financial development within the pass-through decisions and how this affects the monetary transmission mechanism in an economy. This is because an efficient interest rate pass-through will depend on the extent of financial development within an economy (Fiador et al., 2022; Meneses-González et al., 2022; Singh et al., 2008; Syed et al., 2022). Furthermore, financial development plays a critical role in the speed and adjustment process of the money market and retail interest rates to a policy rate change in any economy. Therefore, the paper underlines the prominent role of the financial sector within interest rate pass-through operations. The link between financial development and the interest rate channel can thus be represented in Figure 1.

In essence, the paper contributes to the growing literature on interest rate operations by examining the role of financial development within interest rate operations and processes. In doing so, the paper focuses on the following objectives. First, the paper focuses on the role of

Figure 1. The link between financial development, monetary policy and the interest rate pass-through process.

Source: Author's elaboration



financial development in inducing: the swiftness and magnitude of interest rate pass-through operations in Nigeria. Second, the paper examines the potential asymmetric responses of interest rate operations as a result of objective one above. Third, the paper establishes the period it will take for the money market and retail rates to fully adjust to a policy rate change induced by macroeconomic and financial sector developments. In addition, the paper tests the consistency of the results by breaking the data into sub-periods and checking if the results are consistent with the main findings. Lastly, the paper used a different method to carry out robustness on the main results to confirm the validity and consistency in our findings. To the best of our knowledge, the paper is the first to coherently model the role of financial development within the interest rate pass-through process for Nigeria. Moreover, it will be useful to establish whether financial development strengthens or weakens the pass-through process which has been found to be incomplete and slow in many other studies on Nigeria (Jibrilla & Balami, 2022; Mordi et al., 2019; Oyadeyi, 2022a; Sanusi, 2010).

The vices within the financial system that may have plagued the pass-through process for Nigeria may include ineffective financial sector regulations, underdeveloped capital markets, a sizable informal sector, a low level of banking sector development and competition, and high levels of structural inflation. Therefore, the paper would establish the role of financial sector development on interest rate pass-through for Nigeria. The remaining sections of the paper discuss the review of the literature in the second section, the methods, and data sources in the third section, analysis and the presentation of results in the fourth section, while it would discuss the summary and conclusions and end with some recommendations in the final section.

2. Literature review

2.1 Empirical literature review on interest rate pass-through

Here we review the literature on interest rate pass-through. Interest rate pass-through has been found to either be complete, incomplete, or overshooting according to previous studies. Starting with the recent studies on a panel of countries, Blot and Labondance (2021) conducted an empirical investigation into the influence of monetary policy and how it affects retail interest rates in the Euro Area when it reaches the effective lower bound. The paper found unconventional monetary policies driven by liquidity expansion to affect bank retail rates among these countries. Furthermore, Banerjee et al. (2013) found that there is a pass-through from future money market interest rates to one-month and three-month maturities in four major Euro Area countries. Kopecky and Van Hoose (2012) discovered that imperfectly competitive banking sectors have an impact on the structure of market deposit and loan rates. The paper also demonstrated that retail rates significantly depend on lagged rates, current rates, and anticipated future values. These results were corroborated by other studies such as van Leuvensteijn et al. (2008), and Munir et al. (2022).

Using a non-linear framework, however, Karagiannis et al. (2010) found asymmetric effects of policy rates on the retail interest rates for South-Eastern European countries (SEE countries). Additionally, Angeriz et al. (2008) in examining interest rate pass-through found the impact of the policy interest rate to be weak on inflation in the US, and the Eurozone. The paper found most inflation shocks to be driven by supply-side events. By focusing on the Euro area, the interest rate operations according to De Bondt (2005), were stronger in the long term. Creel et al. (2013) found similar outcomes in the Euro Area. Contrary to De Bondt (2005), Sørensen and Werner (2006) found interest rate operations to be heterogeneous across Euro-area countries.

Disyatat and Vongsinsirikul (2003) showed that monetary easing first triggers an increase in investment demand funded by loans from banks, which gradually builds up price pressures that ultimately lead to a shift in the aggregate price level with a lag. Beutler et al. (2017) found that a shock in interest rate affects loans from banks only by the extent of the shock and exposure of the bank to risks in interest rates. The paper also suggested that bank lending is determined by

how much capital they have, rather than how much liquidity. On the other hand, Juselius et al. (2016) highlighted the role of financial factors within the interest rate cycle as well as output and inflation. The paper found interest rates to have a significant influence through financial factors on output and inflation.

Agarwal et al. (2021) examined interest rate shocks on household consumption via the deposit channel. The paper found that commercial bank deposits pay depositors too little when there is a hike in central bank interest rates because of their market dominance. This outcome is in line with other studies such as Drechsler et al. (2017) and Xiao (2020). In a similar study, DiMaggio et al. (2017) explored the central bank interest rate operations on voluntary deleveraging, household consumption, and mortgage rates. The paper suggested that a significant reduction in mortgage payments by up to 50 percent results in a 35 percent rise in car purchases. In areas where adjustable-rate mortgages were more prevalent, defaults were relatively lower and house prices, car sales, and employment all rose in response to lower interest rates.

Using monthly data, Jamilov and Egert (2014) investigated interest rate processes in five Caucasus countries. The paper found that the pass-through process in Russia, Georgia, Azerbaijan, Kazakhstan, and Armenia was slow, incomplete, and influenced by macro instability and a lower degree of banking sector competition. An incomplete pass-through was also discovered by Karagiannis et al. (2014) in Brazil, Russia, India, and China (BRIC countries). To analyze the pass-through in Indonesia, Puah et al. (2017) used asymmetric threshold autoregressive (TAR) and momentum threshold autoregressive (MTAR) models. They found that Money market rates have an asymmetrical relationship with retail interest rates, and the effect of money market rates on these rates was also incomplete and imperfect. Tang et al. (2015) found similar outcomes to Puah et al. (2017) while using the MTAR and TAR models to verify the presence of an incomplete pass-through in Malaysia.

In a time series study on advanced countries, Ahmad et al. (2013) examined the effects of the LIBOR rate on retail rates in the United Kingdom (UK). The paper found interest rate pass-through to be incomplete in the immediate period and fairly complete over the long term. This result is in line with Bogoev and Petrevski (2012) who also found interest rate operation not to be fully complete in the short-run and fairly complete over the long term. Other studies such as Kobayashi (2008) also found the pass-through process to be incomplete. By focusing on an African economy, Iddrisu and Alagidede (2020) re-examined the impact of South Africa's central bank rate on inflation by establishing the role of interest rate operations and lending channels. Furthermore, the paper found that the lending channel and the interest rate channel both function, but only marginally, in South Africa.

The above studies found interest rate operations and pass-through to be incomplete. However, the following studies at least found a complete pass-through. Greenwood-Nimmo et al. (2022) discovered that the policy rate had a complete effect on lending rates in South Africa. The paper further demonstrated a full pass-through of interest rates to call deposit rates. The pass-through from the policy interest rate to five retail lending rates in Mexico was complete and rapid according to a study by Maravalle and Pandiella (2022). On the other hand, Gregor and Melecky (2018) did not find interest rate adjustments to be fully complete for lending to consumers but found a full pass-through to SME lending.

Banks can uniquely be different in how interest rate processes and operations affect them, and Nizamani et al. (2021) conducted an empirical study to learn more about this phenomenon. The paper discovered that the pass-through process in Pakistan was most heavily influenced by smaller banks with higher capital and liquidity. Short-term and long-term interest rate adjustments were found to be faster and more complete in China by Li and Liu (2019). Monetary contraction, as shown by Abuka et al. (2019), decreases bank lending, leading to a rise in loan application rejections and a fall in both loan volume and interest rates. Doojav and Kalirajan (2016) showed

that there are asymmetries in the way the policy rate affects retail rates. Furthermore, the paper showed stronger long-run impacts on the deposit rates than lending rates for Mongolia.

2.2 Empirical literature review on financial development and interest rate channel

In this section, we discuss extant studies on the impact of financial development on interest rate pass-through. One of the first studies to examine this relationship in the last two decades was Singh et al. (2008). They explored the impacts of financial development on monetary transmission mechanisms with a focus on the interest rate channel. The paper demonstrated that financial market developments strengthened interest rate operations in terms of speed and completeness. The paper also found the pass-through process to be stronger in advanced economies compared to Asian countries. The paper recommended a stronger pass-through process in the future for Asian economies. The results of Fiador et al. (2022) also found similar outcomes to Singh et al. (2008). Fiador et al. (2022) however, went further by showing that financial market development and financial institution development strengthens interest rate operations in 37 African countries.

For studies that focus on emerging market countries, Syed et al. (2022) focused on the asymmetric effects of financial development on interest rate operations and processes. The paper showed strong evidence of an asymmetric effect of financial sector development and non-performing loans over the long term. They demonstrated that non-performing loans respond differently to short and long-run positive and negative shocks emanating from macroeconomic variables and financial development. The findings demonstrated that the non-linear ARDL technique was able to show stronger effects on the impacts of financial development on non-performing loans. Furthermore, Ozdemir and Altinoz (2012) found that the structure of financial markets is critical within the pass-through process in emerging countries.

Gigineishvili (2011) explored the factors that influenced interest rate pass-through across 70 developing, emerging, and developed countries by focusing on the macroeconomic, financial, and bank-level determinants. The paper found that competition among banks, quality of credits, and a flexible exchange rate system, strengthened interest rate processes at the financial and bank level. At the macro level, the paper found per capita income and inflation to directly impact the pass-through process, while market volatility has an indirect impact on interest rate pass-through. In a similar study, Saborowski and Weber (2013) also found the pass-through to be incomplete but to a larger degree in industrial economies compared to developing economies. Mojon (2000) on the other hand showed that the adoption of the single monetary policy, the integration of the money market, and the expansion of the debt securities market should lead to a fall in the effect of monetary policy within the Euro Area. The study also demonstrates how competition among banks weakens the interest rate pass-through cycle asymmetry.

In a study of advanced countries, Akinci et al. (2022) demonstrated that across the US, UK, Spain, Germany, France, and Italy, the interest rate falls when the financial system becomes stable, and the banking sector has improved leverage. Furthermore, Meneses-González et al. (2022) found financial development to strengthen interest rate adjustments to the deposit rates, while it does not strengthen the adjustment processes to the lending rates across 43 countries from 2000 to 2019. In a specific country analysis, Rajan and Yanamandra (2015) found that financial inclusion plays a dominant role in money transmission in the economy of India. Nyamongo and Ndirangu (2013) found financial innovation to strengthen the interest rate channel.

In summary, the literature has been able to show that much of the research on the link between financial development and the interest rate channel of monetary policy has focused on a panel data set, while several studies have also considered the interest rate channel without considering the impact of financial development within their estimated models. To contribute to the frontier of knowledge, the paper will examine the nexus between monetary policy and financial development and how they affect interest rate transmission in Nigeria.

3. Methodology

3.1 Theoretical framework

The paper's theoretical foundation is built upon the Monte-Klein model for maximizing bank profits. Previous studies that have used this theory in modelling interest rate channel includes Misati et al. (2011), Nel et al. (2011), Mbowe (2015), and Oyadeyi (2022a). The model is practical and relatable to the Nigerian economy as it is able to show the pass-through channel by which monetary policy decisions affect banking sector interest rates. The theory assumes that because commercial banks interact directly with central banks, they can optimize their profit relative to their balance sheet. According to the model, asset items on the balance sheet must be equal to liabilities. That is, liability items such as settlements and deposits must be equal to asset items such as loans and reserves. Therefore, putting this in equation form gives the below.

$$R + L = D + S \quad (1)$$

If commercial banks conduct clearing activities with the central bank and provide loans denoted by i_L , incur deposits denoted by i_D , and pay for their costs of deposits and loans denoted by mL , the banks with a negative settlement balance will be penalized at rate i_P where the penalty is charged equal to the central bank policy rate. Therefore, our function of profit maximization can be specified as:

$$\Pi(D, L) = i_L L - i_D(R + L - S) - i_P \sigma(S - R) - mL \quad (2)$$

Based on the aforementioned information, commercial banks have two options: the value of loans they grant and the amount they decide to keep in reserves. Based on these considerations, the following results from differentiating equation 2 with respect to loans and reserves will give the following.

$$i_L - i_D = m \quad (3)$$

$$i_D = \sigma i_P \quad (4)$$

A linear connection between the lending rate and the policy rate is produced by combining equations 3 and 4.

$$i_L = m + \sigma i_P \quad (5)$$

As a result of the objectives, the paper will examine two approaches to determining the pass-through process. The first, called the monetary approach, would look at how the policy rate affects the money market rate, while the second would look at how the policy rate affects retail interest rates. Respecifying equation 5 to fit this narrative gives:

$$r_{mt} = \alpha_0 + b_1 r_{pt} + \varepsilon_t \quad (6)$$

$$r_{rt} = \alpha_1 + b_2 r_{pt} + \varepsilon_t \quad (7)$$

Equation 6) demonstrates the effect of the policy rate on the money market rate and Equation 7) highlights the effect of the central bank rate on the banking sector retail interest rates. r_{pt} denotes the central bank policy rate, r_{mt} denotes the money market rate, whereas r_{rt} denotes the retail interest rate. ε_t is the error term. That is, interest rate operations and processes are an indication of how central bank rates are transmitted to the economy through the banking sector to verify

completeness ($b_n = 1$) or otherwise ($0 < b_n < 1$). The pass-through may also overshoot, in which case, $b_n > 1$ (Oyadeyi, 2022a). Based on the objectives of the paper, which is to examine the role financial development plays within the pass-through process, therefore, Equation 6 and Equation 7 would be respecified to show the role of financial development as a determinant of interest rate pass-through.

$$r_{mt} = \alpha_0 + b_1 r_{pt} + b_2 fd_t + b_3 r_{pt} * fd_t + \varepsilon_t \quad (8)$$

$$r_{rt} = \alpha_0 + b_1 r_{pt} + b_2 fd_t + b_3 r_{pt} * fd_t + \varepsilon_t \quad (9)$$

Where fd_t denotes financial development index and $r_{pt} * fd_t$ denote the joint effect of financial development and the central bank rate.

3.2 Building an index for financial development

In the literature on financial development, there are multiple indicators used to represent financial development. In most cases, researchers examine financial development using the broad money supply as a ratio of GDP or use the ratio of credit to GDP. In some other instances, some studies use capital market indicators to represent financial development indicators. The paper, however, adopts an index for financial development by incorporating all these measures of financial development as indicated in the literature on financial development. By developing an index for financial development, this paper will add to the existing body of knowledge. Consequently, the existing measures for financial development are incorporated into the financial development index (FD).

The measures of financial development were generated from Beck et al. (2000) database. Previous studies such as Abanikanda (2022) and Oyadeyi and Akinbobola (2020) have used these measures of financial development with robust outcomes in their individual studies of Nigeria's financial development. The first step in creating this index is to identify the financial development indicators presented in Table 1. Afterward, the paper adopts the principal component analysis (PCA) in Equation 10) to create the financial development index. The paper selects k ($k = 1 \dots p$) as the k^{th} eigenvalue, subscript k as the value of the principal component that ties the standardized indicator p . The PCA computes the financial development index as indicated in Equation 10), while μ are the weights from the PCA. Finally, bms , ba , cps , smc , svt , tds , and svm represents the different PCA dimensions.

$$fd_t = -10\mu\lambda_1 bmsk + -10\mu\lambda_2 bak + -10\mu\lambda_3 cpsk + -10\mu\lambda_4 smck + -10\mu\lambda_5 svtk + -10\mu\lambda_6 tds k + -10\mu\lambda_7 svmk \quad (10)$$

3.3 Estimation techniques

To achieve the objectives of the paper, the study will adopt the autoregressive distributed lag (ARDL) model. However, for robustness, the error correction model (ECM) was employed. Equation 8 and Equation 9) represents the long-run equation of our models. Whereas Equation 11 to Equation 12) denotes the short-run form of Equation 8 and Equation 9) respectively using the ARDL framework. Therefore, Equation 8-Equation 9) can be respecified in its short-run as:

$$\Delta rr_{mt} = \alpha_0 + \sum_{k=1}^{\pi} h_k \Delta rr_{mt-k} + \ell_1 \Delta fd * pr_{pt-j} + \sum_{j=1}^{\eta} n_j \Delta pr * fd_{pt-j} + \sum_{j=1}^{\eta} b_j \Delta pr_{pt-j} + \sum_{j=1}^{\eta} m_j \Delta fd_{pt-j} + \varepsilon_t \quad (11)$$

Table 1. Description and measurement of variables

Variables	Measures	Sources
Financial Development Indicators (FD)	Broad Money Supply to GDP Ratio (BMS)	CBN Bulletin (2021)
	Bank Assets to GDP Ratio (BA)	CBN Bulletin (2021)
	Credit to Private Sector to GDP Ratio (CPS)	CBN Bulletin (2021)
	Stock Market Capitalization to GDP Ratio (SMC)	CBN Bulletin (2021)
	Stock Market Value Traded to GDP Ratio (SMV)	CBN Bulletin (2021)
	Total Debt Securities to GDP Ratio (TDS)	CBN Bulletin (2021)
	Stock market Value Traded to Stock Market Capitalization ratio (SVM)	CBN Bulletin (2021)
Monetary Policy	Monetary Policy Rate (MP)	CBN Bulletin (2021)
Money Market Rate	Treasury Bill Rate (TBR)	CBN Bulletin (2021)
Deposit Rates	The Savings Rate (SAV)	CBN Bulletin (2021)
	3 months Deposit Rate (3M)	CBN Bulletin (2021)
	6 Months Deposit Rates (6M)	CBN Bulletin (2021)
	12 Months Deposit Rates (12M)	CBN Bulletin (2021)
	Over 12 Months Deposit Rates (O12M)	CBN Bulletin (2021)
Lending Rates	Prime Lending Rates (PLR)	CBN Bulletin (2021)
	Maximum Lending Rates (MLR)	CBN Bulletin (2021)

Note that the financial development indicators were identified from Beck et al. (2000) database.

$$\Delta rr_{it} = \alpha_0 + \sum_{k=1}^{\pi} h_k \Delta rr_{it-k} + \ell_1 \Delta fd * pr_{pt-j} + \sum_{j=1}^{\eta} n_j \Delta pr^* fd_{pt-j} + \sum_{j=1}^{\eta} b_j \Delta pr_{pt-j} + \sum_{j=1}^{\eta} m_j \Delta fd_{pt-j} + \varepsilon_t \quad (12)$$

Equation 11-Equation 12) will be estimated using the ARDL model and ECM model for robustness since our variables were non-stationary in their level form. The reason why we use these methods is because we need the error correction terms to generate the mean adjustment lag as well as the asymmetric mean adjustment lags, which are important in knowing the number of periods it will take the lending rates to adjust to a shift in monetary policy changes induced by developments within the financial sector. where η and π are the number of lags, and Δ denotes the short run operator. If Equation 11-Equation 12)'s exhibit cointegration, then these equations are respecified to incorporate the dynamic adjustment to the long term, which is specified in Equation 13-Equation 14) as follows:

$$\Delta rr_{mt} = \alpha_0 + \sum_{k=1}^{\pi} h_k \Delta rr_{mt-k} + \ell_1 \Delta fd^* pr_{pt-j} + \sum_{j=0}^{\eta} n_j \Delta pr^* fd_{pt-j} + \sum_{j=0}^{\eta} b_j \Delta pr_{pt-j} + \sum_{j=0}^{\eta} m_j \Delta fd_{pt-j} + \vartheta (rr_{mt-1} - pr_{pt-1}) + \varepsilon_t \quad (13)$$

$$\begin{aligned} \Delta rr_t = & \alpha_0 + \sum_{k=1}^{\pi} h_k \Delta rr_{t-k} + \ell_1 \Delta fd^* pr_{pt-j} + \sum_{j=0}^{\eta} n_j \Delta pr^* fd_{pt-j} + \sum_{j=0}^{\eta} b_j \Delta pr_{pt-j} \\ & + \sum_{j=0}^{\eta} m_j \Delta fd_{pt-j} + \vartheta (rr_{t-1} - pr_{pt-1}) + \varepsilon_t \end{aligned} \quad (14)$$

Where ϑ denotes the adjustment speed, and ℓ is the coefficient of the main explanatory variable (the joint effect of the independent regressors) in the current period. Co-integration will exist if ϑ is statistically not equivalent to zero. Furthermore, the mean adjustment lag (MAL) will be used to establish the time period it will take interest rates to respond to a policy rate change. While the mean adjustment lag shows how many months it takes for retail and money market rates to completely adjust to a change in the policy rate, the error correction term shows how quickly rates can change within a single month (Oyadeyi, 2022a). The mean adjustment lag can be specified as:

$$MAL = \frac{1 - \ell_n}{\vartheta} \quad (15)$$

The process of adjustment will be swift if the mean adjustment lag is low, and otherwise if the adjustment lag is high. According to Scholnick (1996), the mean adjustment lags can be symmetric or asymmetric. Equation (15) represents the symmetric adjustment process. However, an asymmetric process of adjustment will imply that the residuals are either above or below the mean whereby, they adjust either downwards (if above the mean) or upwards (if below the mean) to the mean in the long-term. As a result, the error correction term is split into the positive and negative series. This can be represented below.

$$\begin{aligned} ECT^+ &= EC, & \text{if } ECT > \mu \\ ECT^+ &= 0 & \text{If } ECT < \mu \end{aligned} \quad (16)$$

And

$$\begin{aligned} ECT^- &= EC & \text{if } ECT^- < \mu \\ ECT^- &= 0 & \text{if } ECT > \mu \end{aligned}$$

Where μ denotes the residual in the cointegrating equation and is always zero since it represents the mean error correction. Whenever the residual is greater than the equilibrium (ECT^+), the retail rate is higher than the equilibrium rate, and vice versa. Therefore, the asymmetric mean adjustment lag can be seen by decomposing the residuals into two independent error correction terms.

$$\begin{aligned} \Delta rr_{mt} = & \alpha_0 + \sum_{k=1}^{\pi} h_k \Delta rr_{mt-k} + \ell_1 \Delta fd^* pr_{pt-j} + \sum_{j=0}^{\eta} n_j \Delta pr^* fd_{pt-j} + \sum_{j=0}^{\eta} b_j \Delta pr_{pt-j} \\ & + \sum_{j=0}^{\eta} m_j \Delta fd_{pt-j} + \vartheta_1 ECT^+ + \vartheta_2 ECT^- + \varepsilon_t \end{aligned} \quad (17)$$

$$\begin{aligned} \Delta rr_t = & \alpha_0 + \sum_{k=1}^{\pi} h_k \Delta rr_{t-k} + \ell_1 \Delta fd^* pr_{pt-j} + \sum_{j=0}^{\eta} n_j \Delta pr^* fd_{pt-j} + \sum_{j=0}^{\eta} b_j \Delta pr_{pt-j} \\ & + \sum_{j=0}^{\eta} m_j \Delta fd_{pt-j} + \vartheta_1 ECT^+ + \vartheta_2 ECT^- + \varepsilon_t \end{aligned} \quad (18)$$

The asymmetric mean adjustment lag would be specified in equations (19) and (20) respectively.

$$MAL^+ = \frac{(1 - \ell_1)}{\vartheta_1} \quad (19)$$

and

$$MAL^- = \frac{(1 - \ell_1)}{\vartheta_2} \quad (20)$$

Where Equation (19) is the positive mean adjustment lag, whereas Equation (20) is the negative mean adjustment lag. The mean adjustment lags will not be the same if the coefficients of the positive and negative lags are not the same, and the Wald test would test if the positive and negative changes are the same. If they are not different from zero, then the adjustment process would be symmetric and otherwise if the Wald test results is different from zero, which would then imply that the retail interest rates would adjust differently to a shift in the central bank rate.

3.4 Description and measurement of variables

The data source was gathered from the period of 1981 to 2021 from the 2021 edition of the CBN statistical bulletin. The data used to achieve the objectives have been used in previous studies on interest rate pass-through in Nigeria (such as Mordi et al., 2019; Oyadeyi, 2022a; Sanusi, 2010), thereby giving a level of confidence on the data being used. While the data on financial development indicators were adopted from Beck et al. (2000) database on financial development indicators. Studies such as Abanikanda (2022) and O. Oyadeyi and Akinbobola (2020) had used these indicators to measure the extent of financial development in Nigeria, hence, giving a level of confidence in the selection of the data being used. Furthermore, it is important to note that the monetary policy rate is the main instrument used by the authorities to control bank lending and deposit rates, money market rates, as well as ensure price stability and control inflation in Nigeria. Therefore, it is very important in the formulation of Nigeria's macroeconomic environment and financial system. Table 1 illustrates how the variables are captured, and the data sources used in capturing these variables.

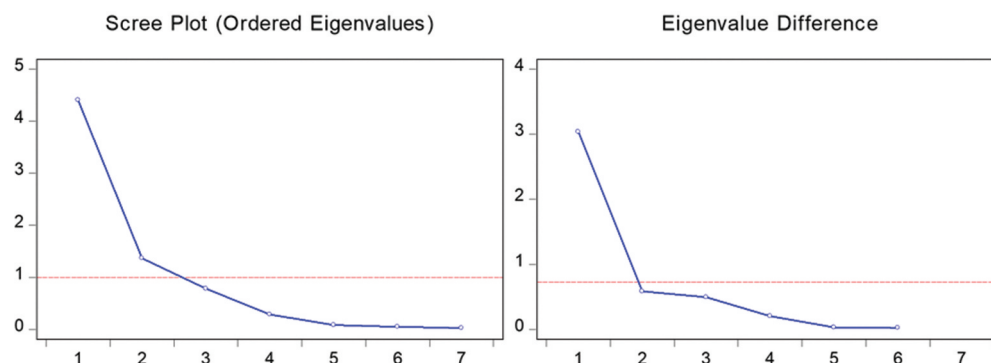
Table 2. The principal component analysis results

Number	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
PC 1	4.402064	3.03512	0.6289	4.402064	0.6289
PC 2	1.366944	0.584292	0.1953	5.769009	0.8241
PC 3	0.782652	0.495148	0.1118	6.55166	0.936
PC 4	0.287504	0.204488	0.0411	6.839164	0.977
PC 5	0.083016	0.032215	0.0119	6.92218	0.9889
PC 6	0.050801	0.023782	0.0073	6.972981	0.9961
PC 7	0.027019	—	0.0039	7	1
Panel B: Principal components (eigenvectors)					
Variable	PC 1				
FSD	0.415005				
BSDS	0.44985				
BSDA	0.419887				
SMDS	0.432513				
SMDA	0.401348				
BMD	−0.14867				
FEFF	0.280806				

Source: Author's illustration from PCA results.

Figure 2. Scree plot of eigen after PCA.

Source. Author's computation from PCA.



4. Results and their interpretation

4.1 Pre-estimation

The first step of the analysis is to create an index for financial development as discussed in Equation (10) using the principal component analysis procedure. This index is thus represented as “FD” in the analysis and was created exactly the way it was specified in Equation (10). Before diving into the main analysis, the paper conducted a preliminary examination of the data in Nigeria by computing the principal component analysis. Multicollinearity is more likely to occur across the seven indicators of financial development. The research used principal component analysis to calculate the corresponding financial development index in an effort to resolve the issue of multicollinearity. The results of the PCA are shown in Table 2; in this case, only the component with an eigenvalue larger than one and variables with a loading factor more than 0.30 were included in the analysis.

As can be seen in the table below, the PCA revealed a single component (eigenvalue 4.4021) that accounts for nearly 63% of the total variation. As a result, we only considered the first component, which seems to be the only one keeping around 63% of the original data's volatility. From Panel A in Table 2, all the 7 principal components (PC) consist of the measures of financial development as indicated in Table 1. The ordering follows the impact of the variables on the overall index (check Panel B in Table 2). It can also be seen that BSDS has a larger effect compared to the other variables, followed by SMDS, BSDA, FSD, SMDA, FEFF, and BMD. Lastly, Figure 2 reveals that the PCA has converged well, without any obvious structural breaks, as seen by the Scree plot of eigenvalues following the PCA.

After computing the PCA results, the paper proceeds by measuring the descriptive features of the variables. The results of the descriptive statistics in Table 3 showed that the mean and median values of the variables are very close, meaning that the variables used in estimating the results are trustworthy. The skewness statistic showed that only the maximum lending rate was negatively skewed. The kurtosis showed that the financial development index, the maximum lending rate (MLR), and the savings rate (SR) are less peaked while the others are greatly peaked. The Jarque-Bera statistic showed that variables such as FD, TBR, PLR, MLR, SAV, and 3 M follow a normal distribution. Even though MP, 6 M, 12 M, and O12M are not normally distributed, this is not a problem due to the large sample size of the data and the post diagnostic test results which showed that the individual models are sound and able to produce significant results.

Table 4 displays the results of the correlation analysis, showing that all dependent variables are positively correlated with MP and negatively correlated with FD, except for the MLR (the maximum lending rate) which positively correlates with FD. Since none of the correlation coefficients exceeds 0.8, then we can agree that even though the correlation analysis ranges from moderate to high for

Table 3. Descriptive statistics

	FD	MP	TBR	PLR	MLR	SAV	3M	6M	12M	O12M
Mean	6.5E-17	13.00	12.92	17.31	22.33	7.03	11.15	11.37	11.32	11.21
Median	-0.49	13.00	12.50	17.50	22.42	4.80	10.11	10.48	10.31	10.00
Maximum	5.39	26.00	26.90	29.80	36.09	18.80	23.24	25.85	25.64	26.29
Minimum	-2.49	6.00	5.00	7.75	10.00	1.41	4.40	4.65	4.71	2.40
Std. Dev.	2.12	3.96	4.73	4.64	6.08	5.00	4.16	4.49	4.56	4.74
Skewness	0.59	0.73	0.48	0.27	-0.19	0.90	0.79	1.06	1.01	0.87
Kurtosis	2.19	4.54	3.20	3.52	2.70	2.45	3.60	4.46	4.08	4.34
Jarque-Bera	3.45	7.75	1.65	0.95	0.40	6.07	4.82	11.34	9.01	8.24
Probability	0.18	0.02	0.44	0.62	0.82	0.05	0.09	0.00	0.01	0.02
Sum	1.3E-15	533	530	710	916	288	457	466	464	459
SSD	180	627	896	860	1478	1002	691	808	833	900
Observations	41	41	41	41	41	41	41	41	41	41

Source: Author's Computation, 2023

Table 4. Correlation coefficient

	MP	TBR	3M	6M	12M	O12M	SAV	PLR	MLR
FD	−0.32	−0.09	−0.40	−0.42	−0.46	−0.48	−0.74	−0.13	0.28
MP	–	0.80	0.74	0.76	0.76	0.74	0.46	0.62	0.63

Source: Author's Computation, 2023

MP, it does not lead to a spurious estimation of results. On the other hand, FD has a low to high correlation with the dependent variables. Dickey and Fuller's (1981) and Phillips and Perron's (1988) tests were utilized to estimate the unit root properties of the variables. Table 5 shows the results of the tests confirming that the variables were stationary when expressed as differenced values.

4.2 The impact of monetary policy and financial development on interest rate channel

The results of our investigation are summarised in Table 6. The results shed light on how monetary policy rate transmission incentivised by financial development affects money market, lending, and deposit rates. This is exemplified by the impact of FD*MP in our models. In theory, the money market rate, deposit rates, and lending rates should all respond directly to the monetary policy rate. These rates, however, should be related to financial development indirectly. Accordingly, the interest rate operations and processes ought to be weakened by the combined effect of monetary policy and financial development. As earlier mentioned, a complete pass-through will either have a figure of 1 or 100 percent, while an incomplete pass-through will obtain a figure lower than 1 or 100 percent. An overshooting pass-through on the other hand will have a value greater than 1 or greater than 100 percent.

Based on the results, the pass-through from monetary policy to the treasury bill rate (representing our money market rate) is almost complete and perfect at 99 percent (0.99). The significance of the outcomes of the interaction term is not statistically significant and irrelevant to be of any practical importance. Thus, interest rate operations are not found to be complete, but to a very high degree and the long term results (0.95) for the treasury bill rate are consistent with the short-term results. The bound test results allow us to know if the variables are cointegrated, implying a long run relationship if cointegrated. If the F-statistic falls below the lower bound figure then the variables are not cointegrated, and otherwise if it falls above the upper bound figure. However, it is inconclusive if the F-statistic fall within the two bounds.

For the deposit rates, the paper considers five deposit rates (the savings rate, 3, 6, 12, and over 12 months deposit rates). The findings showed that the central bank's policy rate, as well as the financial development index and the joint effect of those variables, do not significantly strengthen or weaken the savings rate in Nigeria in the short. The long term results are insignificant due to the bound test results. Besides, monetary policy mostly has short term effects on interest rates. The error correction term is negative but insignificant, meaning that there may not be a long term equilibrium movement, corroborating the long run results since they are insignificant.

For the impact of the policy rate on the remaining deposit rates (3, 6, 12, and over 12 months deposit rates), the pass-through is also incomplete, albeit to a lower degree at 40 percent (0.40), 46 percent (0.46), 48 percent (0.48), and 45 percent (0.45) respectively. On the other hand, financial development directly improved the 3, 6, 12, and over 12 months deposit rates by 3.2, 3.5, 3.2, and 4.0 respectively. Furthermore, the findings show that the effect of the interaction term shows a negative and significant effect on the 3 months (−2.9), 6 months (−3.3), 12 months (−3.1), and over 12 months deposit rates (−3.4) in the immediate term. The long term results were insignificant due to the bound test results, although these figures were −0.17 for 3 months, −0.19 for 6 months, −0.18 for 12 months, and −0.22 for the over 12 months deposit rates. Finally,

Table 5. Unit root analysis

Variable	ADF		PP		Status
	Levels	First Difference	Levels	First Difference	
FD	-1.031 (0.7323)	-5.459 (0.0001)***	-1.091 (0.7101)	-7.968 (0.0000)***	I(1)
MP	-0.357 (0.5495)	-8.848 (0.0000)***	-0.370 (0.5448)	-8.968 (0.0000)***	I(1)
TBR	-0.853 (0.3402)	-7.739 (0.0000)***	-0.651 (0.4289)	-7.739 (0.0000)***	I(1)
SAV	-1.651 (0.4471)	-2.029 (0.0421)**	-1.147 (0.6876)	-6.396 (0.0000)***	I(1)
3M	-1.441 (0.5516)	-3.577 (0.0113)**	-2.514 (0.1199)	-7.892 (0.0000)***	I(1)
6M	-1.583 (0.4809)	-3.519 (0.0131)**	-0.774 (0.3748)	-7.884 (0.0000)***	I(1)
12M	-1.666 (0.4394)	-3.457 (0.0153)**	-0.733 (0.3928)	-7.780 (0.0000)***	I(1)
O12M	-1.374 (0.5842)	-4.156 (0.0025)***	-0.752 (0.3841)	-7.765 (0.0000)***	I(1)
PLR	-2.236 (0.1974)	-2.664 (0.0911)*	-0.411 (0.5289)	-9.589 (0.0000)***	I(1)
MLR	0.7089 (0.8642)	-7.0174 (0.0000)***	0.297711 (0.7671)	-8.7954 (0.0000)***	I(1)

Source: Author's Computation, 2023 Where '***', '**', and '*' are significance at 1 percent, 5 percent and 10 percent respectively. The probability values are in parentheses while the T Statistics are not in parentheses.

the error correction term had the appropriate sign and is significant, thereby aligning with theoretical underpinnings.

For lending rates, the paper considered the prime lending and maximum lending rates. These results showed that in the immediate term, banks' lending to their prime or most important customers was unaffected by financial development or monetary policy. However, interest rate processes are confirmed to be incomplete, albeit to a lesser degree, due to the interactions between these variables. In addition to being statistically significant, the correction term also has the appropriate sign. However, the long-term results showed that interest rate pass-through in Nigeria is heavily influenced by monetary policy, financial development, and the interplay between the two. That is, there is a higher degree of pass-through between the two (0.71). Long-term interest rate processes are severely weakened by the joint effect between monetary policy and financial development (-0.22). For maximum lending rates, the findings confirm that interest rate operations and processes is not fully complete, although to a greater extent (0.69). Financial development also significantly improved the maximum lending rate in Nigeria. Nonetheless, the influence of the monetary policy rate on interest rate pass-through in Nigeria is diminished by the interaction term and likewise not complete. The outcomes of the bound tests rendered the long run findings irrelevant.

Evidence from the asymmetric error correction terms showed that banks could make adjustments to their long-term equilibrium component in response to shifts in monetary policy and financial development, regardless of the direction of change. The Wald test further confirmed that asymmetry exists in the two error correction terms, meaning that they are not equal. We

Table 6. Impacts of financial development and monetary policy on interest rate pass-through

	TBR	SAV	3M	6M	12M	O12M	PLR	MLR
Short Run Results								
D(FD)	-0.5881	0.6952	3.1803	3.534	3.2127	3.9995	1.4833	2.8333
	-0.5211	-0.351	(0.0003)***	(0.0001)***	(0.0004)***	(0.0000)***	-0.2452	(0.0140)**
D(MP)	0.9881	0.1236	0.3973	0.4647	0.4787	0.4462	0.3206	0.6867
	(0.0000)***	-0.2302	(0.0002)***	(0.0001)***	(0.0000)***	(0.0001)***	-0.1128	(0.0001)***
D(FD*MP)	-0.0262	-0.0913	-0.2885	-0.3304	-0.3098	-0.344	-0.208	-0.3255
	-0.6725	-0.1291	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0211)**	(0.0006)***
ECT(-1)	-0.5948	-0.0728	-0.5361	-0.5981	-0.6046	-0.5694	-0.9649	-0.4594
	(0.0005)***	-0.5229	(0.0001)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0001)***
Bound Test Results	5.7789	0.3467	3.0687	3.5872	3.4576	4.2982	6.8307	3.1828
Long Run results								
FD	1.0386	-5.0919	1.6232	1.8276	1.686	1.3798	2.6913	2.1397
	-0.4113	-0.6887	-0.1589	(0.0898)*	-0.1132	-0.2361	(0.0063)***	-0.1854
MP	0.9501	-0.1449	0.7412	0.7769	0.7917	0.7836	0.7066	1.4949
	(0.0003)***	-0.9125	(0.0012)***	(0.0003)***	(0.0003)***	(0.0007)***	(0.0003)***	(0.0000)***
FD*MP	-0.044	0.296	-0.1729	-0.1939	-0.186	-0.1724	-0.2156	-0.0157
	-0.6815	-0.7869	(0.0824)*	(0.0384)**	(0.0461)**	(0.0911)*	(0.0092)***	-0.9083
C	0.6334	8.1455	0.8812	0.5941	0.4162	0.3596	7.7638	3.543
	-0.8363	-0.6326	-0.7458	-0.8137	-0.8688	-0.8945	(0.0018)***	-0.3217
ECT+	3.0477	3.0204	4.1557	3.7594	3.6845	3.5585	1.9393	2.7269
	(0.0006)***	(0.0007)***	(0.0000)***	(0.0000)***	(0.0001)***	(0.0002)***	(0.0008)***	(0.0002)***
ECT-	-3.0614	-2.0525	-2.463	-2.4022	-2.2991	-1.6282	-1.9058	-3.6841
	(0.0006)***	(0.0045)***	(0.0000)***	(0.0006)***	(0.0018)***	(0.0133)**	(0.0006)***	(0.0000)***
MAL	-1.7252	-14.9876	-2.4036	-2.2242	-2.1662	-2.3603	-1.252	-2.8855
MAL+	0.3367	0.3613	0.3101	0.3539	0.3555	0.3777	0.6229	0.4861

(Continued)

Table 6. (Continued)

	TBR	SAV	3M	6M	12M	O12M	PLR	MLR
MAL-	-0.335	-0.532	-0.523	-0.554	-0.57	-0.825	-0.634	-0.36
Wald Test	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***
Serial Correlation	0.0794	0.506	0.7518	0.8613	0.8589	0.3875	0.4805	0.6016
Heteroscedasticity	0.9815	0.75	0.8518	0.8321	0.4238	0.6056	0.0543	0.9011

Source: Author's Computation, 2023

Where '***', '**', and '*' are significance at 1 percent, 5 percent and 10 percent respectively.

The lower and upper bound test results are 3.79 percent and 4.85 percent respectively.

The probability values are in parentheses while the coefficients are not in parentheses.

estimated the mean adjustment lags to confirm how long the dependent variables respond to an incentive-based change in the regressors. The mean adjustment lags reveal how many years it takes for a model to reach its full long run equilibrium, while the error correction term reveals the adjustment speed in any given year. The results of the mean adjustment lag demonstrated that it requires two years for the treasury bill rate, 3, 6, 12, and over 12 months deposit rates to completely adjust to a central bank policy change. For the prime lending rate, it takes roughly one year, whereas it takes roughly three years for any adjustment process for the maximum lending rate. Finally, since the model has been found to be asymmetric, then the interpretations of the nonlinear mean adjustment lags are more appropriate. The asymmetric mean adjustment lag results showed that all the estimated models fully adjusted in less than a year to either an upward or downward monetary policy change incentivized by changes in financial development. The asymmetric MAL results are robust because the models have been found to be nonlinear as revealed by the Wald test. This implies that banks will change their rates within the year that the policy rate changes occur (regardless of the direction of change).

The research findings indicate that the interest rate operations and processes (coefficient of MP) is generally modest, with the long term findings generally larger than the short term results. This supports the theoretical expectation that shorter-term interest rate maturities should be lower than longer-term maturities, suggesting that interest rate rises with increasing maturity. Therefore, the findings suggest that there is still a lower level of interest rate pass-through in Nigeria as a result of financial development. This is to be anticipated, as financial development would have a larger effect on financial intermediation and a greater influence of banks on depositors and borrowers, decreasing the demand elasticity of deposits and loans, leading to a lower degree of pass-through, and thereby weakening the interest rate channel. The serial correlation and heteroscedasticity tests suggest that the models are consistent, concluding the analysis.

The findings on the impact of financial development on interest rate processes are not in line with previous studies on the topic such as Nyamongo and Ndirangu (2013), Fiador et al. (2022), Meneses-González et al. (2022) whose studies found financial development to strengthen interest rate operations and processes. There are several factors that cause interest rate stickiness which leads to an incomplete pass-through in any economy. Some of these factors include the problems of asymmetric information, credit rationing, adverse selections, bank switching costs, adjustment costs faced by banks, moral hazards, and risk-sharing behaviour (De Bondt, 2002, 2005; Mordi et al., 2019; Oyadeyi & Akinbobola, 2022). Our results show that the joint effect of financial development and central bank monetary policy weakens interest rate operations and processes, and this was in line with previous studies such as Sørensen and Werner (2006), Singh et al. (2008), Akinci et al. (2022), and Syed et al. (2022). This result also implies that financial development would have a weakened effect on lending, in line with a similar study on the Vietnamese economy by Nguyen et al. (2022).

4.3 A test of the constancy of the results overtime using sub-sample analysis

4.3.1 The impact of monetary policy and financial development on interest rate channel using a sub-sample from 1981 to 2011

In Table 7, we decided to break our analysis into sub-sample periods to test the constancy of the mean over time. Therefore, this section would examine the same analysis as the previous section but from a time period of 1981 to 2011, while the subsequent section would focus on the sub-sample period of 1991 to 2021. The results of the sub-sample were consistent with the full sample results. In addition, the result of the prime lending rate was significant in the short run for our sub-sample, unlike the full sample result which was insignificant. Furthermore, the sub-sample period showed that even though interest rate processes were incomplete, the adjustment process is characterized by a higher degree compared to the full sample and even overshoots for the treasury bill rate (1.03). This suggests that banks are actively engaged in raising treasury bill rates in the

Table 7. Sub-sample (1981–2011): Impacts of financial development and monetary policy on interest rate-pass-through

	TBR	SAV	3M	6M	12M	O12M	PLR	MLR
Short Run Results								
D(FD)	-0.306	0.357	2.8373	3.4624	3.1507	4.1264	1.6105	2.6108
	-0.7575	-0.5401	(0.0009)***	(0.0002)***	(0.0011)**	(0.0002)***	-0.1974	(0.0024)***
D(MP)	1.0265	0.1737	0.6258	0.672	0.6658	0.6205	0.4806	0.9566
	(0.0000)***	-0.1301	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0382)**	(0.0000)***
D(FD * MP)	-0.0354	-0.0645	-0.2471	-0.3066	-0.2793	-0.3368	-0.2188	-0.295
	-0.6305	-0.3148	(0.0002)***	(0.0000)***	(0.0002)***	(0.0001)***	(0.0286)**	(0.0001)***
ECT(-1)	-1.0905	-0.1595	-0.6905	-0.7115	-0.6806	-0.6576	-0.9676	-0.7593
	(0.0000)***	-0.2369	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0001)***	(0.0000)***
Bound Test Results	2.7795	0.2307	3.0291	2.8775	2.3703	2.5382	8.0457	2.854
Long Run results								
FD	1.5507	2.238	0.9121	1.363	1.2312	1.2136	1.6645	3.4385
	(0.0241)**	-0.5201	-0.2693	-0.1143	-0.1959	-0.2518	-0.145	(0.0013)***
MP	0.9413	-0.2872	0.9063	0.9446	0.9783	0.9435	0.9225	1.2598
	(0.0000)***	-0.7198	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***
FD*MP	-0.1342	-0.4044	-0.0674	-0.1248	-0.1165	-0.1468	-0.1025	-0.2275
	(0.0480)**	-0.2411	-0.4143	-0.1487	-0.2241	-0.1689	-0.367	(0.0252)**
C	-0.3894	9.6581	-0.0263	-0.5892	-1.0269	-0.9843	5.5853	3.6481
	-0.7814	-0.339	-0.9888	-0.7622	-0.6414	-0.6855	(0.0319)**	(0.0999)*
ECT+	2.8528	2.6042	4.5252	4.5825	4.4496	4.1827	3.8609	5.4402
	(0.0039)***	(0.0028)***	(0.0004)***	(0.0003)***	(0.0005)***	(0.0025)***	(0.0003)***	(0.0001)***
ECT-	-3.8457	-2.97	-4.3934	-4.5813	-4.286	-3.2608	-2.2309	-7.0208
	(0.0025)***	(0.0012)***	(0.0005)***	(0.0003)***	(0.0007)***	(0.0063)***	(0.0055)***	(0.0000)***
MAL	-0.9495	-6.6733	-1.8061	-1.8365	-1.8795	-2.0328	-1.2597	-1.7056
MAL+	0.3629	0.4088	0.2756	0.2851	0.2875	0.3196	0.3157	0.2381

(Continued)

Table 7. (Continued)

	TBR	SAV	3M	6M	12M	O12M	PLR	MLR
MAL-	-0.2692	-0.3584	-0.2838	-0.2852	-0.2985	-0.41	-0.5463	-0.1845
Wald Test	(0.0001)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0001)***	(0.0000)***	(0.0000)***
Serial Correlation	0.6228	0.721	0.6846	0.9006	0.5693	0.7742	0.1173	0.9198
Heteroscedasticity	0.3711	0.7265	0.6159	0.5531	0.477	0.4692	0.0691	0.4888

Source: Author's Computation, 2023 Where ****, ***, and ** are significance at 1 percent, 5 percent and 10 percent respectively. The lower and upper bound test results are 3.79 percent and 4.85 percent respectively. The probability values are in parentheses while the coefficients are not in parentheses.

money market above the policy rate adjustments to improve investment in money market instruments and thereby improve their own profits from money market dealings.

The findings on the asymmetric error correction terms (positive and negative) are also consistent with the full sample findings. The findings demonstrated that banks are able to adjust to their long run equilibrium part in response to changes in monetary policy and financial development, regardless of the direction of change. These findings were backed by the Wald test results which demonstrated that the negative and positive error correction terms are not equal, thereby confirming asymmetry among the error correction terms. The mean adjustment lag was found to be two years for the 3, 6, 12, over 12-month deposit rates, and maximum lending rates. Also, it took one year for the treasury bill and prime lending rates. The asymmetric mean adjustment lag results showed that it takes less than a year for complete adjustments of either upward or downward central bank policy rate changes incentivized by financial development changes on bank interest rate changes, consistent with the full sample results. Finally, results from tests of serial correlation and heteroscedasticity were consistent. These findings corroborate previous findings such as Sørensen and Werner (2006), Singh et al. (2008), Akinci et al. (2022), and Syed et al. (2022). This result also implies that financial development would have a weakened effect on lending, in line with a similar study on the Vietnamese economy by Nguyen et al. (2022).

4.3.2 The impact of monetary policy and financial development on interest rate channel using a sub-sample from 1991 to 2021

Table 8 shows an estimation of the sub-sample over the years 1991 through 2021, allowing us to verify that our findings have remained stable over time. For this reason, this section will analyze the models from a time frame of 1991 to 2021. For the treasury bill rate, 3, 6, 12, over 12-month rate, and the maximum lending rate, the subsample findings were consistent with the full sample results. While financial development and the interaction term were not significant in the short run, the pass-through from the policy rate to the savings rate was significant for our sub-sample, albeit to a lesser degree. Also, the sub-sample findings demonstrated that changes in the central bank's policy rate and financial development have a negligible influence on the prime lending rate. Additionally, the results from the sub-sample period indicated that the pass-through process was slightly weakened in the sub-sample results, with the exception of the treasury bill rate, which adjusted completely. This implies that the rates at which banks offer treasury bills are fully responsive to changes in the central bank's policy rate.

The findings on the asymmetric error correction terms (positive and negative) also corroborate the full sample findings. The findings demonstrated that banks could adjust to their long run mean in line with adjustments in the central bank's policy rate and financial development, regardless of the direction of change. These findings were backed by the Wald test results which demonstrated that the negative and positive error correction terms are not equal, thereby confirming asymmetry. Finally, the mean adjustment lag demonstrated that it takes roughly two years for the treasury bill rate, 6 months, 12 months, and over 12 months deposit rates to completely adjust to the central bank's policy rate shifts. Also, it takes one year for the prime lending rate to fully adjust, while it takes roughly three years for the 3 months and maximum lending rates to adjust completely. Finally, it takes about six years for the savings rate to adjust completely to a central bank policy change incentivized by financial developments. Since the model has been found to be asymmetric, then the interpretations of the nonlinear mean adjustment lags are more appropriate.

Finally, the asymmetric mean adjustment lags results showed that asymmetric monetary policy adjustments incentivized by financial development changes take less than a year for all the estimated models to completely adjust to a monetary policy change, consistent with the full sample results and the previous sub-sample results. It is also important to note that the asymmetric results are more appropriate than the symmetric findings since the Wald test showed that the error correction terms are nonlinear. Finally, the serial correlation and heteroscedasticity tests

Table 8. Sub-sample (1991–2021): impacts of financial development and monetary policy on interest rate-pass-through

	TBR	SAV	3M	6M	12M	O12M	PLR	MLR
Short Run Results								
D(FD)	-0.8378	0.7355	3.1125	4.2922	4.1104	5.4993	0.629	2.3248
	-0.5168	-0.172	(0.0012)***	(0.0003)***	(0.0003)***	(0.0000)***	-0.6069	(0.0879)*
D(MP)	1.0085	0.1601	0.3901	0.3725	0.3913	0.267	0.0543	0.487
	(0.0001)***	(0.0703)*	(0.0065)***	(0.0204)**	(0.0141)**	(0.0689)*	-0.7942	(0.0312)**
D(FD*MP)	-0.0162	-0.0529	-0.2642	-0.3791	-0.3728	-0.4553	-0.1119	-0.3037
	-0.8554	-0.2594	(0.0006)***	(0.0001)***	(0.0001)***	(0.0000)***	-0.2653	(0.0076)***
ECT(-1)	-0.624	-0.1871	-0.4177	-0.702	-0.7556	-0.8561	-1.0203	-0.5003
	(0.0029)***	(0.0759)*	(0.0097)***	(0.0012)***	(0.0005)***	(0.0000)***	(0.0004)***	(0.0019)***
Bound Test Results	4.4812	1.0275	2.0025	2.36711	2.4577	3.2081	5.5862	3.4375
Long Run results								
FD	0.8089	3.931	2.7345	3.4753	3.4795	3.6251	0.6164	0.0661
	-0.665	-0.2159	-0.2031	(0.0119)**	(0.0058)***	(0.0011)***	-0.5947	-0.9775
MP	0.9088	0.8554	0.934	0.9441	0.9657	0.9471	0.0532	0.9735
	(0.0238)**	-0.1919	(0.0363)**	(0.0008)***	(0.0003)**	(0.0000)***	-0.7895	(0.0106)**
FD*MP	-0.026	-0.2826	-0.216	-0.2793	-0.2807	-0.3026	-0.1097	0.0859
	-0.8572	-0.2054	-0.2015	(0.0097)***	(0.0045)***	(0.0006)***	-0.2298	-0.6318
C	1.6375	-9.2178	-2.8011	-2.7852	-3.1812	-3.313	16.9863	12.6137
	-0.7491	-0.3481	-0.6288	-0.4039	-0.3066	-0.1883	(0.0000)***	(0.0148)**
ECT+	2.0719	1.5695	3.7533	4.8442	4.1806	4.168	4.821	6.1492
	(0.0047)***	(0.0206)**	(0.0001)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0006)***	(0.0001)***
ECT-	-2.8793	-1.9047	-3.013	-2.9715	-3.2318	-2.5587	-2.7803	-5.1432
	(0.0003)***	(0.0032)***	(0.0005)***	(0.0003)***	(0.0000)***	(0.0011)***	(0.0019)***	(0.0001)***
MAL	-1.6286	-5.6271	-3.0268	-1.9644	-1.8168	-1.7	-1.0898	-2.6061
	0.4905	0.6708	0.3368	0.2847	0.3284	0.3492	0.2306	0.212

(Continued)

Table 8. (Continued)

	TBR	SAV	3M	6M	12M	O12M	PLR	MLR
MAL-	-0.353	-0.5528	-0.4196	-0.4641	-0.4248	-0.5688	-0.3999	-0.2535
Wald Test	(0.0000)***	(0.0005)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***
Serial Correlation	0.1013	0.1621	0.7221	0.6304	0.6136	0.2452	0.6824	0.391
Heteroscedasticity	0.7268	0.936	0.9015	0.6214	0.3084	0.6483	0.202	0.2144

Source: Author's Computation, 2023

Where ***, **, and * are significance at 1 percent, 5 percent and 10 percent respectively.

The lower and upper bound test results are 3.79 percent and 4.85 percent respectively.

The probability values are in parentheses while the coefficients are not in parentheses.

Table 9. Robustness check: the ECM procedure

	TBR	SAV	3M	6M	12M	O12M	PLR	MLR
Short Run Results								
D(FD)	-1.0167	0.8256	2.6467	2.956	2.6569	3.5888	0.6561	2.9858
	-0.2981	-0.1933	(0.0008)***	(0.0005)***	(0.0015)***	(0.0000)***	-0.6177	(0.0045)***
D(MP)	1.0156	0.154	0.4126	0.4465	0.4504	0.3804	0.3398	0.7085
	(0.0000)***	(0.0748)*	(0.0001)***	(0.0001)***	(0.0001)***	(0.0006)**	-0.1229	(0.0000)***
D(FD * MP)	0.0062	-0.1042	-0.2441	-0.2832	-0.2628	-0.3123	-0.1539	-0.3422
	-0.9346	(0.0352)**	(0.0001)***	(0.0000)***	(0.0001)***	(0.0000)***	-0.1326	(0.0001)***
ECT(-1)	-0.6108	-0.0898	-0.4017	-0.4654	-0.4836	-0.5177	-0.6187	-0.3738
	(0.0003)***	-0.295	(0.0010)***	(0.0003)***	(0.0002)***	(0.0000)***	(0.0006)***	(0.0041)***
Cointegration	YES(1)	NO	NO	NO	NO	YES(1)	NO	NO
Long Run results								
FD	0.6227	0.6415	2.101	2.2843	2.1421	2.1938	1.9167	2.0865
	-0.4116	-0.4359	(0.0021)***	(0.0009)***	(0.0015)***	(0.0026)***	(0.0969)*	(0.0645)*
MP	0.9911	0.4787	0.7958	0.8105	0.808	0.7965	1.2567	1.6747
	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***
FD*MP	-0.0197	-0.1791	-0.2043	-0.2287	-0.2252	-0.2363	-0.1243	-0.0255
	-0.7519	(0.0113)**	(0.0004)***	(0.0001)***	(0.0001)***	(0.0002)***	-0.1893	-0.7794
ECT+	0.0222	-0.0411	-0.363	-0.3665	-0.2642	-0.2849	-0.219	-0.2101
	-0.9458	-0.8499	-0.2518	-0.246	-0.3991	-0.3707	-0.1441	-0.2395
ECT-	-0.2409	0.0471	-0.2067	-0.2854	-0.2842	-0.285	-0.2124	-0.0942
	-0.4627	-0.7944	-0.4014	-0.2679	-0.2738	-0.2285	-0.1411	-0.652
MAL	-1.6271	-12.3001	-3.0967	-2.7572	-2.6112	-2.5348	-1.865	-3.5909
MAL+	44.8208	-26.8813	-3.4268	-3.5015	-4.78	-4.6063	-5.2699	-6.3883
MAL-	-4.1261	23.4681	-6.0176	-4.4954	-4.4431	-4.6051	-5.4333	-14.244
Wald Test	-0.5697	-0.755	-0.6951	-0.8411	-0.9605	-0.9999	-0.9744	-0.6723

(Continued)

Table 9. (Continued)									
	TBR	SAV	3M	6M	12M	O12M	PLR	MLR	
Serial Correlation	0.1472	0.7392	0.9786	0.804	0.9582	0.9417	0.1784	0.4246	
Heteroscedasticity	0.8878	0.7142	0.9624	0.9229	0.5599	0.4863	0.0501	0.7391	

Source: Author's Computation, 2023
Where ^{****}, ^{***}, and ^{**} are significance at 1 percent, 5 percent and 10 percent respectively.
The Johansen cointegration procedure was used to test for cointegration.
The probability values are in parentheses while the coefficients are not in parentheses.

were consistent and right fit based on the results. The results of the main analysis in this section were in line with previous studies such as Sørensen and Werner (2006), Singh et al. (2008), Akinci et al. (2022), and Syed et al. (2022). This result also implies that financial development would have a weakened effect on lending, in line with a similar study on the Vietnamese economy by Nguyen et al. (2022).

4.4 Robustness checks

Table 9 displays the robustness results using the error correction mechanism (ECM) procedure. The whole essence of this sub-section is to confirm whether the results of the robustness analysis will be consistent with the main findings using a slightly different procedure. The analysis covers the full sample from 1981 to 2021. The stationarity test results showed that all the variables had unit roots. Therefore, the paper checked the cointegration tests to confirm whether long term relationships can be established. Even though the cointegration results showed that long run relationships exist in only two of the eight models, we decided to proceed to run the ECM analysis because it is important in achieving the objectives of the study and it will help in computing our asymmetric error correction terms. The short term results were consistent with the main analysis as well as the two sub-sample analyses in the previous sub-sections. The extent of pass-through was however stronger in the main analysis compared to this section (robustness analysis).

The paper used the Johansen cointegration procedure to test for cointegration and found that the treasury bill rate model and the over 12 months deposit rate model were cointegrated, indicating that the two models have long run relationships. The other models, however, did not exhibit cointegration. The long-term effects of the regressors and their interaction term on the treasury bill rate revealed that only the central bank's policy rate had a significant impact on the treasury bill rate, albeit less than one, indicating an incomplete pass-through, with a very high degree of pass-through at 0.99. However, the model for over 12-month deposit rates demonstrated that monetary policy and financial development significantly enhanced the interest rate channel, albeit incompletely, but with a larger degree at 0.79. The coefficient of the interaction term, which is 0.24 in absolute terms, demonstrates how the interaction term weakens the effect of the central bank's policy rate on the over 12 months deposit rate. Finally, the post-test findings using the heteroscedasticity and serial correlation tests demonstrated that the models are, in fact, homoscedastic and have no serial correlation.

5. Conclusion

The paper examined the interest rate transmission in Nigeria and examined the role of financial progress and developments in incentivizing interest rate operations and processes. The analysis covered the period from 1981 to 2021. However, the paper also tested the constancy of these results by breaking the samples into two distinct periods. The first sub-sample spanned the period 1981 to 2011, while the second sub-sample spanned 1991 to 2021. Furthermore, the analysis also tested for robustness to confirm if the full sample results are consistent across each model. The analysis confirmed that the results across each sub-sample and the robustness results are consistent with the main analysis.

To be more specific, the results showed that interest rate pass-through in Nigeria is incomplete across the samples except for the treasury bill rate which was complete and overshoot in one of the sub-samples. The reasons for interest rate stickiness are because of reasons such as asymmetric information problems, bank costs, credit risk, and many others. Also, the findings confirmed that financial development weakens the impact of monetary policy on the interest rate pass-through process. This shows that financial development would weaken the interest rate channel by decreasing the demand elasticity of savings and loans, resulting in a smaller degree of pass-through, and increasing the influence of banks over depositors and borrowers. Evidence from the asymmetric error correction terms confirmed that banks could make adjustments to their long-term mean in response to shifts in monetary policy and financial development, while the

asymmetric mean adjustment lag results showed that these changes happen within the immediate year that a central bank policy rate change occurs.

As a result of these findings, it becomes imperative that policymakers should account for financial development when designing monetary policy effectiveness since financial development can hinder or strengthen the interest rate channel of monetary policy. Therefore, to mitigate the potential negative consequences of future financial development on the economy, sound risk management practices as well as adequate supervision are required to ensure a stable financial system and macroeconomic environment. In addition, since the paper found that financial development strengthens interest rate operations in the long run due to larger long run coefficients compared to the short run coefficients, therefore, this implies that policymakers should be aware that when designing financial development policies, it will have a more significant impact over the long run. Lastly, on the issue of overshooting interest rates, which may be problematic in the money market, it is important to be aware of the problem of new developments as well as new financial innovations that may cause interest rates to overshoot. This issue must be adequately taken care of when designing and implementing new financial development and monetary policies for the future.

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