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Disclaimer

Foreword

The bi-annual publication of BNR Economic Review intends to provide information to the public on economic matters, focusing on features and challenges of the Rwandan economy. This 18th volume of BNR Economic Review consists of four research articles touching on topical issues related to price stability, external sector sustainability as well as the role of financial sector development and related risks in Rwanda. The papers aim to provide concrete evidence-based analyses and policy recommendations that can help to ensure price stability and a sound financial system.

The first article in this volume considers a widely established economic literature that assigns a positive link between monetary aggregates and prices. The paper contributes to the empirical debate on the role of money in monetary policy by examining the features of the relationship between money growth and inflation in the Nonlinear VAR framework for Rwanda, over the period spanning from 2007 to 2020. The findings point to an estimated threshold value approximated at 15.3 percent for the money growth indicator (M3) in the case of headline inflation and 17.1 percent on core inflation. The paper also identifies two inflation regimes displaying clear and diversified features, namely inflationary and non-inflationary stressful episodes, and reveals that switching from one regime to another regime provides a better signaling probability on the ex-post inflation that could be the basis of the forecast of the future path of inflation. Based on these results, the paper concludes that using information included in monetary aggregates in monetary policy decisions can provide important timely warning signals of transitions between inflation regimes and thus can be a useful indicator of risks to price stability.

Cognizant of the efforts and various policies needed to restore the persistent deficit trade balance, the second study contributes to the broader debate on the role of the exchange rate in restoring external balance and empirically examine the drivers of trade balance adjustment in Rwanda, using quarterly data spanning the period 2000Q1 to 2021Q4. The emphasis of the paper is to test whether the trade balance responds differently to Rwandan francs (FRW) appreciations than it does on the FRW depreciations. On one hand, estimates from a linear Autoregressive Distributed Lag (ARDL) model suggest that the Real Effective Exchange Rate (REER) does not affect trade balance in the short-run but improves it in the long run, partially approving the J-curve phenomenon. On the other hand, the non-ARDL specification reveals a significant long-run relationship between trade balance and REER depreciations and not with REER appreciations. Specifically, the non-ARDL model results show that 1

percent REER depreciation improves the trade balance by 0.93 percent in the long-run. The study recommends the consideration of asymmetric impacts of FRW on trade balance when developing trade policies.

The remainder of this volume comprises two studies that focus on the financial system of Rwanda. Based on the fact that the banking system in Rwanda is prone to interest rate risk emerging from different sources, the third paper of this volume assesses the effect of interest rate risk on the financial sector, particularly on the banks' balance sheets in Rwanda, using data from 10 licensed commercial banks with available data from 2012Q1 to 2019Q2. This paper sheds light on the interest rates that can potentially disrupt the value of assets and liabilities and, ultimately, the net worth of the banks. Specifically, the findings suggest that most commercial banks were more sensitive to the changes in the deposit rate, whereby an estimate of 1 percent increase in the deposit rate induced a decline in net worth equivalent to 1.1 percent. The study thus informs the financial regulators to ensure appropriate monitoring of interest risks build-up and take timely actions to protect the financial system.

Financial development has been one of ideas which policy makers put forward to foster economic growth and sustain it. However, several schools of thought have come up with mixed results regarding the relationship between financial development and economic growth. The fourth paper attempts to find out which finance-growth nexus hypothesis is applicable to Rwanda, using new measurement namely, the financial development index that represents the multifaceted nature of financial development i.e. access, depth and efficiency of either financial institutions or financial markets. The results point to the demand-following theory i.e. economic growth precedes financial development and this is driven mostly by financial institution depth, implying that the growth of the economy will lead to more demand of the financial markets' services and the financial markets growth will lead to even further growth.

Comments and questions can be sent to the Director of Research on phitayezu@bnr.rw, KN 6 Avenue 4, P.O Box 531 Kigali-Rwanda.

RWANGOMBWA John
Governor

CONTENTS

THRESHOLDS EFFECT OF MONEY GROWTH AND INFLATION IN RWANDA: A NONLINEAR VAR MODEL

Placide Aime Kwizera[1]

[1]Economist, Research Department, National Bank of Rwanda and a PhD candidate in joint doctoral program in Economics of the Universidade do Minho and Universidade de Coimbra, Portugal.

ABSTRACT

This paper estimated the threshold value of money growth and inflation as an early warning indicator for shifts in the inflation regimes, using quarterly data for Rwanda during the period 2007 to 2020. The Nonlinear VAR methodology allows us to capture possible nonlinearities such as asymmetric reactions to shocks and empirically test for changes in the relationship between money growth and inflation. The estimated threshold value is approximated at 15.3 percent for the money growth indicator (M3) in the case of headline inflation while the threshold value is equivalent to 17.1 percent on core inflation. The estimated values split the data into two regimes, the inflationary stressful episode, and the non-inflationary stressful episode. The findings revealed that switching from one regime to another regime provides a better signaling probability on the ex-post inflation that could be the basis of the forecast of the future path of inflation. We also presented the historical decomposition from the TVAR to the contribution of the four identified shocks on both cases of headline and core inflation. The overall results obtained support the view that money growth provides timely warning signals of transitions between inflation regimes. Thus, money growth provides an important early warning indicator to the risks of the departure of inflation from price stability.

Keywords: Inflation, money supply, Threshold VAR

JEL classification: E52, E63, E64

1. INTRODUCTION

The prime role of most central banks around the world is to achieve stable economic growth by maintaining low and stable inflation; it is also commonly believed that inflationary flows create macroeconomic instability, and the emergence of this phenomenon poses a serious threat to policy making.

The existence of a positive relationship between money and prices is well agreed upon in the economic literature. A large consensus can be found on both the direction and the dimension of the effect of an increase in the monetary aggregate on price developments. The statement that, in equilibrium, monetary policy is neutral hinges on the quantity equation which in turn defines a positive one-to-one relationship between monetary and price growth over a long-term horizon. On the other hand, others have posited that money serves as a useful crosscheck for monetary policy analysis and remains an important determinant of long-term inflation. The economic profession, however, highlights that, money is not the sole cause of price developments in the short run and that a certain value must elapse before the one-to-one relation emerges, the neutrality may not hold over shorter horizons.

The studies conducted in most countries on whether the relationship is linear or non-linear implies that money growth and inflation are consistently positively related and money plays a crucial role in balancing the price level. Nelson (2003) and Gerlach (2004) argue that money contributes to the understanding of inflation dynamics and should, thus, remain an integral part of modern monetary policy. Since the National Bank of Rwanda switched to a price-based monetary policy framework, it is important to determine a threshold level of money growth, which acts as a 'warning signal' of the departure from the price stability goal using the threshold vector autoregressive (TVAR) model. This is a widely used technique for estimating non-linear relationships among macroeconomic time series. The discussion applies to a wide class of popular non-linear structural vector autoregression models, such as the TVAR, STVAR, TVP-VAR, and Markov-Switching VAR, to mention a few.

The previous studies mainly applied the traditional time series analysis based on linearity assumptions; however, the real-world issues do not adhere to linearity assumptions and may not adequately characterize the dynamics that we are

looking for. This paper contributes to the modern monetary policy literature and policymaking in at least three ways. First, to determine a threshold level of money growth which acts as a 'warning signal' of the risk of the departure of inflation from the price stability regime by trying to evaluate ex post the leading properties of money growth for price dynamics. Second, we try to disentangle the regimes that may turn an increase in money growth to suddenly raise the inflation, which may help the National Bank of Rwanda to distinguish inflationary from non-inflationary episodes of sustained monetary expansion. This signaling probability contains a valuable piece of information to forecast inflation at a specific horizon within the given regime, supporting other toolkits used by the National Bank of Rwanda to respond adequately to inflationary risks and succeed in maintaining price stability.

Third, we explore a historical decomposition of shocks (HD) for the proposed TVAR model. This allows us to differentiate which of the macroeconomic shocks (implicit in our TVAR system) were the main determinants of the behavior of the economy by estimating the magnitude of the contribution of each shock and the relative roles played by exogenous and endogenous shocks.

The remainder of this paper is organized as follows, after the introduction; a review of relevant literature is presented in section 2. Section 3 discusses the methodology and data. Section 4 reports the empirical results, and discussions of results. Section 5 presents conclusion and policy recommendations.

2. LITERATURE REVIEW

2.1 View of inflation in various economic doctrines

The theoretical foundations of this research are based on the viewpoints of economic doctrines on inflation and emphasizing non-linear inflationary dynamics. Classical economists were the first to put forward the theory of money inflation; they considered that monetary factors were able to completely explain inflation. Their theory of economic literature is known as the "quantity theory of money." Fischer, through his equation of exchange, explained inflation on a monetary basis, then Marshall looked at the "quantity theory of money" from the Cambridge doctrine. After that, in a new form of the quantity theory of money, Friedman articulated his interpretation of the quantity theory of money as a theory of demand for money. In addition, the followers of this doctrine, considering the conditional expectations of the formation of inflationary expectations based on past information, believe that monetary policies in the short run will affect the level of production and other real variables, but in the long term, they will make money neutral.

In the rational expectation model, it is also highlighted that the person does not just look at the past information in forecasting inflation, but uses all the available data for prediction, including the past experience and information on the expected future state serves all the available data for prediction. Furthermore, people do not make systematic mistakes in their predictions. Regular errors are easily discovered and corrected over time, and the way of shaping their expectations varies in the same way. The new classics, who believe in the formation of expectations based on rational expectation, argue that monetary policies are both neutral in the short run and the long run, only unforeseen monetary policies affecting real variables in the short term.

The theory of demand-pull inflation also perceives the cause of the rise in inflation as the increase in demand. Increasing demand could be driven by an increase in investment and autonomous consumption, expansionary fiscal policy, expansionary monetary policy, declining money demand, and improving trade balance. John Maynard Keynes (1939) offers his argument that inflation prevails if the demand for consumer goods exceeds supply at full employment level, then this excess demand creates an inflationary gap and prices rise so much that this gap is filled. In the cost-push inflation theory, contrary to the doctrine of money

and the Keynes doctrine, the imbalances in the supply sector, and in particular, the increase in the cost of production and transmission of the total supply curve is the main reason for rising prices.

The structuralist view indicates that inflation is likely to develop due to the state of unbalanced economic, political, and cultural structures. Various and often complex factors play a role in creating and sustaining this inflation. In analyzing the inflationary dynamics, attention to the process of its linear or nonlinear behavior is of particular importance because the existence of extreme volatility and uncertainty in the behavior of some economic variables such as inflation due to the nature of these variables can lead to economic instability in society.

Therefore, the existence of these uncertainties causes behavioral inflation that is based on nonlinear functions, not considering the nonlinear behavior of economic variables causes an error. Therefore, the use of linear models to investigate and explain the influence of other economic variables on inflation cannot reveal the realities of the economy altogether.

2.2. Theoretical derivation of money and inflation

This section sets out a minimum model of the determination of prices to emphasize the role of monetary factors in the inflation process. Time should be thought of as being measured in quarters since monetary policy is assumed to have short-run inflationary effects. Let us begin our analysis with a Phillips curve of the form:

$$\pi_{t+1} = \pi^{e}_{t+1,t} + \alpha_y \left(y_t - y^{*}_t \right) + \alpha_z z_{t+1} + \varepsilon_{t+1} \quad \text{..... (1)}$$

Where $\pi_t \equiv 4\Delta p_t \equiv 4\left(p_t - p_{t-1}\right)$ is the annualized inflation rate in the quarter t, p_t is the price level, $\pi^{e}_{t+1,t}$ is expectations in the quarter t, of inflation in the quarter $t+1$ (which we specify further below) y_t is output, y^{*}_t is potential output, $y_t - y^{*}_t$ is the output gap, z_t is an exogenous variable, or shift factor (for instance, a supply shock) (we discuss the dating of the exogenous variable further below), and ε_t an iid "cost-push" shock, and where $\alpha_y \succ 0$

In P^* models (Hallman, Porter and Small,1991 and Reimers,1994) inflation is instead assumed to be governed by

$$\pi_{t+1} = \pi^e_{t+1,t} - \alpha_p \left(p_t - p^*_t \right) + \alpha_z z_{t+1} + \varepsilon_{t+1} \quad \text{..... (2)}$$

Where $\alpha_p \succ 0$. Thus, the P^* model replaces the output gap with the negative of the "price gap," $p_t - p^*_t$ as the key determinant of inflation (Some of the literature in monetary economics have defined the price gap with the opposite sign, as $p^*_t - p_t$).

Here p^*_t the long-run equilibrium (LRE) price level, denotes the price level that would result with the current money stock, provided output is at potential and velocity at its long-run equilibrium level. Thus, p^*_t is defined as:

$p^*_t \equiv m_t + v^*_t - y^*_t$, where m_t is the money stock (in empirical work typically M2 or M3), $v_t \equiv p_t + y_t - m_t$ its velocity, v^*_t is the LRE velocity, which is specified further below. While the micro-foundations of the P^* models are not clear (to us, at least), the model has been used to account for the behavior of prices in several countries and is typically seen among proponents of monetary targeting as providing a theoretical rationale for focusing on policy deliberations on the behavior of monetary aggregates.

For these reasons, we use P^* a model setup here. Since we focus on the role of monetary aggregates, it is informative to follow Svensson (2000) and express the P^* model in terms of the real money gap, $\tilde{m}_t - \tilde{m}^*_t$, where

$\tilde{m}_t \equiv m_t - p_t$, is real money balances and $\tilde{m}^*_t \equiv m_t - p^*_t \equiv y^*_t - v^*_t$ is LRE real money balances.
Since the real money gap is the negative of the price gap:

$$\tilde{m}_t - \tilde{m}^*_t \equiv \left(m_t - p_t\right) - \left(m_t - p^*_t\right) = -\left(p_t - p^*_t\right) \quad \text{..... (3)}$$

We can then write the P^* model as:

$$\pi_{t+1} = \pi^e_{t+1,t} + \alpha_m \left(\tilde{m}_t - \tilde{m}^*_t\right) + \alpha_z z_{t+1} + \varepsilon_{t+1} \quad \text{..... (4)}$$

Where $\alpha_m \equiv \alpha_p \succ 0$, the P^* model consequently assigns a crucial role to the real money gap as a predictor of future inflation, analogous to the role of the output gap in traditional Phillips curves. One immediate consequence of this is that to the extent the P^* model accounts for the behavior of inflation, the real money gap i.e nominal money growth is the natural indicator of future inflation.

2.3. Empirical literature

As previously discussed, the monetarist theory has been empirically tested and gained extensive support during the Ronald Reagan and Margret Thatcher regimes in the U.S. and U.K. Similarly, the importance of money supply was recognized by the Bank of Japan in the 1970s, when the Bank began announcing forecasts for money growth (Assenmacher-Wesche et al., 2008). However, in later years, Monetarism was subject to criticism, with economists such as Kaldor (1985) and Tobin (1981), questioning the assumption of the homogeneity of the money supply. Many subsequent studies showed that velocity did not remain stable, leading to an unstable short-run relation between money supply and inflation (Estrella and Mishkin, 1997; Stock and Watson, 1999; Gerlach and Sevensson, 2003).

Following these studies, several empirical studies provide support for a strong link between money growth and inflation. Using spectral analysis, Benati (2009) shows that there has been an almost one-for-one, relatively stable relation between long-run money growth and the rate of inflation in the U.S. and U.K. over the last two centuries. Crowder (1998) also finds a strong long-run relationship between money growth and inflation. The trend growth component in inflation as measured by the consumer price index (CPI) is found to be explained completely by the trend component of the monetary base growth.

DeGrauwe and Polan (2005), also testing the quantity theory of money relation for a sample of 160 countries over a period of 30 years using Ordinary Least Squares (OLS) and fixed effects estimation, observe a strong positive link, however, not proportional relation, between long-run inflation and the rate of money growth. They, however, find that the strong link between inflation and money growth is driven by the group of high inflation countries in the sample. De Grauwe and Polan

(2005) find that the relationship between inflation and money growth is weak for low-inflation countries.

More recently, Amisano and Fagan (2013), employing a Markov Switching model and Bayesian methods on data from the euro area, Germany, the U.S., the U.K., and Canada, find that money growth is an important predictor of price shocks. Employing a multivariate state-space model to investigate the effect of money on prices in the U.S., El-Shagi, and Giesen (2013) also observe a significant effect of money growth on prices in the U.S. Canova and Ferroni (2010) examine the monetary policy–inflation relation in the U.S. employing a structural model and Bayesian estimation methods. They find that policy shocks explain inflation volatility; however, the effectiveness of policy in generating changes in inflation has fallen over time. Similar evidence is documented by Canova and Menz (2012) for Japan.

Amisano and Colavecchio (2013) investigate the non-linearity in the pass-through from money supply to inflation in a Bayesian Markov Switching framework for the U.S., the U.K., the Euro area, and Japan over 1960–2012. They find evidence of a nonlinear relation between money growth and inflation. The non-linearity is attributed to different monetary regimes. The link between money growth and inflation is found to be strong during the high-inflation periods of the 1970s and 1980s, and weak during low inflation periods.

Reynard (2012) examines the inflation paths of countries during normal times and periods of financial crises. He argues that the inflation paths of countries depend on the response of monetary aggregates to these crises. Studies suggest that monetary aggregates contain important information for predicting changes in inflation and that the quantity theory is still alive (Teles and Uhlig, 2013).

The following table presents selective empirical findings of some studies with a different database, monetary variables, and time. Most of them employed cross-section data on a group of countries for some time for homogeneous countries. While others use time-series data, examining the correlation of money supply and inflation in a single country for a long time. The common monetary variables that are often employed in the chosen papers are M1, M2, and M3. The general conclusion that can be drawn from the surveyed articles is that, as postulated by the monetarist, most authors detected a long-run impact of changes in money

supply on inflation rates. Nevertheless, most papers ignored all other possible determinants of inflation and concentrated only on money growth in the analysis as the main determinant of inflation.

Table 1: Survey of selected studies on the linkage between money supply and inflation

Author	Monetary Variable	Sample	Period	Main Findings
Us (2004)	Base money (Mo)	Turkey	1990:01–2002:04	No relationship
Altimari (2001)	M1, M2 & M3	Euro Area	1980-1997	Positive relationship
Diouf (2007)	Broad money	Mali	1979:1-2006:1	LR and SR correlation
Pindiriri (2012)	M3	Zimbabwe	2009-2011 (monthly)	Positive
Jones & Khilji (1998)	M1 & M2	Pakistan	1973 to 1985	Positive
Nikolic (2000)	M3, M2, Mb & Mo	Russia	1992-1998	Weak correlation
Darrat (1986)	Narrow money	North Africa	1960-980 (quarterly)	Positive
Thornton (2008)	Money in circulation, M1 and M2	African economies	1960-2007	Weak for counties with inflation and money growth below 10%
Drevall&Ndung'u (2001)	M1&M2	Kenya	1974 – 1996	Exist only in the short run
Simwaka et.al (2012)	M2	Malawi	Monthly (1995-2007)	Positive relationship
Morana& Bagliano (2007)	M1, M2 & M3	USA	1959:1- 2003:2	Positive long run correlation
Kabundi, A (2012)	M3	Uganda	Monthly (1991-2011)	Positive
Akinbobola (2012)	M1 & M2	Nigeria	1986:1-2008:4	Positive
Zhang (2012)	M2	China	1980 -2010	Positive

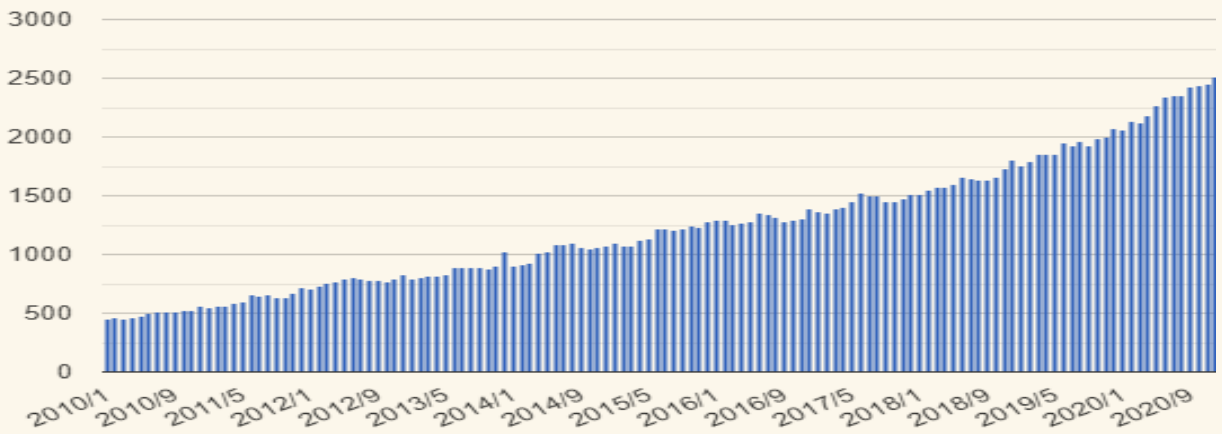
Source: Author's literature survey

2.4. Money supply and inflation developments in Rwanda

Over the past two decades, the paces of price increases in Rwanda have been kept at moderate levels. However, to manage inflation is no easy task, because there are other factors uncontrolled by the monetary policy like drought which leads to the shortage of food production and supply and changes in international price situations (like that of crude oil) among others. This is in contrast to the monetarist view, which states that inflation is always and everywhere a monetary phenomenon. For the broad money indicator (M3), we provide data for Rwanda from January 2010 to February 2021 to see the historical evolution of monetary developments.

The average value for Rwanda during that period was 1253.11 billion Rwanda Franc with a minimum of 452.06 billion Rwanda Franc in March 2010 and a maximum of 2560.75 billion Rwanda Franc in February 2021.

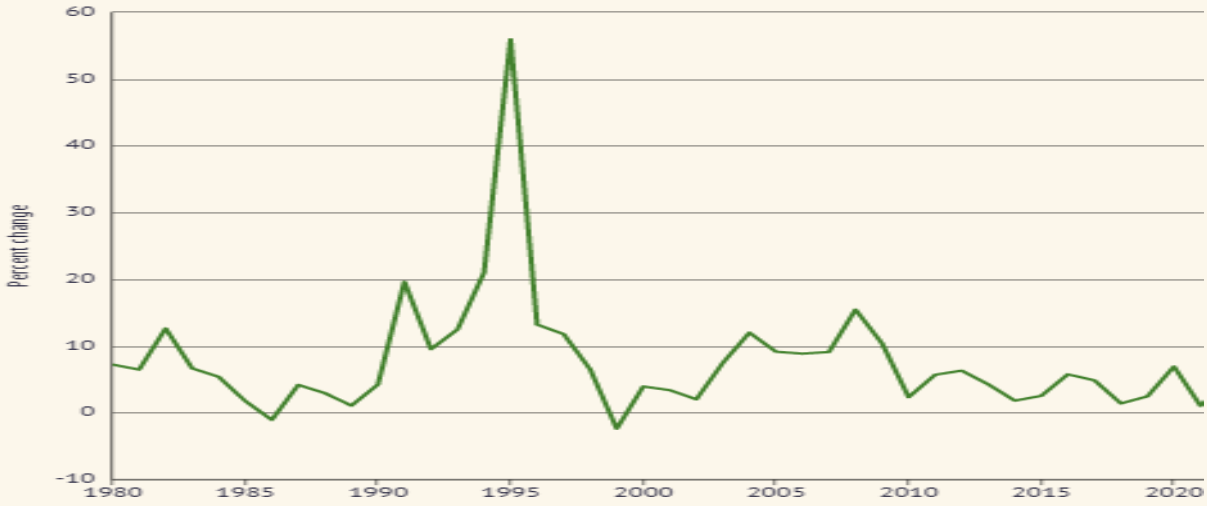
Figure 1: Evolution of money supply in Rwanda



Source: TheGlobalEconomy.com

On other hand, in 2020, the inflation rate for Rwanda was 6.9 percent. Though Rwanda's inflation rate fluctuated substantially in recent years, it tended to decrease through the 2001 - 2020 period ending at 6.9 percent in 2020. This is in line with the monetary policy objective of attaining price stability while ensuring sustainable economic growth through the means of monetary policy.

Figure 2: Evolution of inflation in Rwanda



Source: IMF: World Economic Outlook (WEO)

3. METHODOLOGY AND DATA

3.1. Methodology

This paper follows the approach used by Balke (2000) and Li and St-Amant (2008) to study money growth and inflation using a threshold vector autoregression (TVAR) to test whether the relationship between money growth and inflation shifts when the level of money growth reaches a certain (threshold) value. The TVAR models are part of an increasingly rich literature of non-linear models which have developed from the switching regression model (Quandt, 1958). The TVAR models have been applied in post-industrial economies (see Balke, 2000) who tests the effects of credit regimes on the amplitude of business cycles in the United States, Altissimo and Violante (2000) who test for threshold effects in the relationship between unemployment and output in the United States, and Atanasova (2003) who tests for credit regime effects on business cycle amplitudes in the United Kingdom.

The choice of the TVAR model has several interesting features: First, it is a relatively simple way to capture possible nonlinearities such as asymmetric reactions to shocks or the existence of multiple equilibria (which, in a time-series

context, might be reflected in multimodal stationary distribution). Secondly, the variable by which different regimes are defined can itself be an endogenous variable included in the VAR. Therefore, this makes it possible that regime switches may occur after the shock to each variable. As the effects of the shocks are dependent on both the initial conditions, along with the sign and size of a shock and the impulse response functions are no longer linear, it is possible to identify the disparities between the high inflation and low inflation episodes under development of money supply.

The threshold VAR can be specified as follows:

$$Y_t = \alpha^1 + \beta^1(L)Y_t + \left[\alpha^2 + \beta^2(L)Y_t\right]\mathrm{I}(S_{t-d} \succ \delta) + \left[D^1 + D^2\mathrm{I}(S_{t-1} \succ \delta)\right]U_t \quad \text{..... (5)}$$

where Y_t is a vector of endogenous variables, U_t are the structural residuals, and are assumed to be normally distributed and independent, each of unit variance. The lag polynomial $\beta^i(L) = \beta_1^i L + \beta_2^i L^2 + \ldots \beta_p^i L^p \; i \in \{1,2\}$ represents VAR parameters associated with the two regimes. The matrices D^1 and D^2 map the structural residuals to the reduced form residuals in both regimes.

The function I takes on the value of 1 when the threshold variable S_{t-d} exceeds the critical threshold value of δ, and 0 otherwise. Because the matrices D imply a regime-dependent mapping between the reduced form residuals and the structural residuals, this also implies regime-specific covariance matrices.

Balke identifies the four shocks using a Cholesky ordering in the order that I introduced the variables. This is an identification assumption and implies the D matrices will be lowering triangular. I similarly take $d = 1$, as per the original paper. The TVAR can thus be described as two locally linear VARs, whose dynamics can be described by the parameters with the superscript 1 if the threshold variable is below the threshold, and the additional terms kicking in when the threshold variable is above the threshold. The lag order p is set to 4, as per the rule of thumb. For the linear model, it is relatively straightforward to understand that the impulse responses in such a case will remain constant over the given time, simply because

the covariance structure does not vary over time. Additionally, impulse responses in a linear model can be derived directly from the estimated coefficients and the estimated impulse response shocks are thus correspondingly symmetric in terms of size, persistence, and sign (Afonso et al., 2011). However, when moving on to discuss the non-linear model, the complexity inevitably increases given we cannot repeat such assumptions as the same properties will not necessarily hold (Koop, Pesaran & Potter, 1996). In a typical nonlinear case, we appraise whether the economic dynamics diverge across the different regimes and then examine the size, persistence, and sign of an impulse shock response function to see if they differ from one regime to another. The non-linear impulse response function in contradiction to the linear impulse response function is more complex, and is given by the following function:

$$NLIRF = \mathrm{E}\left[Y_t + k \mid \Omega_t - 1, \varepsilon_t\right] - \mathrm{E}\left[Y_t + k \mid \Omega_t - 1\right] \quad \text{..... (6)}$$

In the function, $\Omega_t - 1$ denotes the data set at the given time $t-1$, and ε_t is the exogenous shock. The function design indicates that we have to condition the sign and the size of the shock, with consideration to the history of the variables in the model (Balke, 2000).

Look at the conditional expectations from the non-linear impulse response function, which are given by $\mathrm{E}\left[Y_t + k \mid \Omega_t - 1, \varepsilon_t\right]$ and $\mathrm{E}\left[Y_t + k \mid \Omega_t - 1\right]$ must be estimated while simulating the model, according to the estimation procedure presented by Balke (2000):

Firstly, to be able to create the simulated forecast series, we draw the shock effects from the starting period 0 to q of the residuals of the estimated threshold vector autoregression model and thereafter for each respective initial value of the residual, which means that each point of our data sample is utilized through our model. After that, we condition the resulting forecast series on the specific sequence of the initial values and the shocks and by doing so the simulation will return one given an estimation of $\left[Y_t + k \mid \Omega_t - 1\right]$.

Following this, we repeat the simulation conducted in the first forecast using the same residuals and initial values. However, we modify the function to let the shock of the focused variable be fixed to ± 2 standard errors or ± 1 standard error at the given time $t = 0$. Thus, the second simulation returns one estimate of the function $\left[Y_t + k \mid \Omega_t - 1\right]$.

Next, we compute the difference between the first and second estimation, which returns one simulated value for our nonlinear impulse response function. To ensure that any potential asymmetries which could arise due to sampling variation in the drawn shocks are removed, the procedure will be with 500 iterations. As a result, the average of these 500 nonlinear impulse response function calculations provides our estimated nonlinear impulse response function (Balke, 2000; Afŧnso et al., 2011 and Atanasova, 2003).

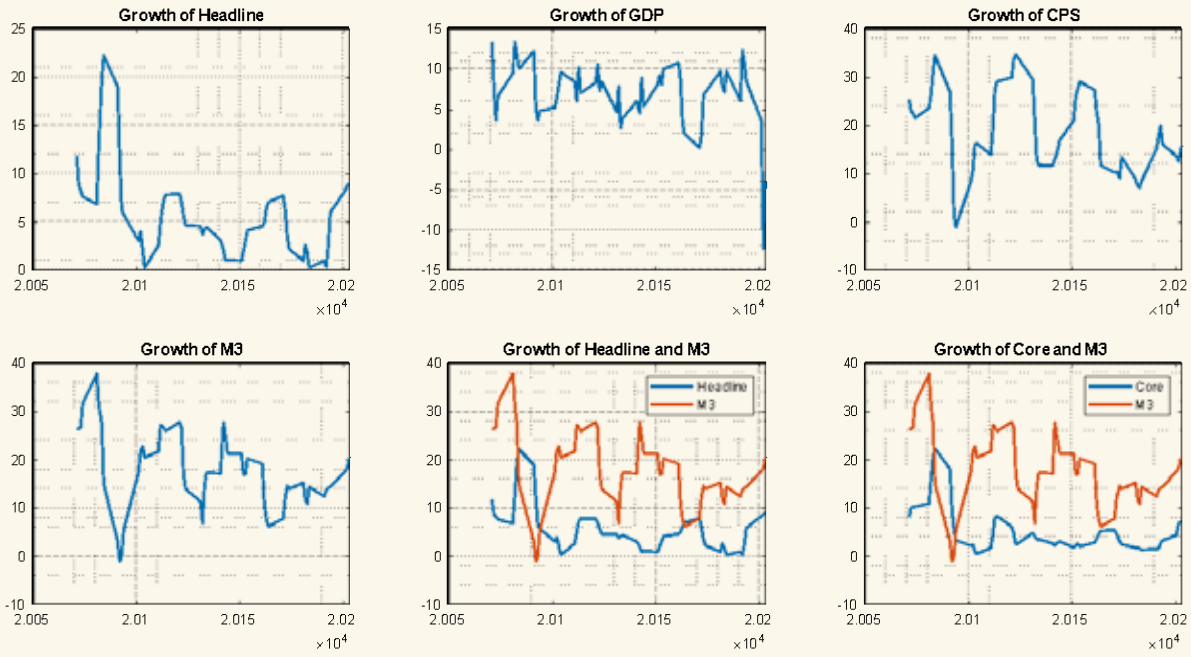
3.2. Data presentation

Before delving into the workings of the empirical estimation, it may be helpful to offer a small overview of the data gathering process. This paper uses quarterly time series spanning from 2007 to 2020. The variables considered for this study are the indicator of money supply (M3), Consumer Price Index (CPI) for the inflation rate, Real Gross Domestic Product (RGDP), and Credit to Private Sector (CPS).

We therefore, present results based on the four shocks, which are labeled as output shock, credit shock, price shock, and money shock. The growth in money supply is used as the threshold variable. All the variables come from the National Bank of Rwanda.

We plotted the quarterly percentage change annualized in broad money and inflation rate data together to observe the pattern of movement in these two variables. As per Figure 1, it can be seen that there are consistencies in the movement of money supply and inflation rate. An increase in the money supply also leads to a spike in the inflation rate. This shows that there is a pattern in the movement of money supply and inflation rate.

Figure 3: Sample data visualization



Source: Author's computation

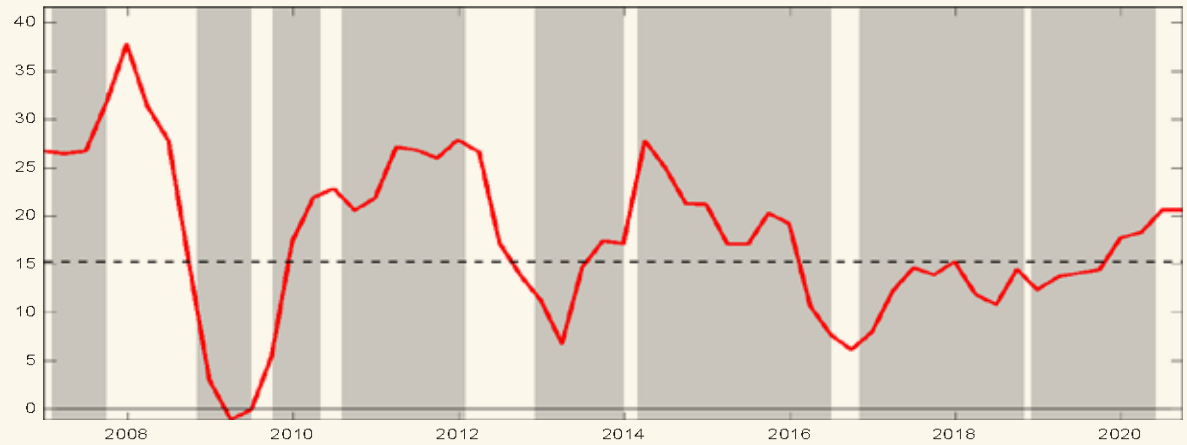
We believe that the non-linear behavior of inflation suggests that linear modeling is not able to explain the changes in inflation, and the use of non-linear time series models can provide a better interpretation of the inflationary dynamics based on different regimes. Also, the non-linear behavior of inflation can indicate the difference in the speed of convergence towards the inflation target in the economy. Hence, with the understanding of the above patterns of movement in broad money and inflation, we move further into developing a TVAR model for further analysis.

4. EMPIRICAL ANALYSIS AND RESULTS

In this section, we present the estimated threshold values from the TVAR model on headline inflation and core inflation separately. Following the process outlined by Hansen (1996), the results show a p-value of 0.000 for the calculated Wald-statistic, strongly confirming the suspected presence of non-linearities and providing support for the use of the two regime threshold VAR model. We perceive the money growth as a threshold variable to present a flavor of the two inflation regimes or episodes as proposed by Balke (2000). The inflation rises in the

expansion of money growth, and most of the observations in the high inflation regime or episode coincide with NBR monetary expansion.

Figure 4: Estimated threshold value of money growth and headline inflation

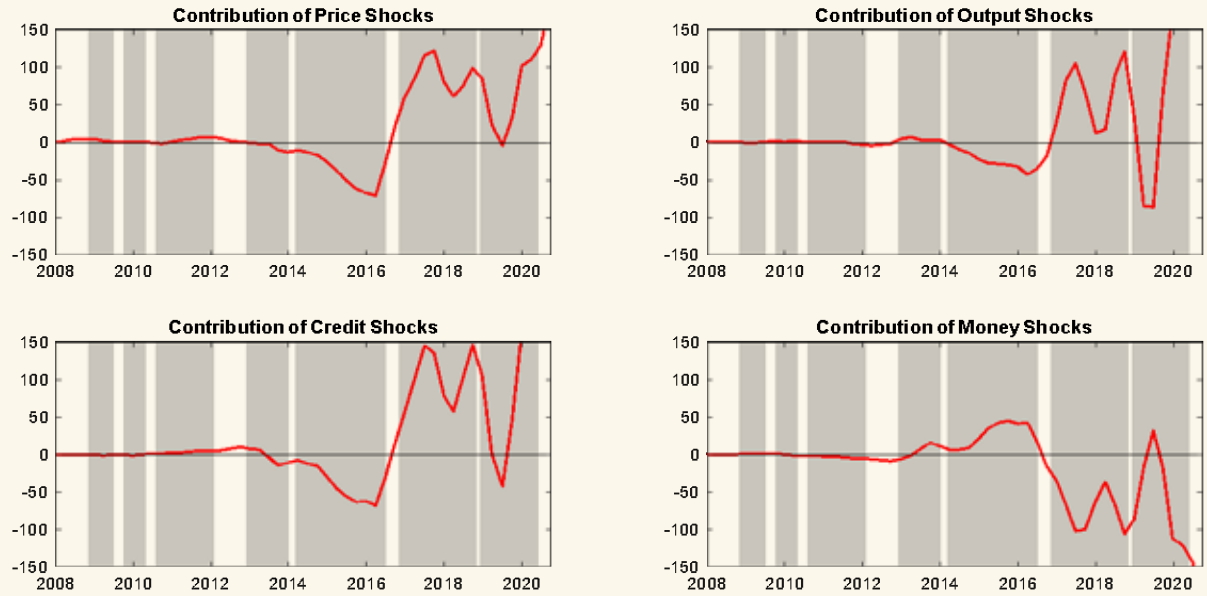


Source: Author's estimation

The estimated threshold value is approximated at 15.3 percent for the money growth indicator (M3), following the procedure outlined in the section of methodology. This means that our model estimates Rwanda to be in the inflationary episode when the money growth is above 15.3 percent. Thus, the estimation divides the data into two regimes, in the inflationary regime, which is the state of an inflationary stressful time, and in the non-inflationary regime, which is the regime with the state of a non-inflationary stressful time. As we can see from the plotted graph in figure 4, the estimated threshold value appears to offer a good estimator for historically tracking inflationary stressful time and non-inflationary stressful time.

It is straightforward to verify under a linear VAR, the change in forecast function (CFF) can be analytically evaluated, and is identical to the historical decomposition for linear VAR models. Analogously, the remainder in a linear VAR model is zero by construction. The CFF generally does not have an analytical form in non-linear models and is often evaluated numerically using Monte Carlo integration, such as Koop, Pesaran, and Potter (1996). In non-linear models, the remainder emerges because the non-linearity causes the contributions of shocks and the forecast to not add up. The remainder can thus be interpreted as the extent that the nonlinearity interacts with the shocks.

Figure 5: Historical decomposition and change in forecast function of headline inflation from TVAR



Source: Author's estimation

Figure 5 above presents the historical decomposition of money growth from the TVAR to the contribution of the four identified shocks. Following Balke (2000), we also plot the CFF, but he uses a horizon of 12 quarters to compute the CFF. For us, we consider the entire sequence of shocks as this is the only construction wherein a linear VAR model, the CFF is equivalent to the historical decomposition and the remainder from the CFF is zero. Thus, we are evaluating the CFF in a manner much closer to the conditional structural decomposition by Kilian and Vigfusson (2017).[2]

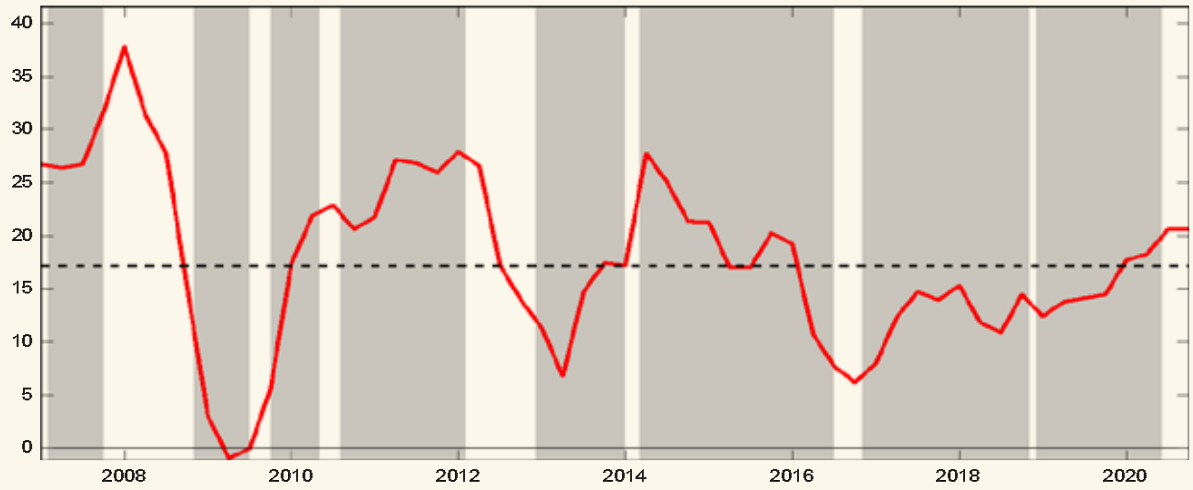
While there are many similarities between the historical decomposition and the CFF, the divergences between the two are most prevalent during or around the contraction. This is not surprising as the threshold, which is the source of the non-linearity, tends to kick in during expansion (see Figure 4). This can also be seen by observing the remainder term evidencing its largest variations during and around expansion, which can be interpreted as when the non-linearity is being particularly relevant in propagating shocks. Even if the remainder term in the CFF is useful in

[2]To ensure that any remainder calculated in our empirical work is due to the non-linearity interacting with the shock, and rules out the possibility that the remainder may be picking up the effect of a shock that has a high level of persistence. Note though that if the model's propagation mechanism is not extremely persistent, choosing a sufficiently long horizon, such as 12 quarters, may provide a sufficiently good approximation.

understanding when the non-linearity is particularly relevant for propagating shocks, it does not decompose these fluctuations induced by the non-linearity to contributions by any particular shocks.

However, the above-presented findings show the model output for both the high inflationary regime and low inflationary regime as estimated by the TVAR model for the case of headline inflation. It is prime to consider also the core inflation which captures the direct effect of monetary policy.

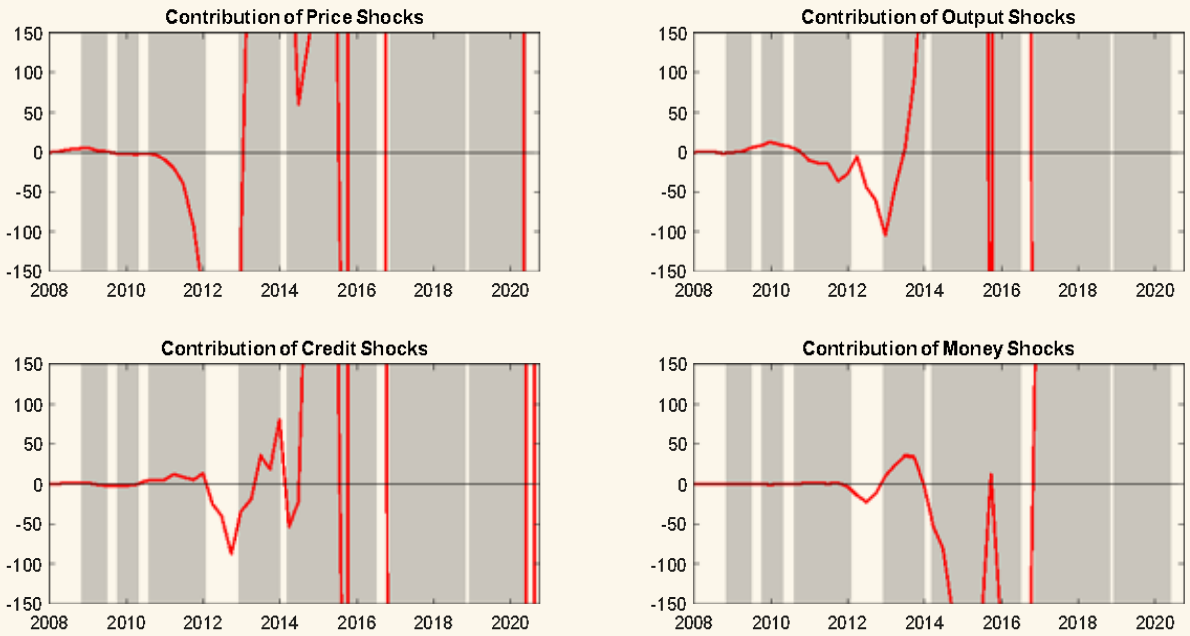
Figure 6: Estimated threshold value of money growth and core inflation



Source: Author's estimation

We keep following the same step to estimate the threshold value between money growth and core inflation. The result is quite meaningful and supports the economic theory with the threshold value of 17.1percent greater than 15.3 percent on the headline inflation. Thus, the conduct of monetary policy should focus on core inflation that is, a measure of inflation that excludes the rate of increase of prices for certain volatile components in price indexes, even if the monetary policy is capable of controlling overall inflation in the long run, it cannot fully control relative price movements such as those for food and energy.

Figure 7: Historical decomposition and change in forecast function of core inflation from TVAR



Source: Author's estimation

The measures of core inflation attempt to strip out or smooth volatile changes in particular prices to distinguish the inflation signal from the transitory noise. Thus, relative to changes in headline inflation measures, changes in core measures are much less likely to be reversed, provide a clearer picture of the underlying inflation pressures, and so serve as a better guide to where headline inflation itself is heading. Of course, if a particular shock to non-core prices is not temporary but, rather, turns out to be more persistent, then the higher costs are likely to put some upward pressure on core prices. Moreover, the forecast horizon set is the same as in the case of headline inflation, so that the change in forecast reflects shocks that occurred over the same quarters. Keeping in mind the usual caveat about interpreting reduced-form time-series models, linear or nonlinear, a few interesting episodes stand out in figure 6, not surprisingly, because the feedback from the headline is smaller compared to the case of core inflation, the direct link between monetary development and core inflation is still substantial.

5. CONCLUSION

Building on the existing literature that establishes a long-run link between inflation and money growth, this paper has estimated the threshold value of money growth and inflation as an early warning indicator for shifts in inflation regimes, using quarterly data for Rwanda during the period 2007 to 2020. The non-linear VAR methodology allows us to capture possible non-linearities such as asymmetric reactions to shocks and empirically test for changes in the relationship between money growth and inflation. The discussion applies to a wide class of popular non-linear structural vector autoregression models, such as the TVAR, STVAR, TVP-VAR, and Markov-Switching VAR, to mention a few. We modeled inflation as a process characterized by two regimes: non-inflationary and inflationary in which the probability of shifting from one regime to the other depends on a measure of money growth.

The estimated threshold value is approximated at 15.3 percent for the money growth indicator (M3) in the case of headline inflation. This means that our model estimates Rwanda to be in the inflationary episode when the money growth is above 15.3 percent. Thus, the estimation divides the data into two regimes, in the inflationary regime, which is the state of an inflationary stressful time, and in the non-inflationary regime, which is the regime with the state of a non-inflationary stressful time. Moreover, it is prime to consider also core inflation which captures the direct effect of monetary policy. We keep following the same step to estimate the threshold value between money growth and core inflation. The result is quite meaningful and supports the economic theory with the threshold value of 17.1percent greater than 15.3 percent on the headline inflation.

This result is striking on monetary growth above the estimated thresholds; we expected a much higher correlation with prices. However, findings suggest that the predictive capacity of monetary aggregate for headline inflation dynamics may be weaker compared to the core inflation consistently with the modern theory of the monetary policy. Thus, the conduct of monetary policy should focus on core inflation that is, a measure of inflation that excludes the rate of increase of prices for certain volatile components in price indexes, even if the monetary policy is capable of controlling overall inflation in the long run, it cannot control relative price movements such as those for food and energy. We also presented the historical decomposition of findings from the TVAR to the contribution of the four

identified shocks on both headline and core inflation. Bearing in mind that the usual caveat about interpreting reduced-form time-series models, linear or nonlinear, a few interesting episodes stand out in historical contribution of the shocks on headline and core inflation is not surprising, because the direct link between monetary development and core inflation is still substantial.

The overall results obtained support the view that money growth provides timely warning signals of transitions between inflation regimes. Although, the signals coming from money growth are considered noisy. This caution aside, we believe that the results are sufficiently robust supporting the claim that money growth is a leading indicator of shifts in the inflation regime.

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ASYMMETRIC EFFECT OF REAL EFFECTIVE EXCHANGE RATE AND TRADE BALANCE ADJUSTMENT: THE CASE OF RWANDA

Emmanuel Bahati Ngarambe[3]
Wilberforce Nuwagira[4]
Wilson Kamali[5]

[3] Senior Statistician, Statistics Department, National Bank of Rwanda

[4] Senior Principal Economist, Research Department, National Bank of Rwanda

[5] Director, Statistics Department , National Bank of Rwanda

ABSTRACT

This paper investigates the empirical evidence of the impact of exchange rates on the trade balance in Rwanda. A novel feature of the study is the focus on examining whether the relationship between real exchange rate and trade balance is symmetric or asymmetric by comparing results from linear and nonlinear Autoregressive Distributed Lag (ARDL) models respectively. The non-linear ARDL approach to cointegration and the associated error correction methodologies examines whether Rwandan francs appreciations affect trade differently than does Rwandan francs depreciations. We use quarterly data spanning the period 2000Q1 to 2020Q4. Results from the linear model reveal that the real exchange rate does not affect trade balance in the short-run whereas it improves trade balance in the long run, partially confirming the J-curve phenomenon. The empirical findings from the non-linear model revealed that depreciations improve the trade balance in the long run whereas appreciations have no impact. The Wald test results indicate the existence of significant long-run asymmetric effects of REER on the trade balance, while short-run asymmetry was not supported. In light of the results obtained, policymakers should be aware of the consequences of asymmetric impacts of Rwandan francs' appreciation and depreciation in the development of trade policies so that international competitiveness is not adversely affected.

Keywords: Real effective exchange rate, Trade balance adjustments, Asymmetry.

JEL classification: F31, F32

1. INTRODUCTION

The importance of real effective exchange rate (REER) in correcting trade imbalance has been studied extensively. Theoretically, to improve the country's trade balance, two approaches are at the disposal of policymakers to change the country's competitiveness. The internal approach relies on supply-side policies, such as influencing labor productivity or wages by curbing inflation, decreasing taxes, or relaxing rigid labor market conditions. Alternatively, the external approach consists of devaluing/depreciating the currency (Stucka, 2004). The external approach stipulates that a devaluation or depreciation of a currency pushes domestic prices of goods down, increases exports and reduces imports, and eventually improves the country's trade balance. However, the response of an economy's trade balance to currency depreciation is believed to follow a J-curve, i.e. a depreciation of the domestic currency initially worsens the trade balance because of adjustment lags such as recognition lags, production lags, delivery lags, etc., but ultimately the trade balance improves as demand and supply adjust (Bleaney and Tian, 2014).

Several empirical studies analyzed the relationship between REER and trade balance adjustment and revealed mixed results. A strand of studies identified a stable link between REER and trade balance. The empirical model of Bahmani-Oskoee (1985) suggested that following a currency depreciation the trade balance deteriorates due to lag structure on exchange rates and then improves it in the long run. In analyzing this behavior, Schaling and Kabundi (2014) revealed that real depreciation enhances the South Africa–US trade balance in the long run, hence supporting a J-curve phenomenon. Another strand of researchers has shown that the response of trade flows to REER depends on the level of disaggregation of the trade data. Studies in this group argue that aggregated flows suffer from aggregation bias in that one industry may react favorably to depreciation than another industry, hence, advocated the J-curve test at the industry level (Bahmani-Oskooe and Gelan, 2019 ; Chiloane et al., 2014; Yazici & Klasra, 2010 ; Durmaz, 2015) . These studies are based on the assumption that the real exchange rates impact trade balance linearly. However, recent studies have shown that exchange rates have asymmetric effects on exports and imports and hence on trade balance (Bahmani-Oskooee & Fariditavana, 2015, 2016). They argue that the reactions of traders (i.e exporters and importers) to currency appreciation and

depreciation are different. Arize et al. (2017) argue that during currency appreciation if traders do not exit their market, the rate at which their export receipts decline is different from the rate at which these receipts increase when the currency depreciates. Furthermore, Bussiere (2013) evidenced that the response of prices of traded goods to exchange rate is asymmetric, and ultimately trade balance follows suit.

Rwanda has recorded a sizeable and persistent current account deficit over the period under study largely driven by the merchandise trade deficit. This trade deficit in goods is a result of higher imports compared to stagnant and less diversified exports. However, despite this persistent trade deficit the size of Rwanda's trade elasticities has not been studied extensively. Nuwagira and Muvunyi (2016) examined the presence of the Marshall-Lerner condition i.e. the requirements for depreciation to improve the trade balance and found that the condition does not hold for Rwanda using quarterly data spanning the period 2000 to 2015. The regression results of their export models found that the improvement of Rwanda's trade balance is determined by external demand and less by the fluctuation of REER. Similarly, Muvunyi et al. (2019) examined trade elasticities of exports and imports separately and showed that that income is a more important determinant of trade flows than the REER.

The main purpose of this study is to contribute to the broader debate on the role of the exchange rate in restoring external balance and empirically examine the drivers of trade balance adjustment in Rwanda. Rwanda was chosen for two reasons. First, there is a limited number of empirical studies that assessed the relationship between exchange rate and trade balance in Rwanda. Apart from the two studies reviewed previously, that examined the impact of exchange rate on exports and imports separately, to the best of our knowledge no study on the real exchange rate and trade balance relationship has been conducted. Second, previous studies on Rwanda's trade elasticities used linear models, which assumed the asymmetric effect of real exchange rate on trade flows. In this study, we extend the analysis on Rwanda' trade balance adjustment by re-visiting this linear specification using recent data by employing the ARDL model developed by Pesaran et al. (2001) and introduce the non-linear ARDL model developed by Shin et al. (2014) to examine the asymmetric effects of exchange rates changes.

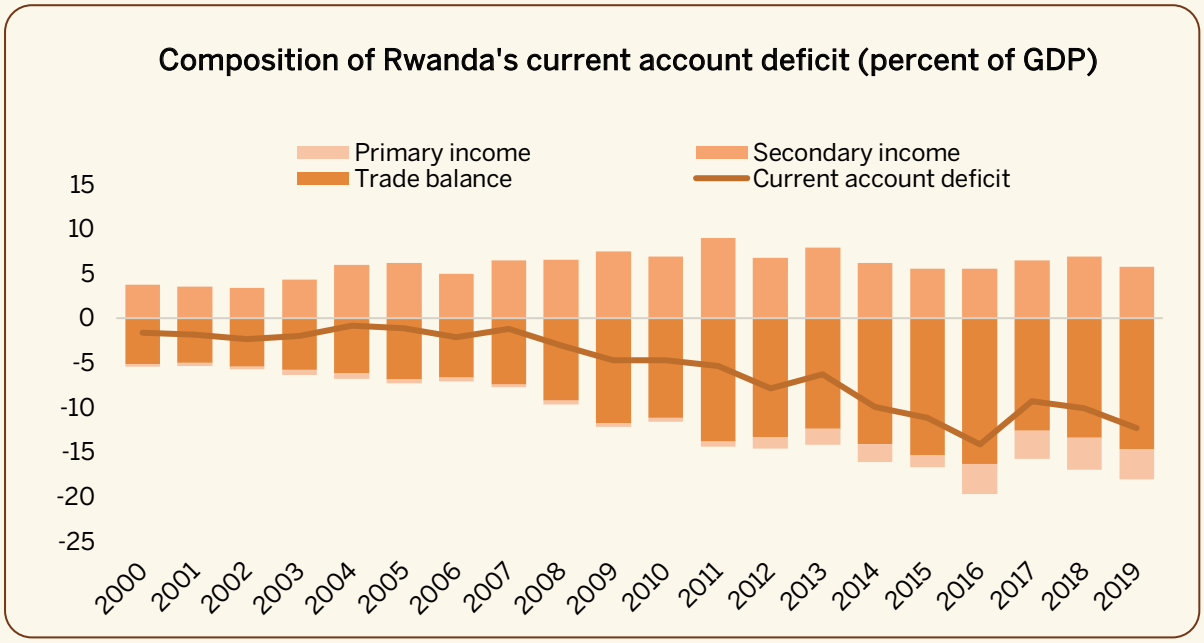
The rest of the paper is organized as follows. Section 2 describes the developments in trade balance and real effective exchange rates. In section 3, we provide brief theoretical and empirical reviews. Section 4 explains the models and econometric methodology discusses data source and definition. Section 5reports empirical results and Section 6 concludes.

2. STYLIZED FACTS OF RWANDA'S REAL EFFECTIVE EXCHANGE RATE AND TRADE BALANCE

In this section, we describe the development of Rwanda's trade deficit and real effective exchange rates. The real effective exchange rate is calculated for Rwanda's ten trading countries based on the consumer price index (CPI). An increase in the exchange rate denotes depreciation and vice versa.

Over the last two decades, Rwanda has been running a persistent current account deficit mainly driven by the trade deficit, which outstrips massive inflows from official and private transfers. The growing trade deficit has been driven by stagnant and less diversified exports coupled with strong imports necessary to satisfy the domestic demand for consumption and investment. However, in recent years, Rwanda has put in place various policies aimed at diversifying its exports base, notably value addition for its traditional commodities, improving Rwanda's manufacturing base supported by the "Made in Rwanda" program and investments in key services like tourism and travel as well as passenger transports.

Figure 1: Composition of Rwanda's current account deficit (percent of GDP)



Source: Authors' calculation

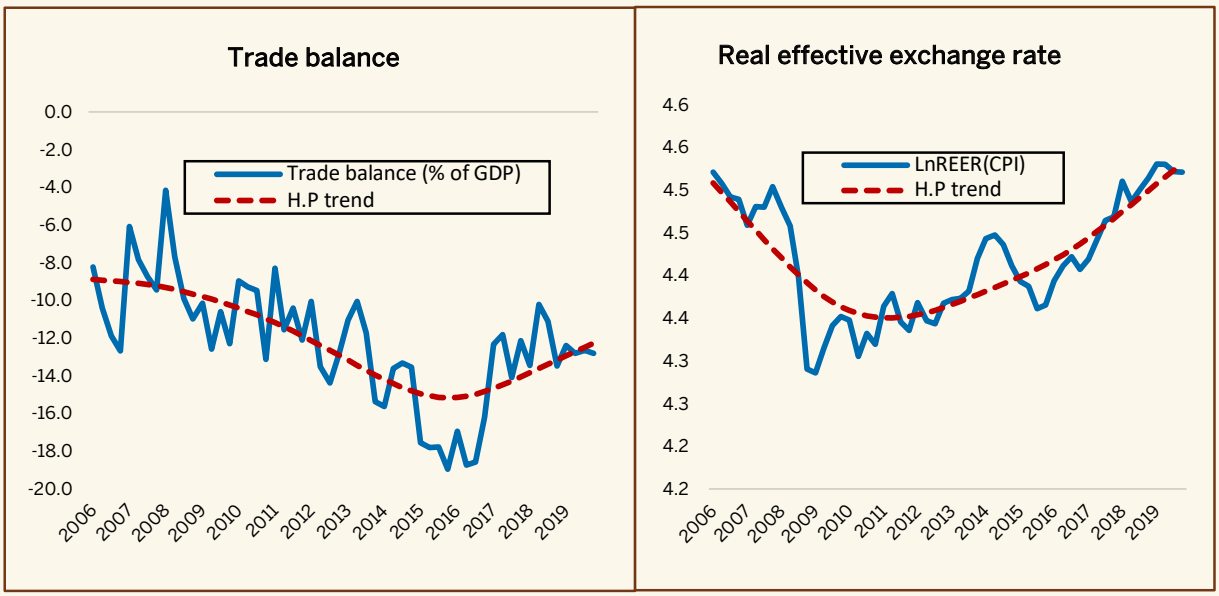
Over the period under review, exports represent 14.8 percent of GDP on average, nearly a half of imports share to GDP (27 percent). Rwanda's trade deficit continued to widen, reaching its peak in the last quarter of 2015, about19 percent of GDP due to decreased exports on account of the decline in international commodity prices. However, since 2017, the trade deficit has started to improve mainly supported by improving commodity prices and higher receipts from service exports, albeit continued higher imports, reflecting government efforts to diversify its exports base by reducing its overreliance on traditional commodity exports mainly composed of coffee, tea, and minerals, which are vulnerable to fluctuations in international prices. Receipts from travel and tourism have grown significantly averaging 4.2 percent of GDP over 2016-2019. Rwanda's travel and tourism revenues, which account for nearly half of all service exports, surpassing revenues collected from traditional exports to become the country's top foreign exchange earner. The government of Rwanda in partnership with the private sector has been working on diversifying tourism attractions and products to boost revenues from the sector. Traditionally, Rwanda's tourism revenues have been looked at through visiting gorillas, Nyungwe, and Akagera national parks. In 2014, the government launched a tourism product 'MICE: Meetings, Incentives,

Conferences and Exhibitions' to diversify the sector. Following higher investment in the sector through the construction of hotels, the country's efforts are paying off. The International Congress and Convention Association (ICCA) ranked Rwanda as Africa's number three tourism destination for meetings, incentives, conferences, and exhibitions. As a result, over the last decade, revenue generated by MICE grew by 180 percent, and the number of delegates visiting Rwanda for such events jumped from 15,000 to 28,300. Similarly, revenues from air transports have grown considerably following government investment in the national airline operator (i.e. Rwandair).

The real effective exchange rates have been appreciating over the period 2006-2010 before relinquishing most of these gains through 2019 (Figure 1, left panel). During the appreciation phase in line with theory, the trade deficit widened, averaging 9.7 percent of GDP (Figure 1, left panel). However, the trade deficit hardly reversed despite a depreciation of the REER in the second phase. This could be explained by the structure of the country's trade flows. First, despite a significant decline in the share of traditional exports to total exports, from 90 percent in 2006, they still represent a significant share to total exports, 30 percent in 2019. Prices of these traditional raw commodities are internationally determined and, hence, are less sensitive to the changes in REER. On the other hand, Rwanda's imports are highly dominated by investment goods and intermediary goods, where the latter category comprises imports used as inputs to manufacture exports. Kharroubi (2011) argued that when a country is vertically specialized its exports depend much on imports volume since some exporters use these imports as inputs to produce exports, resulting in a co-movement between exports and imports. Therefore, a tighter co-movement between imports and exports decreases the response of the trade balance to a change in the real exchange rate[6].

[6] We found a strong correlation between imports of intermediary goods and non-traditional exports of 0.89.

Figure 2: Trade balance and real effective exchange rate



Source: Authors' calculation

3. LITERATURE REVIEW

3.1. Theoretical literature

Theoretically, the link between the real exchange rate and trade balance is analyzed via three theories. The first aspect of this literature examining the relationship between real exchange rate and trade balance dates back to Bickerdike (1920), Robinson (1947), and Metzler (1948) which has come to be the sources of what is commonly known as Bickerdike-Robinson-Metzler (BRM) condition or elasticity approach to the balance of payments. This condition relates the response of the trade balance to exchange rate changes and the domestic and foreign price elasticities of imports and exports. The approach was further extended into the Marshall-Lerner condition (Marshall, 1923; Lerner, 1944), referred to ML henceforth, which states that a currency devaluation (or real depreciation) will lead to an improvement in the trade balance if the sum of the elasticities (in absolute values) of the demand for imports and exports with respect of the real exchange rate exceeds a unit. If this condition is satisfied, then the real devaluation of a currency can lead to an improvement in the current

account. The ML condition is analyzed using two methods. The elasticities method involves directly estimating the import and export demand price elasticities while the indirect method entails estimating the dynamic reaction of the trade balance to a real domestic depreciation. The indirect method is generally referred to as the J-curve phenomenon, which explains how a devaluation of a country's exchange rate affects its trade balance over time.

Generally, since the short-run elasticities are thought to be low, the trade balance initially worsens before eventually improving, thus tracing the shape of a J. In the short-run, following a currency devaluation domestic importers face inflated import prices as paid in domestic currency, leading to a decrease in net exports. In addition, as the demand for exports and imports is fairly inelastic in the short-run due to sluggishness in the change of consumer's behavior and the lag of changing old contracts, domestic exporters in the country devalue their currency in the face of lower exports prices. The trade balance worsens by the value of total imports in foreign currency multiplied by the magnitude of the rise in the price of foreign currency since contracts made before the depreciation force fixed prices and volumes. The short-run period is commonly known as the "exchange rate pass-through period". In the long run, as domestic demand starts to shift from foreign to domestic production of substitution goods as a reaction to the higher prices of imports, the trade balance improves. Furthermore, the markets in the home country experience an increase in export volume due to the decrease in export prices. The period of these two long-run factors is commonly known as the "volume adjustment period" and they have a favorable impact on the trade balance.

The second theoretical postulation is the monetary approach to the balance of payments, which focuses on the effect of monetary variables on the balance of payments. This theoretical approach contends that the balance of payments disequilibrium represents an imbalance between the supply and demand for money, suggesting that excess money supply encourages imports, resulting in the trade deficit and outflow of foreign exchange reserves (Carbaugh, 2004).

The literature on the theoretical foundations of this approach originates from the work of Mundell (1968), Dornbusch (1971), and Frankel (1971). This theoretical approach is strongly supported by the empirical literature (Jimoh, 2004; Dausa, 2005).

The third is the Keynesian Absorption Approach, which was first modeled by Meade (1951) and Alexander (1952). This approach is the combination of Keynesian macroeconomics and the elasticities approach. It conjectures that there will be an improvement in the trade account if domestic absorption is less than domestic output growth (Dunn and Mutti, 2000). In other words, if the domestic expenditure on consumption and investment is greater than the national income, the trade balance worsens.

In conclusion, the theoretical postulations are dependent on the assumptions about the types of trade, the presence of adjustment costs, market structure, and the presence of hedging opportunities. In this case, the link between the real exchange rate and trade balance remains analytically inconclusive, thus this relationship becomes an empirical issue.

3.2. Empirical literature

On the empirical front, several studies have investigated the role of real exchange in improving trade balance. Guechari (2012) examined the effects of REER on Algeria's trade balance and revealed a significant positive impact of the real effective exchange rate on Algeria's bilateral trade balance with the US and France, and on Algeria's total trade balance in long-run, and a significant negative impact on trade balance for all cases in the short-run. The study found that the real effective exchange rate helps in predicting the trade balance and the real depreciation has a long-run positive impact on the total trade balance of Algeria.

Lossifov and Fei (2019) assessed the role of exchange rates in restoring external balance in Turkey in the-post-2008 period. Their study found that the REER has been an important determinant of real trade flows but the effect is not symmetric. During the period of REER appreciation through 2008Q3, the transmission channel operated mainly through increasing imports from Turkey's higher purchasing power in terms of foreign goods baskets. In the period of REER depreciation, the transmission channel has operated through both export promotion and import compression through their price elasticities, as the REER depreciation appears to have overshot the slightly negative total factor productivity growth in the post-2006 period.

Begovic and Kreso (2017) investigated the adverse effect of real effective exchange rates on the trade balance in European transition countries. Their study found that the depreciation of REER deteriorates the trade balance in European transition countries, which could be explained by high import dependence and low export capacity and competitiveness of transition countries, and by the fast transmission of higher import prices into domestic prices. Findings in this paper imply that policymakers in European transition countries should not use exchange rate policy to improve the trade balance.

Individual country studies have also shown that results can be different depending on the level of aggregation of trade flows. Ziramba and Chifamba (2014) used aggregated trade flows for South Africa and found no significant effect of a rand depreciation on South Africa's aggregate trade balance. In the same country, using data on the South African manufacturing sector, Chiloane et al. (2014) found that rand depreciation has favorable effects on the sector's trade balance. Similarly, Yazici and Klasra (2010) investigated the response of two sectors of the Turkish economy, i.e., manufacturing and mining, and found an inverse of the J-curve pattern in both sectors. Durmaz (2015) investigated the response of REER to 58 Turkish industries that trade with the rest of the world and found support for short-run deterioration combined with long-run improvement of the trade balance in 11 industries. Bahmani-Oskooee and Kovyryalova (2008) using cointegration and error correction techniques for the period 1971 to 2003 analyzed the impact of the real exchange rate volatility on international trade, considering 177 commodities traded between the United States (US) and the United Kingdom (UK). Their results show the volatility of the real bilateral dollar-pound rates has a short-run significant effect on imports of 109 and exports of 99 industries. In the long run, the study revealed that the number of significant cases is reduced, with imports of 62 and exports of 86 industries.

Zakaria (2013) examined the link between exchange rate and trade using regression analysis of standard export demand models as well as the GARCH (1,1) model spanning the period 2000M1-2012M8. The results indicated that Malaysian exports to the US and Japan are significantly linked to exchange rate volatility. In a study of the exchange rate volatility and exports using Johansen's cointegration framework, Mordecki and Miranda (2018) found that commodity exports do not

only depend on the global demand and prices but also the variability in the real exchange rates.

The studies reviewed above rely on the assumption that the relationship between real exchange rate and trade balance is linear. However, a strand of recent studies has analyzed and demonstrated a non-linear relationship between these variables, which implies that the linear approach used by the previous studies may be inappropriate. These studies argue that the trade balance may respond differently to real appreciations and depreciations. Hence, if appreciations are filtered from depreciation, the support for the J-curve may become clearer. In analyzing the existence of the J-curve phenomenon in the U.S and her six major trading partners, Bahmani-Oskooee and Fariditavana (2016) find nonlinear specifications of the trade balance model to be more supportive of the J-curve than the linear specifications.

Mahmood et al. (2017) explored the impact of devaluation and appreciation on Saudi Arabian services sector trade. Their study found short-term and long-term asymmetric effects in all sectors. Overall devaluation confirms the existence of J-curve after some lag. This study also found that appreciation of a Saudi currency has adverse effects on the trade balance in all services sectors except travel, construction, and tourism. They also showed that the increase in world income enhances exports of Saudi Arabia, while the rise in Saudi Arabia's incomes had negative effects on the trade balance of all services sectors except travel and tourism.

Bahmani-Oskooee and Gelan (2019), using data for 23 industries in South Africa, analyzed symmetric effects of rand using the linear ARDL approach of Pesaran et al. (2001) and the nonlinear ARDL approach Shin et al. (2014) to assess asymmetric effects of exchange rate changes. The results from the linear models yielded significant short-run effects of the real rand-dollar rate on the trade balance of all the industries. In the long run, only seven industries had lasting short-term and favorable effects. On the other hand, the results from nonlinear models found that rand depreciation or appreciation had significant asymmetric short-run effects in 18 industries. The important policy implication that emerged out of the study is that the exchange rate policy that fosters either rand depreciation or appreciation benefits some industries and/or worsen others, vice

versa. The study recommended mixing up the monetary policy with other commercial policies such as trade negotiations, subsidies, and tariffs to promote South African trade. Similarly, Bahmani-Oskooee and Durmaz (2016) tested the effects of exchange rate changes on the trade balance of 57 industries that trade between Turkey and the EU using the nonlinear approach. The results from their study found short-run asymmetry effects in all industries, short-run adjustment asymmetry in 24 industries, short-run impact asymmetry in 17 industries, and long-run asymmetry effects in 23 industries.

Iyke and Ho (2017) examined the effects of real exchange rate changes on the trade balance of Ghana during the period 1986Q1 to 2016Q3 using both the linear and nonlinear specifications. The study results of their linear specification found no support of the short- and long-run impact of exchange rate changes on the trade. In contrast, in the nonlinear specification, exchange rate changes affected the trade balance. They found that while depreciations have short-run and long-run effects on the trade balance, appreciations have no impact. In the short run, real depreciation appears to harm the trade balance at lags zero and one, while in the long run, the impact is reversed, hence, supporting the J-curve phenomenon.

Given the limited number of studies in the Rwandan context and taking into account the notion that the relationship between trade balance and the real effective exchange rate could be nonlinear, we investigated the relationship between exchange rate and trade balance using both linear and nonlinear ARDL specifications by focusing on Rwanda.

4. METHODOLOGY

4.1. Model specification and estimation strategy

To capture the asymmetric effect of the real exchange rate on Rwanda's trade balance, we follow both linear (ARDL) and non-linear autoregressive distributed lag model (ARDL), akin to Bahmani-Oskooee and Gelan (2019) in a log-log specification. The choice of this model is premised on the fact that the ARDL technique runs both the long-run effect and the short-run effects in one step. Secondly, the ARDL model does not require pre-tests for unit roots given that it deals with variables that are integrated of different orders i.e I(0), I(1), or a

combination of both, and is robust when there is a single long-run relationship of the underlying variables in a small sample size (Nkoro and Uko, 2016). However, this technique explodes in the presence of an integrated stochastic trend of I (2). To prevent this futile effort, we test for unit root to obtain the orders of integration, though not a necessary condition.

Following Bahmani-Oskooee and Gelan (2019), we begin our specification with a reduced form trade balance equation specified as follows:

$$lnTB_{Rw,t} = \alpha + \beta \ln wgdp_{,t} + \vartheta \ln rgdp_{,t} + \sigma \ln reer_t + \varepsilon_t \quad \text{..... (1)}$$

Where TB_{Rw} is Rwanda's trade balance, defined as exports divided by imports. $wgdp$ is the world gross domestic product or foreign income, used as a proxy for external demand of Rwanda's exports. $rgdp$ is real domestic income and $reer$ is a real effective exchange rate and ε_t is a stochastic error term.

In terms of expected signs, the coefficient associated with foreign income is expected to be positive, implying that an increase in external demand boosts exports and improves the trade balance. The parameter estimate of real domestic income is expected to be negative given that economic growth induces more imports, thereby depressing the trade balance. The coefficient associated with real exchange rate depreciation[7] is expected to be positive as currency depreciation improves the trade balance.

The parameter estimates discussed above mirror the long-run effects of exogenous variables since equation (1) is a long-run model. To assess the short-run effects, to verify the J-curve effect, we convert to an error correction specification and to estimate both the short-run and the long-run effects in a single step, we follow the ARDL approach, similar to Pesaran et al. (2001) specifies as follows:

[7] Real exchange rate is defined in a manner that an increase signifies a depreciation of Rwandan franc

$$\Delta \ln TB_{Rw,t} = \phi + \sum_{j=1}^{n} \delta_j \Delta \ln TB_{Rw,t-j} + \sum_{j=0}^{n} \gamma_j \Delta \ln wgdp_{,t-j} + \sum_{j=0}^{n} \theta_j \Delta \ln rgdp_{,t-j} + \sum_{j=0}^{n} \eta_j \Delta \ln reer_{,t-j}$$
$$+\lambda_0 \ln TB_{Rw,t-1} + \lambda_1 \ln wgdp_{,t-1} + \lambda_2 \ln rgdp_{,t-1} + \lambda_3 \ln reer_{,t-1} + \mu_t \ldots\ldots\ldots(2)$$

From the above specification, the short-run effects are obtained from the first-differenced variables; the long-run effects are reflected in the estimates $\lambda_1 - \lambda_3$ normalized λ_0. In addition, two tests are implemented to avoid spurious regressions, the F-test to establish the joint significance of lagged level variables, signifying the presence of cointegration, and the T-test to establish the significance of λ_0, which must be negative. For both tests, Pesaran et al. (2001) tabulate new critical values that consider the degree of integration of variables. As they show, the upper bound critical values could be used even if some variables in the model are I (1) and some I (0). The interpretation is that if the estimated F-value is greater than a critical value of the upper bound, the null hypothesis of no cointegration is rejected.

Shin et al. (2014) adjust the model specified in (2) to capture the asymmetric effects of the real exchange rate. The modification amounts to disaggregating real exchange rates into depreciation and appreciation to estimate their effects separately. In this case, we first take the positive variable for the partial sum of positive changes in the exchange rates.

Similarly, a negative variable for the partial sum of negative changes in the real exchange rates is created, where positive, where positive and negative changes in the real exchange rates signify depreciation and appreciation of the real exchange rates respectively. The two variables are defined as:

$$reerdep_{,t} = \sum_{j}^{t} i\Delta reer_j^{+} = \sum_{j=1}^{t} \max(\Delta reer_{j,} 0) \quad reerap = \sum_{j=1}^{t} \Delta reer_j^{-} = \sum_{j=1}^{t} \min(\Delta reer_j, 0) \quad \ldots. (3)$$

Following Shin et al. (2014), the non-linear ARDL model can be expressed as:

$$TB_{Rw,t}^{+} = \theta^{+} lreer_t^{+} + \theta^{-} lreer_t^{-} + \mu_t \ldots\ldots\ldots\ldots(4)$$

θ^{+} and θ^{-} are the asymmetric long-run equilibrium parameters associated with positive and negative changes in the real exchange rate. After generating these

variables, we replace $\ln reer$ them with the two partial sum variables to obtain equation (5).

$$\Delta \ln TB_{Rw} = \alpha^{'} + \beta_{j}^{'} \Delta \ln TB_{Rw,t-j} + \sum_{j=1}^{n} \sigma_{j}^{'} \Delta \ln wgdp_{,t-j} + \vartheta_{j}^{'} \Delta \ln rgdp_{,t-j} + \phi_{j}^{'} \Delta \ln reerdep_{,t-j} + \gamma_{j}^{'} \Delta \ln reerap_{,t-j}$$

$$+\pi_0 \ln TB_{Rw,t-1} + \pi_1 \ln wgdp_{,t-1} + \pi_2 \ln rgdp_{,t-1} + \pi_3 \ln reerdep_{,t-i} + \pi_4 \ln reerap_{,t-1} + \xi_t \ldots\ldots(5)$$

Where $\theta^{+} = \frac{\phi}{\beta^{'}}$ and $\theta^{-} = \frac{\gamma}{\beta^{'}}$ if the two partial sums carry the same coefficient in terms of sign and size, the effects are symmetric. Otherwise, they are asymmetric. While the specification in equation (2) is referred to as the linear ARDL model, equation (5) is known as the non-linear ARDL model or asymmetric ARDL model. Shin et al. (2014) indicate that the non-linear ARDL model is subject to similar diagnostic tests and the same estimation procedure as the linear ARDL model.

The non-linear ARDL model specified in equation 5 is used to derive the two dynamic multipliers computed as:

$$m_h^{+} = \sum_{j=0}^{h} \frac{\partial TB_{Rw,t+j}^{+}}{\partial lreer_t^{+}} \quad , \quad m_h^{-} = \sum_{j=0}^{h} \frac{\partial TB_{Rw,t+j}^{-}}{\partial lreer_t^{-}} \ldots\ldots\ldots(6)$$

Where $h \to \infty$ then $m_h^{+} \to lreer^{+}$ and $m_h^{-} \to lreer^{-}$

4.2. Data description and sources

The series presented in models (1), (2), (3), (4) and are constructed as follows. The real exchange rate is the relative inflation-adjusted exchange rate and trade-weighted, computed by multiplying the nominal effective exchange rate by the ratio of consumer price index $REER = \sum_{t=1}^{k} (Neer_{it}) \left(\frac{p_{it}^{*}}{p_{it}} \right)$, where $NEER_{it}$ is the nominal effective exchange rate for Rwanda for the trading partner i, p_{it}^{*} is the price in partner trading country i representing the price of tradable, and p_{it} is the CPI of the home country as a proxy for the price of non-tradable ($NEER = \sum_{t=1}^{k} w_{it} * E_{it}$).

Real gross domestic product (GDP) is the nominal gross domestic product adjusted for inflation. World gross domestic product is foreign income, obtained by aggregating real gross domestic product for all the world economies. Exchange rate depreciation and appreciation are generated through partial sums. Finally, the trade balance is defined as the ratio of exports to imports. This measure of trade balance allows someone to perform nominal and real trade balance analysis without additional data manipulation and it also neatly solves the problem of using the log-form of a trade deficit. Our data series are transformed into natural logarithms and data is sourced from the National Bank of Rwanda (NBR), National Institute of Statistics of Rwanda (NISR), and World Bank's world development indicators (WDI). The empirical analysis builds on quarterly data spanning the period 2000Q1-2019Q4.

5. EMPIRICAL RESULTS

5.1. Unit root test

We start the analysis with the pre-test of the order of integration of variables even though the ADL bound test does not require the pre-test for stationarity, its technique explodes in the presence of integrated stochastic trend of I (2). To avoid this futile effort, we test for unit root to obtain the orders of integration. The test of the presence of unit roots is applied to all selected variables using the Augmented Dickey-Fuller (ADF) test and the results are reported in Table 1. The trade balance and domestic real GDP are stationary at levels, implying that they are integrated of order zero (0) while real effective exchange rate and foreign income proxies by U.S real GDP become stationary after differencing once i.e. I(1).

Table 1: Unit roots test for non-stationarity (Sample: 2000Q1–2019Q4)

	Level		First Difference		Order of Integration
	Intercept	Trend	Intercept	Trend	
Tb	-4.49***	-5.59***	-10.54***	-10.47***	I(0)
Lnreer	-2.27	-2.89	-7.46***	-7.63***	I(1)
Lnrgdp	-0.99	-3.88**	-9.01*	-8.99*	I(0)
Lnwgdp	-0.19	-1.23	-6.42*	-6.39*	I(1)

Note: *, **, ***: denote rejection of null hypothesis at 10%, 5% and 1% significance level respectively.

Source: Author's calculations

5.2. Bounds testing to cointegration

After testing for stationarity of the variables as presented in table 1, we proceed to test for cointegration between the dependent and the explanatory variables in the linear and the nonlinear specifications. The results of the linear and nonlinear ARDL bounds test for cointegration are presented in table (2). First, the test for the existence of long-run cointegration between variables for the linear model is conducted using the linear ARDL bounds test. The results show that the estimated value of the F-test is greater than the upper bound critical value, suggesting that the null hypothesis of no cointegration is rejected, confirming the presence of cointegration between dependent and independent variables. Secondly, also presented in table (2) are the results of the nonlinear ARDL bound test, which is using two tests. The first is theF_{PSS}proposed by Pesaran et al. (2001), which tests the significance of the variables that enter into the nonlinear or asymmetric model equation (4) in level and the second is T_{BDM} developed by Banerjee et al. (1998), which tests the significance of the feedback coefficient. The results from both tests show that the test statistics are greater than their corresponding upper bound critical values, suggesting that the null hypothesis of no cointegration is rejected, hence, the existence of a long-run cointegrating relationship between the selected variables.

Table 2: Cointegration test in the linear and the nonlinear specifications[8]

Model		F-Statistics	95% Lower bound	95% upper bound	Result
Linear ARDL		5.058	3.23	4.35	Cointegration
Non-linear ARDL	F_{PSS}	5.130	2.86	4.01	Cointegration
	T_{BDM}	-4.907	-2.86	-3.99	
Note: F_{PSS} and T_{BDM} denote the F-statistics proposed by Peseran et al. (2001) and the t-statistics proposed by Banerjee et al. (1998).					

Source: Authors' calculation

5.3. Presentation of model results

Table 3 and Table 4 report the results of the linear and nonlinear ARDL models respectively. The linear model shows short-run and long-run dynamics of the trade balance to the changes in the regressors. The nonlinear ARDL estimation presents both the long and short-run estimated coefficients for the different partial sums of real exchange rates. Each model was estimated by imposing a maximum of three lags for both the dependent and independent variable and the selection criteria is based on Akaike Information Criterion (AIC) to select an optimum model. The presence of an asymmetric impact in the long and short run is examined by the Wald test, which tests the null hypothesis of symmetric against the alternative of asymmetric.

5.3.1. Linear ARDL model results

The results from the linear model show that the short-run impact of real exchange rate on trade balance provides positive and negative but not statistically significant effects whereas the long-run coefficient revealed positive and statistically significant effects on Rwanda's trade balance, suggesting that the real exchange rate depreciation favors trade balance. This result does not seem to

[8] The testing procedure uses two critical bounds: upper and lower. If the values of the test statistic exceed the upper bound, the null hypothesis is rejected. If they lie below the lower critical bound, the null cannot be rejected, and if they lie between the critical bounds, the test is inconclusive.

support the traditional definition of the J-curve phenomenon that was tested empirically (Bahmani-Oskooee, 1985), which requires statistically significant negative coefficients (i.e. deterioration of trade balance) in the short-run and positively significant ones (i.e. improvement of trade balance) in the long-run. This implies that if Rwanda is experiencing trade deterioration, a depreciation or devaluation policy will not help in the short run given that the trade balance takes some time to adjust but eventually improves the trade balance in the long run. On the other hand, the long-run estimates are meaningful as cointegration is supported by either the F-stat or the t-test as previously reported in table 2. In addition, the normalized estimated error correction term, ECM= -0.63, is negative and statistically significant, supporting fast adjustment towards the long-run, further supporting the existence of cointegration.

Table 3 also reports few additional diagnostic statistics. We used the Lagrange Multiplier (LM) test to check for serial correlation. The result of the LM statistic is distributed as chi-squared with 2 degrees of freedom. As can be seen, it is insignificant, implying the lack of autocorrelation of residuals. We also tested the stability of the model using the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ) tests. The result showed that the model is structurally stable. In addition, adjusted R^2 is reported judging the goodness of the fit. Lastly, the Jarque-Bera statistic suggests normal distribution.

Table 3: Results from linear ARDL model

Dependent variable: tb			
Variable	**Coefficient**	**T-stat**	**P-value**
Short-term			
Constant	-12.05** (3.82)	-3.16	0.003
Δtb_{t-1}	0.06 (0.13)	0.44	0.660
$\Delta lnreer$	0.32 (0.25)	1.25	0.216
$\Delta lnreer_{t-1}$	-0.27 (0.23)	-1.15	0.255
$\Delta lnrgdp$	-1.07** (0.35)	-3.00	0.004
$\Delta lnrgdp_{t-1}$	-1.03*** (0.28)	-3.73	0.000
$\Delta lnrgdp_{t-2}$	-0.56 (0.34)	-1.65	0.105
$\Delta lnwrgdp_{t-1}$	-2.39 (1.61)	1.48	0.145
$\Delta lnwrgdp_{t-2}$	-2.72* (1.49)	-1.83	0.073
Long-term			
ECM	-0.63*** (0.15)	-4.20	0.000
$lnreer_{t-1}$	0.23* (0.12)	1.84	**0.070**
$lnrgdp_{t-1}$	-0.27** (0.10)	-2.64	**0.011**
$lnwrgdp_{t-1}$	1.37*** (0.45)	2.86	**0.006**
Diagnostics tests	$Adjusted\ R^2 = 0.712; F-statistics = 13.526$; $\chi^2_{LM} = 0.898$; $\chi^2_{HET} = 19.47$; $Jarque-Bera(p-value) = 0.542$; CUSUM: Stable; CUSUMSQ = Stable; RESET = 1.146		

Notes: Standard errors are in parentheses. *, **, *** denote 10%, 5% and 1% significance level. χ^2_{LM} is the Lagrange Multiplier test of residual serial correlation distributed as χ^2 with 2 degrees of freedom; χ^2_{HET} is the Breusch-Pagan-Godfrey test of residual homoskedastic distributed as χ^2 with 15 degrees of freedom. RESET is Ramsey's test for misspecification.

Source: Authors' calculation

5.3.2. Non-Linear ARDL model results

Several studies have argued and empirically proven that the non-existence of the J-curve concept could be due to the fact that they assume an asymmetric relationship between the real exchange rate and trade balance whereas in fact, it is an asymmetric one. Therefore, it is possible that the relationship between the real exchange rate and the trade balance is nonlinear, and thus the assumption that they are linearly associated discounts some important information. Thus, we

proceeded to estimate the nonlinear ARDL model to verify whether the relationship is asymmetric. Table 4 below reports the nonlinear ARDL estimates.

The nonlinear model is based on separating depreciations ($lreer^{+}$) from appreciations ($lreer^{-}$). The results of the nonlinear ARDLmodel suggest that depreciation of the real exchange rate has both short and long-run effects on the trade balance. In the short run, real depreciation appears to have a negative effect on the trade balance at lag one, while in the long run, the impact is reversed. These results are consistent with the J-curve phenomenon as defined by Bahmani-Oskooeeand Fariditavana (2015 and 2016), which implies that the deterioration of trade balance in the short-run but eventually reversed to improve the trade balance in the long run based on the partial sum concepts and $lreer^{+}$ and $lreer^{-}$ variables).In contrast, real appreciation did not affect the trade balance both in the short and long run during the study period. In addition, as clearly shown in Table 4, at a given lag, the short-run coefficient associated with$lreer^{+}$ is different from the one associated with$lreer^{-}$, supporting short-run asymmetric effects of real exchange rate on the trade balance. However, as suggested by Bahmani-Oskooee et al. (2016) this conclusion should be confirmed by a formal test. The study applied the Wald test to examine if the partial sums of the short-run coefficients associated with$\Delta lnreer^{+}$ and $\Delta lnreer^{-}$ variables are significantly different. Short-run asymmetry is obtained if the Wald Statistic appears significant.

The result from Table 4 reveals the Wald statistic denoted by $W_{SR,lnreer}$is 1.11, which is insignificant, hence, failing to reject the null of the short-run symmetry, suggesting that there is no short-run asymmetry of the real exchange rates on the trade balance. Furthermore, the long-run asymmetry is tested using the Wald test by verifying if $\pi_3 = \pi_4$which are coefficients associated with depreciation and appreciations respectively in the nonlinear specifications. The Wald statistics $W_{LR,lnreer}$is equal to 8.77 and is statistically significant, confirming the presence of the long-term asymmetry. The long-run coefficient of $lreer^{+}$is 0.93 and statistically significant while the long-run coefficient of $lreer^{-}$is 0.002but is not significant. This implies that 1 percent depreciation improves the trade balance by

0.93 percent while real appreciation does not affect the trade balance in the long run.

Furthermore, the F-statistics well as the estimated error correction term, $ECM_{t-1} = -0.86$, which is negative and statistically significant, indicates the presence of cointegration of variables in the nonlinear model. The results of long-run estimates of the nonlinear model appear to be more meaningful when supported by the diagnostic statistics as represented in Table 4.

Table 4: Results from nonlinear ARDL model

Dependent variable: tb			
Variable	**Coefficient**	**T-stat**	**P-value**
Short-term			
Constant	-11.28 (2.16)	-5.23	0.000
Δtb_{t-1}	0.19 (0.14)	1.32	0.192
$\Delta lnreer^{+}$	0.32 (0.35)	0.91	0.367
$\Delta lnreer^{+}_{t-1}$	-0.78* (0.42)	-1.89	0.064
$\Delta lnreer^{-}$	0.36 (0.48)	0.76	0.448
$\Delta lnreer^{-}_{t-1}$	-0.09 (0.47)	-0.20	0.845
$\Delta lnrgdp$	-1.24*** (0.36)	-3.45	0.001
$\Delta lnrgdp_{t-1}$	-0.65** (0.312)	-2.069	0.043
$\Delta lnwrgdp$	-0.47 (1.73)	-0.27	0.789
$\Delta lnrgdp_{t-1}$	1.73 (1.75)	0.99	0.327
Long term			
Dependent variable: tb			
Variable	**Coefficient**	**T-stat**	**P-value**
$lnreer^{+}_{t-1}$	0.93 (0.30)	3.10	0.003
$lnreer^{-}_{t-1}$	0.02 (0.18)	0.13	0.901
$lnrgdp_{t-1}$	-0.97 (0.32)	-3.02	0.004
$lnwrgdp_{t-1}$	1.88*** (0.54)	3.49	0.001
Long-run asymmetric coefficients	$LR^{+}_{lreer} = 1.08^{***} LR^{-}_{lreer} = 0.03$		
Long run asymmetric coefficients test	$W_{LR,lnreer} = 8.77^{***} W_{SR,lnreer} = 1.11$		
Diagnostics tests	$Adjusted\ R^2 = 0.701$; $F - statistics = 10.251$; $X^2_{LM} = 2.688$; $X^2_{HET} = 20.516$; $Jarque - Bera(p - value) = 0.4498(0.7985)$; CUSUM: Stable; CUSUMSQ = Stable; RESET = 0.038		

Notes: $W_{LR,lnreer}$ refer to the Wald test for the null of long-run symmetry while $W_{SR,lnreer}$ refer to the Wald test for the null of the additive short-run symmetry condition. Standard errors are in parentheses. ***, **, * denote 1%, 5% and 10% significance level. χ^2_{LM} is the Lagrange Multiplier test of residual serial correlation distributed as χ^2 with 2 degrees of freedom; χ^2_{HET} is the Breusch-Pagan-Godfrey test of residual homoskedacity distributed as χ^2 with 15 degrees of freedom. RESET is Ramsey's test for misspecification.

Source: Authors' calculation

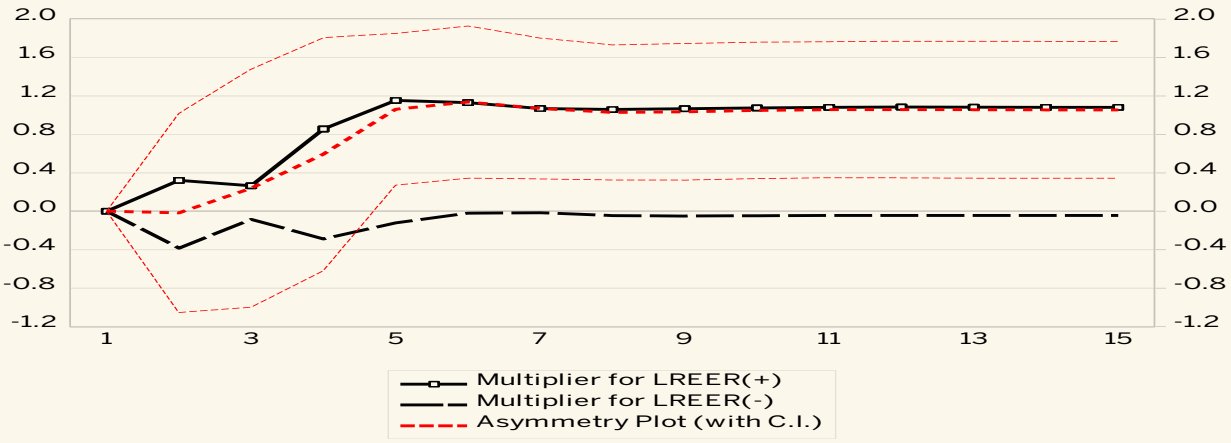
Given that no studies have analyzed the asymmetric effects of exchange rate changes on the trade balance in the case of Rwanda, we are unable to make a

direct comparison. However, the results from this study are in line with many other previous studies conducted in other countries (Bahmani-Oskooee and Durmaz, 2016; Bahmani-Oskooee et al., 2016; Iyke and Ho, 2017; Bahmani-Oskooee and Gelan, 2019) among others. These studies found that nonlinear models yield a significant asymmetric link between the trade balance and the real exchange rate changes.

5.3.2.1. Dynamic multipliers

Given that we have rejected the null hypothesis of symmetry in the long run, we proceed to obtain the asymmetric dynamic multipliers of the positive and negative charges of the explanatory variables. The asymmetric cumulative dynamic multipliers show the pattern of adjustment of the dependent variable, trade balance, to its new long-run equilibrium following a positive or negative unitary shock of its regressors. In this study, our interest is the asymmetric dynamic multiplier of the real exchange rate to capture the impact of appreciation and depreciation on the trade balance. Figure 2 shows the dynamic effects of real exchange rate where real trade balance responds more rapidly to an increase in the REER (depreciation) than its decrease (appreciations) as the asymmetry line moves away so distantly from the zero lines in the upper bound. In addition, the graph confirms the results from the Wald test of the nonexistence of short-run asymmetry as presented earlier.

Figure 3: Long-run and short-run NARDL dynamic multiplier



Source: Authors' calculation

6. CONCLUSION AND RECOMMENDATIONS

The impact of the exchange rate on trade balance has been studied extensively given the role it plays in determining a country's competitiveness. Theoretical literature stipulates that the economies that suffer from trade balance should devalue their currency or put in place policies that promote real depreciations. Several studies have then tried to establish this relationship. It has been suggested that following a country's currency depreciation or devaluation, the trade balance will deteriorate in the short-run before reversing in the long run, a feature commonly known in the literature as the J-curve effect. These studies have assumed a linear relationship between exchange rate changes and trade balance. However, several studies have recently suggested and tested nonlinear impacts of exchange rate movements on trade balances using the nonlinear Autoregressive Distributed Lags (ARDL) models. The nonlinear ARDL approach allows us to decompose the impact of the exchange rate changes in terms of appreciations and depreciations. The presence of asymmetric impacts in the long and short run is detected from the Wald test based on the null hypothesis of the presence of symmetric against the alternative of asymmetric effects.

Given the limited literature in the case of Rwanda, this study examined the effects of exchange rate on the trade balance in Rwanda by using both the linear ARDL and nonlinear ARDL approach. Using quarterly data spanning the period 2000Q1 to 2019Q4, the results from the linear ARDL model did not support the J-curve phenomenon. Only a long-run relationship between trade balance and the real exchange rate was identified and emerged as statistically significant. The long-run coefficient suggested that a 1 percent depreciation improves Rwanda's trade balance by 0.23 percent. In addition, the error correction term appears negative and highly significant, further supporting the long-run relationship. In contrast, there was evidence of short-run and long-run effects of exchange rate changes on the trade balance in the nonlinear specification. While the short-run asymmetry was refuted by the Wald test, the result from the nonlinear ARDL showed that in the short run, real depreciation appears to have a negative and statistically significant effect on the trade balance at lag one, while in the long run, the impact is reversed, hence, supporting the J-curve phenomenon. However, real

appreciations do not have any significant effect on trade balance both in the short-run and long run. This evidence suggests that policymakers should be aware of the consequences of asymmetric impacts of Rwandan francs' appreciation and depreciation in the development of trade policies so that international competitiveness is not adversely affected. In addition, from the results obtained, the improvement of the trade balance after depreciation is very limited, hence, policymakers should weigh the benefits of the improvement in trade balance with potential unfavorable effects of a permanent depreciation. This study also suggests further research to better understand the effect of exchange rates on the trade balance. Previous studies suggested that using a country's trade data with the rest of the world might suffer from aggregation bias. To address this issue, future research should consider modeling Rwanda's trade data with its main trading partners. Alternatively, other studies could utilize the aggregate data according to standard international trade classification to assess the response of trade balance on exchange rate changes by industry.

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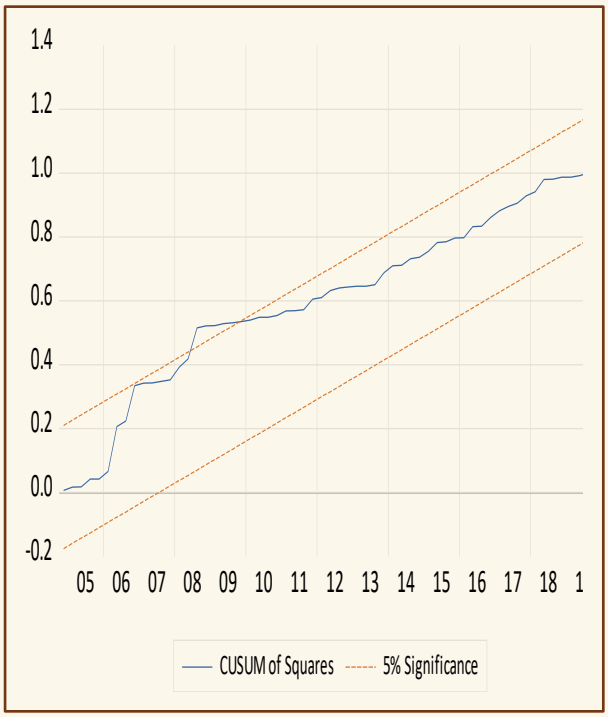
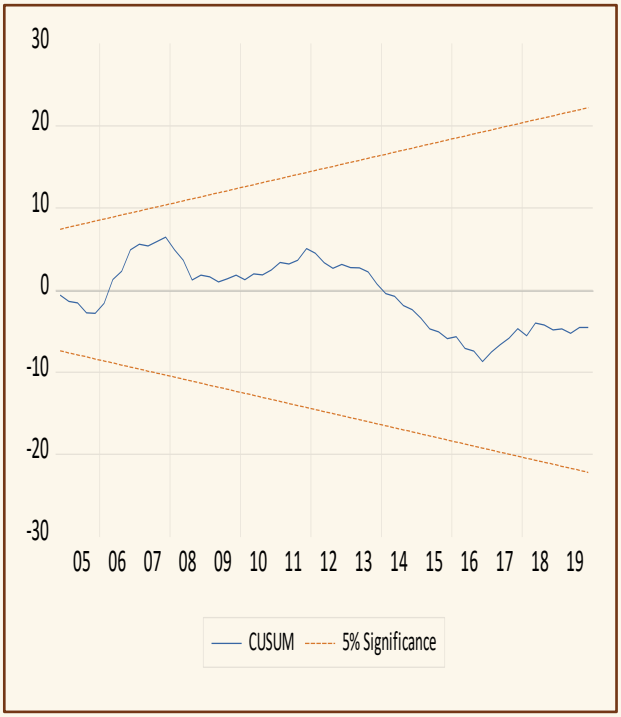
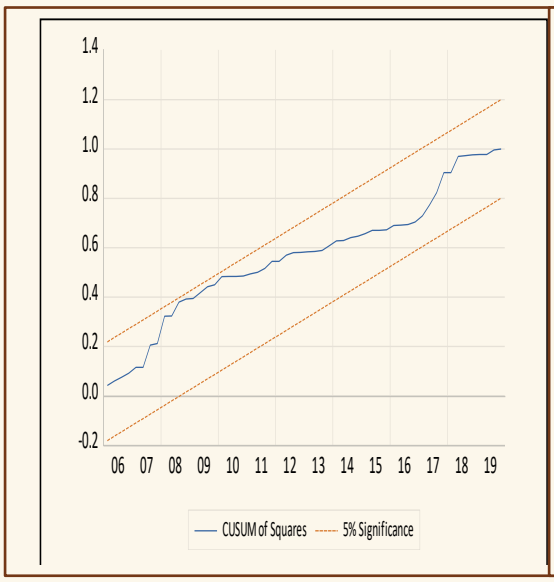
Appendices

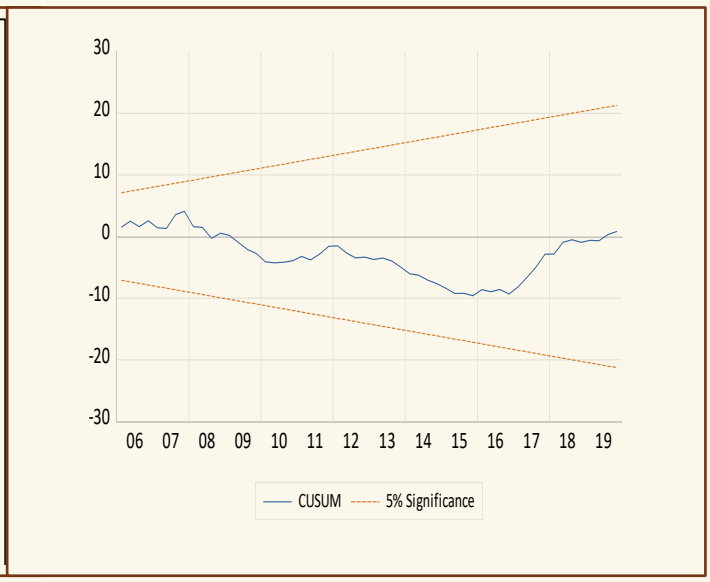
Stability Diagnostics test for Linear ARDL Model





Stability diagnostics test for Nonlinear ARDL Model





UNDERSTANDING INTEREST RATE RISK IN THE RWANDAN FINANCIAL SYSTEM

Patrick Mugenzi[9]

[9] Economist, Monetary Policy Department, National Bank of Rwanda

ABSTRACT

This paper aims at examining the effect that the volatility in interest rates (hereafter called interest rate risk) has on the net worth of banks in Rwanda. The study used the static panel data model, specifically the fixed effect model, to estimate the effect of interest rate risk in the banking sector with data from 10 licensed commercial banks with available data from 2012Q1 until 2019Q2. The findings suggest that most commercial banks were most sensitive to the changes in the deposit rate. Specifically, an increase of 1 percent in the deposit rate induced a decline in net worth equivalent to 1.1 percent. Financial regulators can use this approach to monitor the build-up of interest risks and ensure timely actions to safeguard the financial system's stability.

Key words: Interest rate risk, banks' net worth, fixed-effects model
JEL classification: E43, G32, C33

1. INTRODUCTION

Interest rate risk management in the banking sector has received increasing importance, especially during the last decades of higher interest rate volatility. It has become increasingly important to measure, manage, and assess the impact of this volatility on banking economics. Over the past few years, both banking supervisors and researchers have nearly exclusively focused on banks' credit and operational risk. More recently, considerable attention is being turned to interest rate risk (Fisnik and Afrim, 2015). Since interest rate risks can result in systemic risks with detrimental effects on the financial system's stability, the renewed focus on this channel needs no further justification.

Interest rate risk is a catchall phrase intended to mean the effect of changes in market interest rates on the banks' financial conditions. These changes affect financial institutions in at least two main ways. One is through the balance sheet, and the other is through the income statement (Bednar and Elamin, 2014).

First, the interest rate risk allocation (i.e., who bears the risk) affects monetary policy transmission. If banks take interest rate risk, changes in interest rates affect bank net worth and, ultimately, the supply of loans via the bank balance sheet channel (Bernanke and Gertler, 1995; Jim#nez et al., 2012).

The balance sheet is affected when rising interest rates alter the value of liabilities and assets and reduce the bank's net worth. Because of their differing maturities, an interest rate spike would affect bank assets and liabilities differently. For example, when assets lose value while the liabilities keep theirs, the net worth of the bank drops. In the end, this drop affects the bank's capital levels.

Therefore, some of the banks' assets are affected by market interest rates, declining in value when market interest rates go up. When this happens, it shrinks the capital banks have in hand to absorb losses on their market-priced assets. However, the interest rate risk affects not all bank assets (Bednar and Elamin, 2014).

In Rwanda, loans have been the primary income-earning activity with the highest share on the assets side of all bank balance sheets (Ntirushwamaboko et al., 2021). Deposits dominate the other side of the balance sheet (see appendix A and

B). In fact, changes in the lending rate potentially alter the value of the banks' assets and eventually the banks' net worth. Similarly, the spike in deposit rates will likely affect the value of banks' liabilities. Since banks use short-term deposits whose rates change after maturity to finance loans with longer maturity and a fixed rate, the earnings from loans are pretty limited. However, an interest rate spike may have differential effects on banks' assets and liabilities since they bear distinctive maturities

The primary motivation of this paper is based on the fact that the banking system in Rwanda is prone to interest rate risk emerging from different sources. The paper thus focuses on assessing the effect of interest rate risk on the financial sector, particularly on the banks' balance sheets in Rwanda. This paper sheds light on the interest rates that can potentially disrupt the value of assets and liabilities and, ultimately, the net worth of the banks. Understanding this risk aims to inform financial regulation and ensure appropriate monitoring of interest rate risks build-up to enable timely actions to protect the financial system.

The remainder of this paper is organized as follows, after the introduction; a review of relevant literature is presented in section 2. Section 3 discusses the interest rate risk in Rwandan financial system. Section 4 presents the research methodology, Section 5 presents the results before it ends with conclusion in section 6.

2. LITERATURE REVIEW

The Basel Committee on Banking Supervision (2004) points out several possible ways to define and measure interest rate risks. For supervisory purposes, the Committee suggests estimating the level of interest rate risk for exposures in G10 currencies by the decline of a bank's economic value with its regulatory capital following a standardized interest rate shock. An upward and downward 200 basis points parallel movement of the term structure gives this shock. A number of techniques are available for measuring the interest rate risk exposure of both earnings and economic value. Their complexity ranges from simple calculations to static simulations using current holdings to highly sophisticated dynamic modeling techniques that reflect potential business activities.

Many policymakers have raised concerns about the current levels of interest rate risk in the financial system. Governor Jeremy Stein of the Federal Reserve Board recently warned that a prolonged period of low-interest rates, of the sort we are experiencing today, can create incentives for agents to take on greater duration risk (Stein, 2013). Data unavailability was seen as a significant limitation in empirical work since measuring the effective maturities of assets and liabilities and exposures from derivatives is often impossible from public data. To overcome these limitations, several papers use market data to document negative stock price reactions to surprise increases in interest rates (Flannery & James, 1984; English et al., 2018; Ampudia & Van Den Heuvel, 2017). This result is consistent with the traditional view of banks as maturity transformers. Begenau et al. (2015) document significant exposures of U.S. banks to interest rates using a factor model estimated from public balance sheet data. Gomez et al. (2016) show that bank' exposures to interest rate risk affect monetary policy transmission using data on short-term assets and liabilities.

Hellwig (1994) questions the view that banks necessarily bear interest rate risk. In a Diamond-Dybvig model with aggregate risk, he shows that the optimal contract is such that banks are fully insulated from changes in interest rates. They take variable-rate deposits and make variable-rate loans. More recently, Drechsler et al. (2018) show that frictions in the deposit market enable banks to engage in maturity transformation without being exposed to interest rate risk. Banks' market power results in limited pass-through of market rates to deposit rates so that deposits effectively behave like long-term fixed-rate liabilities. Consequently, holding long-term fixed-rate assets is a way for banks to hedge rather than taking the risk.

Consistent with this view, the net interest margins of U.S. banks have been stable over time, despite significant swings in interest rates (Hoffmann et al., 2018). This matching view is supported by Kirti (2017), who shows that banks with more floating-rate liabilities tend to extend more floating-rate loans.

The major source of interest rate risk in the banking book, namely maturity mismatch or, more precisely, the repricing mismatch, was highlighted in the literature. According to banks, interest rate risk is the most significant source of market risk for commercial banks (IFRI-CRO, 2007). Hence, after credit risks it is

the second most important source of risk for the capital adequacy of these institutions. Banks and regulators are aware of the importance of both risks. But because of the limited availability of appropriate models, they tend to manage these risks separately even though, as Jarrow and Turnbull (2000) point out, economic theory tells us that market and credit risk are intrinsically related to each other and not separable.

Because there is still no standardized access to banks' internally quantified interest rate risk, most models proposed in the literature and applied by banking supervisors rely on accounting-based data. These include Bennett et al. (1986), Planta (1989), Patnaik and Shah (2004), and the Federal Reserve's Economic Value Model (EVM) presented by Houpt and Embersit (1991) and analyzed by Wright and Houpt (1996), and Sierra and Yeager (2004), as well as the standardized framework suggested by the Basel Committee on Banking Supervision (BCBS, 2004).

Several perspectives for assessing interest rate risk exposure are grouped in three perspectives (Ngalawa and Ngare, 2014): (1) the earnings perspective, also known as the traditional approach, which focuses on the analysis of the impact of a change in the interest rate on accrual or reported earnings of banks; (2) the economic value perspective, which reflects the sensitivity of the net worth of the banking institution to fluctuations in interest rates; and, (3) the embedded losses perspective that evaluates the level of interest rate risk a banking institution is willing and able to assume, it considers the impact that past interest rates may have on future performance.

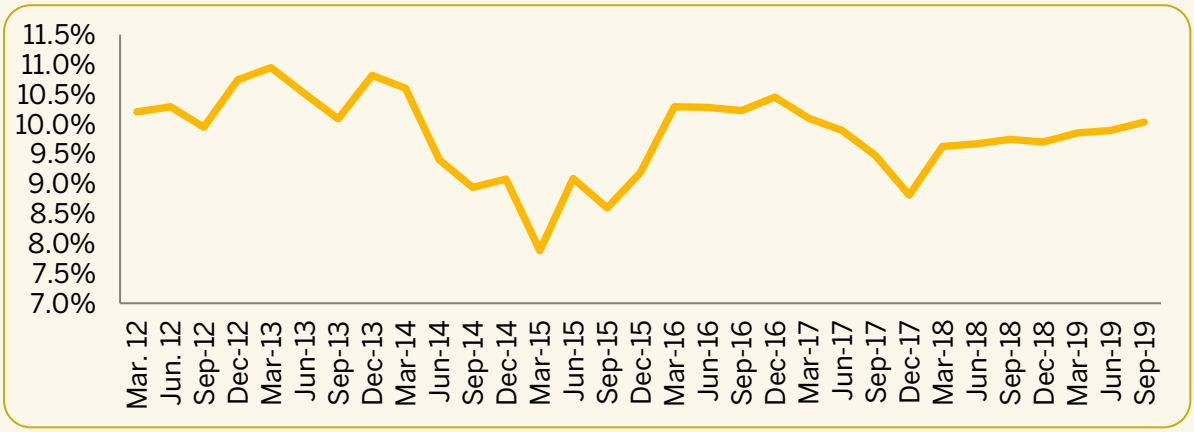
Our paper is inclined towards the economic perspective, which asserts the assessment of the impact of both lending and deposit rate fluctuations on the net worth of the financial system in Rwanda. Since the economic value perspective considers the potential impact of interest rate changes on the present value of all future cash flows, it provides a more comprehensive view of the possible long-term effects of changes in interest rates than offered by the earnings perspective (Ngalawa and Ngare, 2014).

3. INTEREST RATE RISK IN RWANDA'S FINANCIAL SYSTEM

Several indicators support the conventional wisdom that interest rate risk does not pose a significant threat to the commercial banking system. Most notably, the stability of commercial bank net interest margins (NIM) as the proxy of bank's profitability and growth: NIM (the ratio of net interest income to average assets) lends credence to this conclusion. However, the banking system in Rwanda has shown that their net interest margins fluctuate along the period under consideration. Particularly, NIM outstandingly shows three incredible lows in the period of March 2015, September 2015 and December 2017 as broadly highlighted in Chart 3.1.

Net Interest margins, however, offer only a partial view of interest rate risk. They may not reveal longer-term exposures that could cause losses to a bank if the volatility of rates increased or if market rates spiked sharply and remained at high levels. They also say little about the potential for changing interest rates to reduce the ''economic'' or ''fair'' value of a bank's holdings. Economic or fair values represent the present value of all future cash flows of a bank's current holdings of assets, liabilities, and off-balance- sheet instruments. Therefore, approaches focusing on the sensitivity of an institution's economic value involve assessing the effect a rate change has on the present value of its on and off-balance-sheet instruments and whether such changes would increase or decrease the institution's net worth. Given this gap of net interest margin, we extend the analysis of interest rate risk in the financial system by using an econometric model, which considers the effect of changes in market rates on a bank's net worth.

Chart 3.1: Net interest margin (NIM)

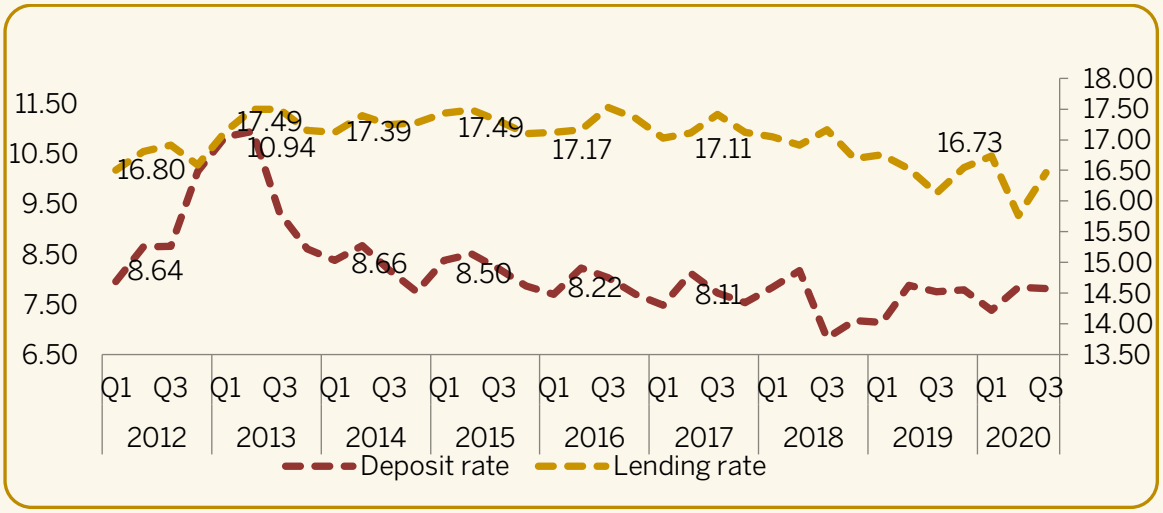


Source: Author's calculation

Chart 3.2 describes a more or less stable lending rate with slight upward and downward trend along the sample period. An upward trend of weighted average lending rate from 2012 until the end of 2013 and after reveals relatively stable fluctuations stretching up to 2018Q3 and then gradually declined. Similarly, the weighted average deposit rate in the banking system presents remarkable volatility in the first two years up to 2014; afterward, it shows a slight wavering, with an exceptional drop in 2018Q3. Deposit rates, among other costs of funds for banks, have not significantly eased, which is linked to the higher negotiation power of big depositors, predominantly corporate institutions, thus making the lending rate stuck at a higher rate.

The volatility of market rates in the banking system caught our attention and thus needs to be explored since their variability triggers changes in the net present value of a bank's net worth.

Chart 3.2: Market interest rates



Source: Author's calculation

4. RESEARCH METHODOLOGY

Panel data of the banking system were analyzed to gauge the effect of interest rates volatility in the banks' financial condition represented by the net worth of the financial system in our model. Banks are heterogeneous and distinct in terms of pricing lending rates on the loans. The cost of deposits depends on the characteristics of depositors, which behave differently in the banking sector. We apply a static panel data model that relates a bank's net worth to interest rate risk exposure, specifically market rates. Given that bank-specific effects[10] may be correlated with explanatory variables and probable omitted bias effect, the random effect model is not consistent, as confirmed by the Hausman test. Therefore, this paper uses the fixed effect model as the appropriate approach to control for unobserved heterogeneity, such as the bank's pricing model in the banking sector.

[10] The example is the bank-specific price lending rate.

4.1. The model and variables of interest

The fixed effects panel data model is presented as follows:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \alpha_i + \mu_{it}$$

Y_{it} stands for Total Assets (TA), Total Liabilities (TL), and Net worth (TA-TL), respectively, as presented in Table 3. These explained variables are scaled in logarithmic form. While X_{it} is a 1×k vector of explanatory variables. Our model considers the bank's specific lending rate and deposit rate as the only independent variables, consistent with most of the literature on the subject matter. We also include the individual-specific intercepts in the model as α_i , i =1,...,n, The α_i are bank-specific intercepts that capture heterogeneities across the banking system. In addition, μ_{it} represents the error term.

The fixed effects estimator is equivalent to demeaning all of the dependent and independent variables with respect to the group and then estimating the model using OLS. Demeaned OLS algorithm in R programming, which is computationally more efficient than estimating regression models with k+n regressors (i.e., the Least-squares dummy variable model), is preferably used. After demeaning the data, there is no need to estimate n-1 dummies and an intercept. The demeaned OLS model can be stated as follows:

$$\tilde{Y}_{it} = \beta_0 + \beta_1 \tilde{X}_{it} + \tilde{\mu}_{it}$$

Using these variables, we estimate the changes in the net worth of the financial system given the volatility in interest rates. In addition, it is essential to highlight the sensitivity of both Total Assets and Total Liabilities in the banking system, given changes in market interest rates in separate models.

The choice of variables follows an economic perspective in assessing interest rate risk in the financial system (Ngalawa and Ngare, 2014). The stated perspective assesses the impact of both lending and deposit rate fluctuations on the net worth of the financial system. Thus, this paper covers data of chosen variables from 10 licensed commercial banks with available data from 2012Q1 until 2019Q2.

5. RESULTS

5.1. Descriptive statistics

Table 1 below depicts the characteristics of the variables observed in the dataset. The common feature in all the variables is the heterogeneity in cross-sectional observations, which is confirmed by standard deviation statistics. The average deposit rate (ADR) reflects the average rate at different maturity in a given bank. This ADR noticeably reveals high variability compared to the other variables under study, which is reasonable since depositors are different across the banks. Again variability in Average Lending Rate (ALR) expresses that banks have not only different loan pricing mechanisms/models but also distinctive rates respective to the size of the loan or the maturity (short-term, medium-term, or long-term). In addition, total assets, total liabilities, and Net worth (Total assets less total liabilities) expressed in logarithmic form as Log TA, LogTL, and Log(TA-TL), respectively, reveal more or less a lower variability compared to other variables.

Table 1: Summary statistics[11]

Variables	Obs	Mean	Std.Dev	Min	Max
Log TA	300	18.54	0.97	15.88	20.59
LogTL	300	18.36	1.00	15.66	20.42
Log(TA-TL)	300	16.65	0.90	14.26	18.99
ALR	300	17.16	1.28	14.40	22.00
ADL	295	7.6	2.15	3.0	14.4

Source: Authors' computations

[11] For Deposit rate, five observations were missing in the data set

5.2 Regression analysis

Since the random effects approach has a significant drawback, which arises from the fact that it is valid only when the composite error term $\omega_{i,t}$ is uncorrelated with all of the explanatory variables. This assumption is more rigid than the corresponding one in the case of the fixed effects. This can also be viewed as a consideration of whether any unobserved omitted variables that were allowed for by having different intercepts for each entity are uncorrelated with the included explanatory variables. A random-effects approach can be used; otherwise, the fixed effects model is preferable. A test for whether this assumption is valid for the random effects estimator is based on a slightly more complex version of the Hausman test.

The Hausman test affirms that the fixed-effects model is appropriate and consistent, as evidenced by (table 2).

Table 2: Hausman test results

	Statistic	Degree of Freedom	P-value
Chi square	6.3805	3	0.0945*

* $p < 0.1$,

Source: Authors' estimations from R Programming

Table 3 presents the results of the three fixed-effects models. Column 1 gives the model results, focusing on explicitly examining the effect of the lending rate and deposit rate on total assets in the banking system. The results from the model highlight that an increase in the lending rate has a negative statistically significant effect on the value of assets. These findings are consistent with the literature such as (Bednar and Elamin, 2014). It is noteworthy to mention that the spike in lending rate would pose a high risk to the value of assets. On the other hand, changes in

deposit rates do not significantly affect the value of assets. Subsequently, the lagged values of assets show a persistent effect in the model.

Similarly, in columns 2 and 3, the findings arrive at the same conclusion mentioned in the previous paragraph on the effect of lagged values. However, one can note that the increase in the lending rate reduces the value of total liabilities more than it does to the value of total assets (see columns 1 and 2). On the other hand, increments in the deposit rate positively affect the value of total liabilities in the banking system (column 2).

Finally, the last model (column 3) reveals that the net worth of the financial system is riskier and more exposed to the upswing in deposit rates but not the lending rate. An increase in the deposit rates significantly shrinks the bank's financial conditions and, ultimately, the capital level of the banking system in Rwanda.

In fact, when interest rates change, these differences can give rise to unexpected changes in the cash flows and earnings spread between assets, liabilities, and off-balance sheet instruments of similar maturities or repricing frequencies.

For instance, a bank that funded a long-term fixed-rate loan with a short-term deposit could face a decline in both the future income arising from the position and its underlying value if interest rates increase. These declines arise because the cash flows on loan are fixed over its lifetime, while the interest paid on the funding is variable and increases after the short-term deposit mature.

Table 3: Regression results

	Dependent variables		
	(1)	(2)	(3)
Independent variables	**Log (TA)**	**Log(TL)**	**Log(TA-TL)**
Log (Y_{t-1})	0.964***	0.951***	0.950***
	(74.1)	(67.92)	(45.2)
ADR	0.005	0.007***	-0.011**
	(1.66)	(2.33)	(-2.75)
ALR	-0.016**	-0.029***	0.012
	(2.66)	(4.14)	(1.23)
N	287	295	287
R2	0.958		0.903
R2 Adjusted	0.957		0.899
F-statistic	2,100.459***		852.557***

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

6. CONCLUSION

The results show a significant risk of the market rates on the balance sheet of the Rwandan financial system.

This study sought to establish the exposure to interest rate risk among commercial banks in Rwanda. From the available data of 10 commercial banks, we have found that a 1 percent positive change in the deposit rate would result in a decline of net worth equivalent to 1.1 percent.[12]

Generally, most of the papers document a significant negative relationship between interest rate movements and bank's capital. This result has been mainly attributed to the typical maturity mismatch between banks' assets and liabilities. Banks usually are exposed to a positive duration gap because the average duration of their assets exceeds the average duration of their liabilities. Thus, the net interest income and the bank value are negatively affected by rising interest rates.

The present paper highlights the interest rates that highly affect a bank's net worth and has the policy implication that understanding this risk informs the financial regulators to ensure appropriate monitoring of interest risks build-up and take timely actions to protect the financial system. The approach used in this paper serves a significant role in evaluating interest rate risk in the banking system as much as traditional accounting approaches, which are primarily used in measuring this risk.

In this paper, we have mainly focused on exploring the effect of market-rate volatility on banks' net worth using an econometric model, particularly the panel fixed-effects model. However, further research is needed using other methods capable of utilizing granular data such as market rates at different maturity, the value of deposits, and the value of loans, to mention a few.

[12] Model 3, which is log-level model (log net worth and market rates at level), the slope -0.011 is interpreted as 100 *(-0.011): -1.1 which is the **semi-elasticity** of net worth with respect to deposit rate. In other words, one percent increase in deposit rate will result in a decline of net worth by 1.1 percent.

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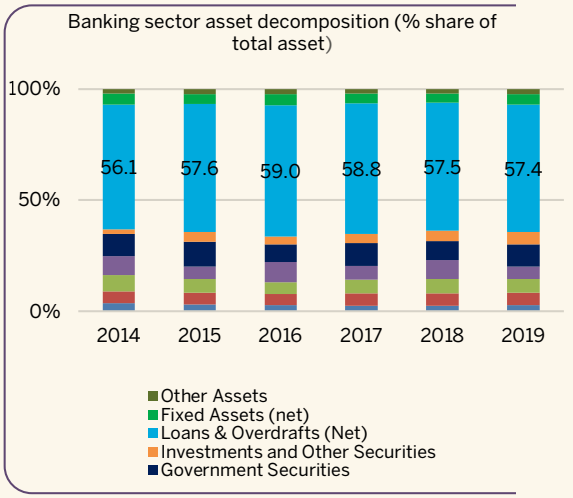
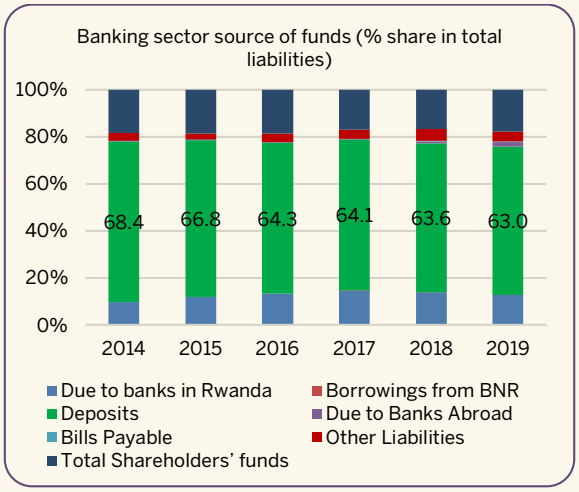
Appendices

Appendix A: Banking sector assets decomposition



Appendix B: Banking sector source of funds



FINANCIAL DEVELOPMENT AND ECONOMIC GROWTH: THE CASE OF RWANDA

Priscille Mikebanyi[13]

Thomas Rusuhuzwa Kigabo[14]

[13] Economist, Monetary Policy Department, National Bank of Rwanda

[14] Chief Economist and Executive Director, Monetary Policy and Research Directorate, National Bank of Rwanda

ABSTRACT

The link between financial development and economic growth has been assessed by many studies on either groups of countries or individual countries which have come up with conclusions reflecting mainly four schools of thought linking the two: the supply-leading phenomenon; the demand-following phenomenon; bidirectional causation between the two; or no/negative association between the two. This study explores this literature and tries to analyze where Rwanda falls in these theories. It uses a recently constructed financial development measure (FD index) that combines many dimensions of financial system development; access, depth and efficiency of both financial intermediaries and financial markets, which is extensively broader than traditional indicators used in the majority of previous studies. The study has employed the augmented Granger non-causality test suggested by Toda and Yamamoto to assess the link between finance and growth, if any, for the years 1980 to 2018. The results suggest that, for Rwanda, the link is described by the demand-following theory, particularly driven by financial institutions. On the other hand, the financial markets and traditional indicators have a bi-directional relationship with economic growth. These findings are important for further research on financial institutions and highlight the importance of nurturing the financial markets so as to drive growth.

Key Words: Economic Growth, Financial Development, Rwanda

JEL Classification: E44, G10, G20, 016

1. INTRODUCTION

Policy makers and economists worldwide have been and are still seeking dynamic areas, which can foster economic growth and sustain it. This search will go on as new ideas are needed to fit the changing world context. Financial development has been one of these ideas that has been highly debated and studied, especially on its contribution to economic growth.

The financial system's functions, as outlined by several studies such as those of Levine (1997), Ang (2008) and Haan et. al (2015), are pooling resources from economic agents with surplus and distributing them in a selective process to those who need them but will leverage on them, facilitating trading and diversifying risk portfolios and enabling corporate control for better performance of firms. In delivering its functions, the financial system reduces information and transaction costs that would otherwise limit how resources would be distributed among different agents. Financial development is therefore described by the World Bank (2020) as the increased efficiency that reflects reduced costs of a country's financial system in delivering these functions and can be classified into increased access, depth, efficiency and stability of the financial system.

The debate has been on whether the progress of the financial system drives/accelerates economic growth as it conducts its primary role of resource allocation. The mostly discussed channel is through its effect on capital accumulation and increased innovation, which are the factors of production for long-term growth according to the Solow model growth theory (Levine, 1997; Ang, 2008; Haan et al, 2015).

Several schools of thought have come up in empirical assessments of the relationship between financial development and economic growth. One school of thought, which is the most popular, is that financial development drives economic growth (supply leading hypothesis), for example Levine (1997), Khan and Senhadji (2000) and Apergis et al (2007). The second school of thought is that economic growth drives the need for a more developed financial system i.e. the demand-following hypothesis (Hossain et al, 2017; Noor et al, 2017). The third school of thought is that they both cause each other (Calderon and Liu, 1999; Okello et al, 2015). The fourth school of thought is that there is no significant relationship between finance and growth or that its growth is detrimental to economic growth (Acarvi et al, 2009; Hashim, 2011;

Effiong, 2015). Many studies have focused on analyzing this theory on groups of countries, whose results and conclusions have many important policy implications for similar countries. However, it is paramount to conduct country level studies considering countries' economic, political, institutional and geographic uniqueness; as these and other characteristics may steer a country's reaction to a certain policy in a different direction from the expected/norm.

In a similar vein, this study extends this analysis to Rwanda's context, considering the high average GDP growth it has recorded in the last 2 decades of about 8%. Rwanda has also made strides in financial system development where, for most of the past, it was bank-based, but more recently, other financial institutions and financial markets have been growing and supplementing the banks' role of intermediating between economic agents with excess resources to those with a resource gap. Do these two analogous developments have anything to do with each other?

This study first conducts an extensive review of literature on the finance and growth relationship both on country-level and on groups of countries and then conducts an empirical case study on Rwanda. It uses the financial development index as the main decision variable as it represents the multifaceted nature of financial development i.e. access, depth and efficiency of either financial institutions or financial markets, using 20 variables that have been aggregated into one (Svirydzenka, 2016). It also analyses which dimension drives the overall relationship between the index and growth. The results are then compared with traditional indicators. It is the first study that uses the financial development index and its subcomponents for a country-level study to the best of our knowledge and it analyses a longer period than previous studies on Rwanda. Existing studies, including those on Rwanda by Kigabo et al (2015), Okello et al (2015) Karangwa and Gichondo (2016), Gisanabagabo and Ngalawa (2016), Nyalihama and Kamanzi (2019) have used indicators that represent mostly one dimension of finance and in most cases, financial depth of financial institutions. A more common finding in these studies is that the finance-growth nexus in Rwanda is defined by the bi-directional theory.

In order to decipher which school of thought/direction of causality between finance and growth in the Rwandan context, the study adopts the Toda-Yamamoto Granger Causality Test. The results point to the demand-following theory i.e. economic growth precedes financial development and this is driven mostly by financial institution

depth. The financial institution efficiency, financial market depth and the traditional indicators have a bidirectional relationship with growth, which offset a little the growth to finance relationship but not enough to reverse the causal direction of the aggregate index.

The rest of the paper is organized as follows: Section 2 surveys the literature on financial system's role and the link of its development to economic growth, Section 3 analyses financial development in Rwanda, Section 4 describes the variables and model specification in Rwanda's analysis, Section 5 presents the results and Section 6 concludes and discusses some policy implications.

2. LITERATURE REVIEW

2.1. The role of the financial system

Many authors including Levine (1997), Ang (2008) and Haan et al (2015), detail the theoretical background on how financial development and economic growth are related by analyzing how efficiency in conducting each financial system's function plays a role in an economy's growth.

Regarding risk amelioration, the financial system reduces liquidity risk by making it easy to transfer and sell off or get back savings from assets such as equity, bonds and demand deposits through reduced information and trading costs. High-return projects, which are more beneficial for the economy's growth, more often need long-term commitment of funds. When savers are assured that they can easily recover their savings from long-term commitments when needed, they are more likely to make long-term investments. In this sense, the function of reducing risk enables an economy to shift to long-term, normally illiquid, investments. Higher returns would lead to more capital accumulation and if the long-term commitment is in research and development, they would promote technological innovation.

The authors also show that the financial system's role of reallocation of resources reduces transaction costs that savers would face e.g. in terms of searching for the best investment opportunities/projects. They may not have the time nor the skills to correctly assess this. Financial institutions' task of acquiring information from borrowers usually reduces this information gap for savers on the aggregate level by finding the higher potential production technologies and entrepreneurs, therefore

enabling savers to invest in projects with little information but high returns in addition to making them feel safe to let go of their money into the intermediaries. Economic agents in need of money for investment will then benefit from the reduced cost and time to pool funds from different savers. Through selection of entrepreneurs with the highest potential as well as production capacities, capital accumulation and innovation will be promoted.

The other financial system function, exerting corporate control, as described by Levine (1997), Ang (2008) and Haan et al(2015), is achieved by collateral, financial contracts and other arrangements enforced by the financial system that ensure that managers run the firm in ways that will bring maximum benefit to the owners or outside creditors. These arrangements encourage investment by reducing the uncertainty of how the funded projects/firms are being run. Another way is through separating ownership from management of the firm which will reduce the monitoring cost for savers. How this works is that instead of many savers monitoring projects, financial intermediaries take over this role and savers are assured of always earning interest from their deposits. This function also leads to reduced information asymmetry as by default, a long-term relationship is developed between the firms and the financial institutions. In terms of long-run growth, financial arrangements that improve corporate control tend to promote faster capital accumulation and growth by improving the allocation of capital.

2.2. The link between financial development and economic growth

Empirical studies on the relationship between financial development and economic growth have led to divergent conclusions, especially because of the use of different sample periods and countries, methodologies and measures of financial sector development.

Levine (1997) presents his findings in his earlier papers with King (1993 b &c), where they assess the relationship between financial sector development and economic growth using averaged cross-sectional data from 1960-1989 on 80 countries from all income levels. They use four variables representing financial development i.e. liquid assets/GDP, size of commercial bank credit vis a vis the total credit allocated by the banks and central bank because it is expected that commercial banks are better at providing the functions of the financial system, credit to private enterprises divided by the total credit and credit to private sector/GDP. They use three growth indicators

variables as the dependent variables i.e. GDP per capita, productivity growth and capital growth. They find that all financial developments indicators predict all growth indicators at both statistically and economically significant levels.

To further elaborate on the effect of the financial development and growth, Levine presents the findings from studies that tried to come up with measures of some financial functions and assesses their effect on growth. First, a study by Levine and Sara Zervos (1996) that uses total value of shares on the stock exchange on the GDP and turnover ratio of stock to assess the relationship between stock market liquidity and the three growth variables mentioned in the Levine and King (1993) study. The relationship is found to be positive and significant. A key control variable is the credit to the private sector used in order to separate the effect of stock market liquidity and other financial development aspects.

Second, Levine describes several studies that use firm level data to show that firms that suffer asymmetric information, whereby outside investors have difficulty monitoring them, are more sensitive to their cash flow. In addition, evidence from Japan, Italy and the U.S.A. shows that firms that have longer relationships with banks have less external finance constraints, pay less interest and are less likely to pledge collateral. Evidence also shows equity price rises of firms with records of bank loans. Hence, countries that effectively reduce liquidity constraints and information asymmetry promote faster growth.

Many other studies prove a positive and significant causal relationship from financial development to growth. Calderon and Liu (2002) use pooled data for 109 countries for the years between 1960 and 1994. They find a statistically bigger causal relationship for developing countries compared to developed countries meaning there is more room for financial development-driven growth for the former. The effect on developing countries is said to be channeled through mostly capital accumulation rather than productivity channel while the inverse is true for developed countries. The results are also stronger when longer term data is used, showing the graduality of the effect of financial development on the real sector.

Apergis et al (2007) find that financial development causally affects growth when they use panel data analysis methods on 65 OECD and non-OECD countries between 1975-2000 after confirming for heterogeneity across time and countries. Petrakos et al (2007) also imply the theory of heterogeneity in their findings from a survey

conducted among academia, private sector and public sector experts from all over the globe on their views about factors underlying economic dynamism. Different factors affect growth in different countries and to varying degrees hence, the difference in policy solutions adopted for each country. However, a lot of these policies are similar.

A study by Khan and Senhadji (2000) also finds a strong positive relationship between four financial development variables and growth when they use a cross section analysis of 159 countries between 1960-1999. The four indicators cover both banking system and market securities and are credit to private sector/GDP (fd1), fd1+ stock market capitalization/GDP (fd2), fd2+public and private bond market capitalization/GDP (fd3) and stock market capitalization. When the data is broken into a pooled time series cross-section form, the relationship becomes insignificant for fd2 and fd3. They explain that the weakened relationship might be because the three financial development indicators are not capturing the change in structures in a given period that would affect growth.

A country specific study on Rwanda by Kigabo et al (2015) using Johnsen co-integration test similarly finds that financial sector development, as measured by credit to private sector boosts economic growth. Likewise, Gisanabagabo and Ngalawa (2016) find that finance precedes growth in Rwanda and a shock particularly to credit to the private sector rather than liquidity creates more fluctuations in growth. Both of these studies use quarterly data from 2000 to 2014 and 1996 to 2010 respectively. Okello et al. (2015) also find that banking development positively affects Rwanda's economic growth. They use broad money/GDP, credit to the private sector/GDP and bank deposit liability/GDP for the banking sector development. However, the results differ for different variables when different tests are used i.e. the Johansen test proves a positive and significant effect when using credit to private sector and bank deposits while the money supply effect is significantly negative but the Granger test gives positive results for bank deposits and money supply. The Johansen test results by Okello et. al are similar to those of a study on Ghana by Adu et al (2013) that finds that financial development boosted growth between 1961-2010 in a statically and economically significant level, using the Autoregressive Distributed Lag (ARDL) model; but this applies when private sector credit share of total credit or as a share of GDP are used as proxies for financial development. When broad money is used instead, the relationship is significantly negative. Pautwoe & Piabuo (2017)'s

also conduct a country-specific study on Cameroun for the years 1980-2014 using an ARDL estimation and conclude that there is a positive long-run relationship between financial development and economic growth. Measures for financial development are the same as those used in the Okello et al. study.

The second theory of the nexus between financial development and economic growth is that economic growth drives financial development which has mixed views. The idea is that as the economy grows, there will be more demand for financial services by investors and savers hence the financial sector infrastructure services will be supplied in response to the new demand (Patrick, 1966). Levine (1997) tests to see if economic growth drives finance but concludes the opposite after finding that initial finance significantly predicts GDP per capita, productivity and capital growth. The results remain the same even when instrumental variables of the legal treatment of creditors are used as a representation of exogenous financial development in other studies. Both cross sectional and pooled cross section time series data also give similar results. A study by Hossain et al (2017) on Bangladesh however, has findings that contradict that of Levine, at least for the particular country. Hossain et al use a diverse set of financial indicators covering financial depth, access, efficiency and stability but compress them into two factors using the Factor Analysis technique and test their causality on economic growth using the Granger Causality test using data from 1988-2013. One of their findings is that economic growth actually drove financial development when measured by depth and stability. The validity of a growth to finance argument in Malaysia was not rejected by Noor et al. (2017) in their assessment of the relationship using an ARDL bounds test using data between 1960 and 2010 and credit to the private sector as their financial development measure.

The third school of thought is that there is a bidirectional relationship between finance and growth. Calderon and Liu (1999) find bidirectional causality but use "Gaweke decomposition test' to test which dependence is stronger. They find the dominating direction to be from financial development to growth as it explains at least 81% of the linear dependence between the two, using the sample of all countries. However, when the sample is broken into different country income levels, the linear dependence of economic growth on finance is stronger for developing countries but for developed countries, the dependence of finance on growth is stronger. Okello et al (2015) also find bidirectional causality in their Granger test when using Rwanda's credit to the private sector as a banking sector development indicator. Other studies

on Rwanda also find bidirectional causality e.g. Karangwa and Gichondo (2016) and Nyalihama and Kamanzi (2019) which both use Granger causality and Johansen cointegration in their analyses. However, Karangwa and Gichondo find a stronger relationship from growth to finance and this relationship is applicable to all sectors of the economy (agriculture, industry and services). They use quarterly credit and real GDP data from 2006 to 2015. On the other hand, Nyalihama and Kamanzi used a geometric mean of banking sector deposits of the current and previous quarters as a share of nominal GDP as the financial development measure and real GDP for economic growth, and assess the years 2006 and 2018 using quarterly data and find a stronger finance to growth link in the industry and services sectors.

Different authors have found a parabolic relationship between financial development and economic growth meaning finance has a positive effect on growth when financial development is low but its effect becomes negligible or negative at very high levels. When Khan and Senhadji (2000) test for non-linearity in their work, they find that indeed the second order term has a negative relationship on growth but they argue that it may have been caused by conditional convergence that was not captured by initial GDP per capita, which was one of their control variables. Arcand et al (2012) also find a non-linear relationship in their cross section and panel analyses when the financial sector exceeds 100% of GDP. It is argued that the cost of financial stability for such high levels of financial sector development exceeds the benefits and that there could be a reallocation of resources to sectors that either have lower returns which are less risky or sectors that feed speculative bubbles such as the housing sector which eventually have negative effects on economic growth. Cecchetti & Kharroubi (2012) find an inverted U-shaped relationship between finance and growth when they analyse 50 emerging and advanced countries. They use credit to private sector/GDP and the share of the financial sector employment over total employment (a financial sector input measure-but only for advanced countries due to data constraints) to measure the financial sector development and find positive effects on growth which becomes negative once the financial sector size exceeds the GDP. A study on finance-growth nexus for emerging economies by Sahay et al (2015), also concludes on a bell-shaped relationship when they use an aggregate financial development index that incorporates financial access, depth and efficiency; arguing that the negative effects from finance mostly come from too much depth rather than efficiency or access.

A number of studies have brought out evidence on the fourth school of thought; the aspect of no relationship or even a negative relationship between finance and economic growth. For instance, Acaravci et al (2009) found no long-run relationship between the two in their panel study that focused on Sub-Saharan Africa using a sample of 24 countries for the years 1975 to 2005. Effiong (2015) finds the same results for a panel of 21 Sub-saharan countries in the years 1986-2010. A study by Hashim (2011) using Spearman rank correlation on Nigeria also proves that there is no relationship between financial development, as proxied by eleven indicators that cover both financial intermediaries and financial stock markets, and economic growth from 2002-2006.

In their subsequent study, Cecchetti and Kharroubi (2015) suggest that the discussion should move from financial development level and economic growth to financial sector growth. They find that financial sector growth negatively affects real economic growth due to a crowding out effect on productivity using manufacturing industry data from 15 advanced OECD countries. Fast financial sector growth is argued to be detrimental to sectors that compete with the financial sector for skilled labour, which is assumed to be inelastically supplied. Since the finance sector is skill-intensive, and skill-intensive sectors are R&D intensive, growth of the financial sector harms R&D intensive industries, sectors that are said to be engines for growth. Therefore, financial sector growth favors low R&D industries. In addition, based on the assumption that "entrepreneurs with high productivity projects are less able to pledge future returns as collateral", exogenous financial sector growth (which is represented by lower transaction cost) is normally followed by strong developments in sectors such as construction where you can easily pledge collateral but whose productivity is low. This reduces the total productivity growth. Samargandi et al (2014) also find a negative long-run relationship between financial deepening and growth for 52 middle income countries. They test for nonlinearity as well and find that finance is detrimental to growth for upper middle-income countries beyond a certain threshold in the long-run and has no effect in the short run. They suggest that the financial sector size is beyond the socially optimal level for upper middle-income countries due to the marginal negative effects.

Along the same thinking, Griffith-Jones et. al (2016) say that the negative relationship between financial development levels and growth is not as relevant for African low-Income countries (LICs), as their financial sectors are still small. However, they raise

the concern that rapid financial sector growth that has been noted in African LICs can be detrimental to the economies if not accompanied by improvement in regulatory capacity or reduced exposure to external shocks, both of which are lacking in most African LICs. Some countries had credit to GDP growths of between 150% and 1550% between 2000-2010, on the back of the aforementioned features that increase their vulnerability to shocks. Nigeria is an example of a country which had a crisis despite its low financial development due to fast credit growth that was used to mostly purchase shares, especially in bank stocks, which led to price bubbles and a financial burst that was made worse by the North-Atlantic crisis. The authors warn that countries, which were not affected by the crisis, should be wary of complacency based on small financial sectors.

Other debates surrounding the relationship between financial development and economic growth are based on e.g. the differences between financial system structures and economic growth. Some argue that bank-based systems have bigger effects on growth and some defend market-based systems. Some say that they are complements. These arguments lie in how effective each structure is in providing the functions of the financial system (Haan et al, 2015). In their review of numerous studies, Valickova et al (2015) find that measures of financial development based on stock markets have a bigger growth effect hence imply a structural efficiency in market-based systems. Another discussion is on how institutional quality affects the relationship between financial development and economic growth. See studies by Effiong (2015) and Haan et al (2015).

Some authors have conducted surveys of studies on the effect of financial development and economic growth. To this end, Nor (2015) concludes that a positive causal relationship exists between financial development and economic growth. Valickova et al (2015) also conduct an empirical analysis on 1334 estimates for 67 studies and find that a strong positive relationship of financial development on growth. They also find varying results between regions due to heterogeneity and hence question the use of similar measures of financial development. The authors also find that their sample literature has no publication bias for particular results but heterogeneity in reported effects is driven by differences in research design. Ang (2008) suggests that despite more studies supporting a causal relationship between finance and economic growth, a generalization should be discouraged and more

country specific studies should be conducted due to the distinctive characteristics and policy environments of each country.

3. FINANCIAL DEVELOPMENTS IN RWANDA

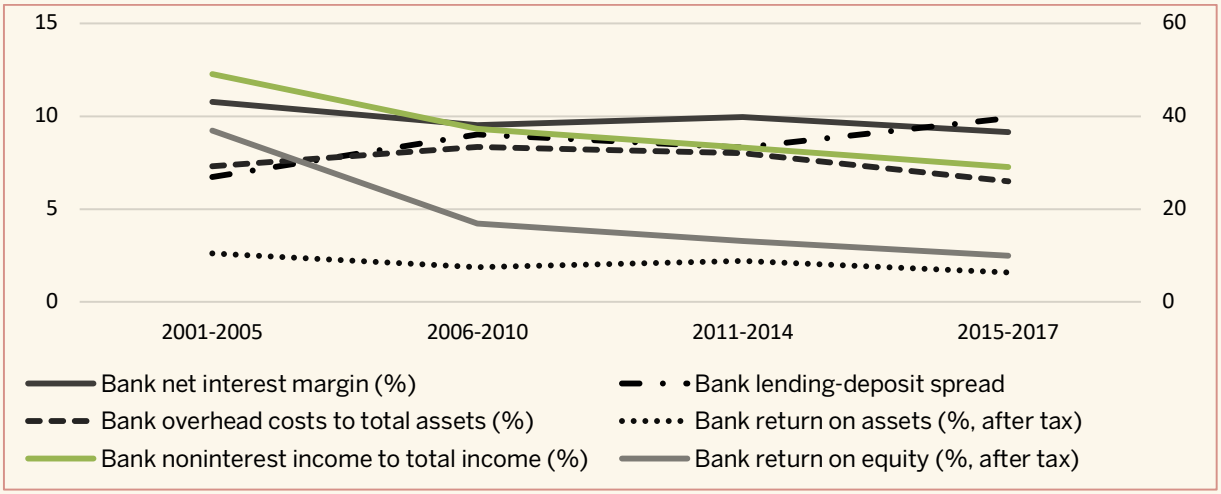
The financial system of Rwanda has evolved over time from being almost purely financial intermediary-based to more recently having a growing and relatively active financial market. Among the financial institutions/ intermediaries, as per June 2020, the banks had the largest assets of about 66%, followed by pensions schemes (17.2%), insurers, microfinance institutions (9.5%) and Non-Deposit Financial Institutions (0.5%). The share of the banking sector has however been gradually declining as the other sectors expand as it was much more in previous years. For instance, it had a share of 71% in 2010. These other sectors have supplemented the financial services by banks and even increased the dynamism of the credit to private sector portfolios, for instance, to the agricultural sector or the small and medium firms that had difficulties obtaining the same due to issues such as collateral (Kigabo, 2021).

The financial sector has also deepened over time as proven by several financial depth indicators. Credit to private sector ratio to GDP has increased from 4.0% in 1980 to 20.1% in 2019 while the ratios of aggregate money supply(M3) and financial system deposit liabilities have increased from to 12.4% to 26.3% and 6.6% to 23.9% respectively (World Bank, 2020 ; Kigabo 2021). Life and non-life insurance premium to GDP also grew from 0.42% in 2000 to 1.67% in 2014. (World Bank, 2020).

In terms of access to financial institutions, bank branches per 100,000 adults has increased from 0.4 in 2004 to 6.1 in 2017 while ATMS per 100,000 adults have increased from 0.04 to 5.6 in the same period (World Bank, 2020). Mobile money, which is used by 60% of adults, has played a key role in financial inclusion in Rwanda. It enables users to access some financial services such as sending/transferring and receiving money, paying bills, buying airtime and even borrowing. Only 23% of adults use it for non-transferring purposes. However, it is the most accessible of the financial system infrastructure because 87% of adults have access to a mobile phone and it takes the shortest time (18.78 minutes) to access a mobile money agent compared to agents to infrastructures of other institutions (SACCOs: 38.86 min, MFIs:41.16min, ATMs:41.21min, Bank branc:42.85min) (Finscope, 2020).

Regarding financial institution efficiency in terms of 'intermediating savings to investments', particularly the banking sector, the net interest margin rate, which is revenues on interest bearing assets divided by interest bearing assets, seems to be falling over time which indicates more efficiency while that of the lending deposit spread is fluctuating upwards which indicates less efficiency in intermediation (Figure 1). Operational efficiency as shown by the overhead costs to total assets and non-interest income to total income also seem to be falling which indicate more efficiency. Return on assets and return on equity, which are measures of profitability, have been respectively stable and declining, which does not show improvement in efficiency. Overall, different indicators point to different efficiency performances.

Figure 1: Financial institution efficiency indicators



Source: Global Financial Development Database

The Financial Market of Rwanda comprises the money market and capital markets which were established in 1997 and 2005 respectively. Instruments traded on the money market are open market operation instruments from the National Bank of Rwanda (NBR) and Treasury Bills that the government uses to borrow. The capital market comprises the stock and bond markets.

The bond market is composed only of government bonds, as the corporate bond market is not yet developed. Outstanding government bonds sold to the domestic market were about 8% of GDP in 2019 from 2.4% in 2017. This amount increased significantly in 2020 by 73% (Own calculation using NBR Statistics). Outstanding

international debt securities in 2017 was 4.5% of GDP from a European bond that was issued by the government in 2013.

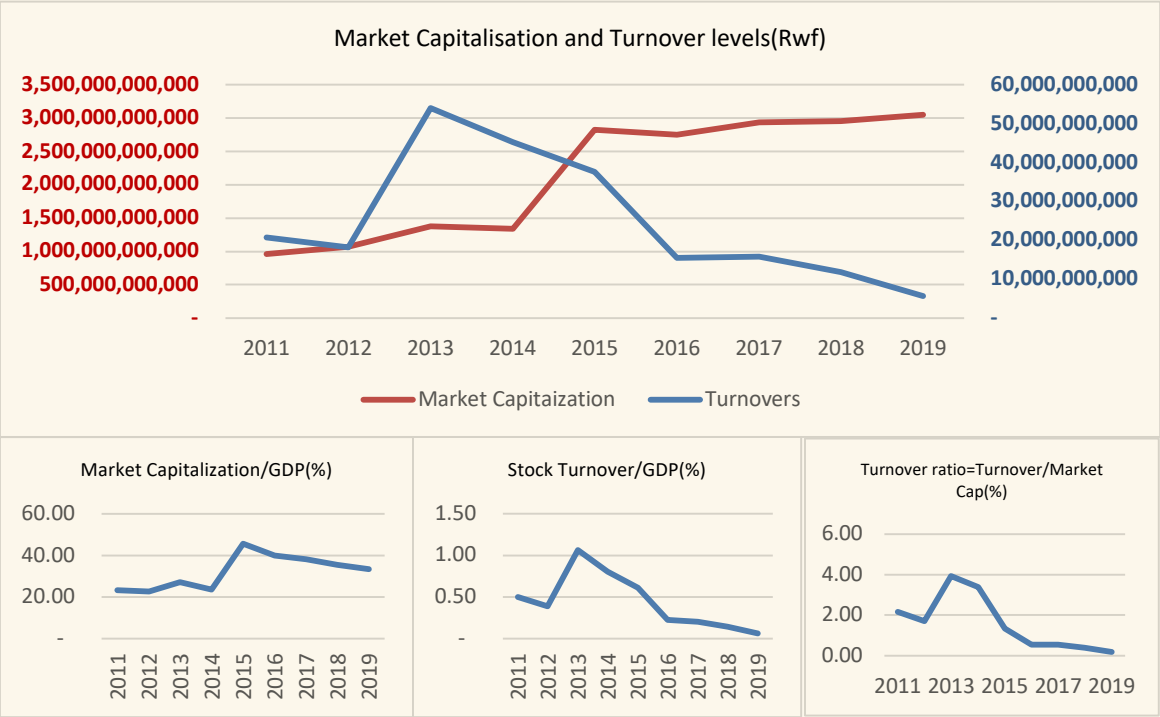
The stock market in Rwanda is still quite young, hardly 10 years old and small in absolute level when compared to other countries (Table 1). Rwanda stock exchange was officially launched in 2011 where it started with 3 listed or cross listed companies which have grown to a total of 10 companies in 2020. Therefore, in terms of access, only 10 companies can be financed through this market so far. Market capitalization, which is an indicator of financial market depth, has had an upward trend and has had an average of 32.16% of GDP between 2011 and 2019, which is not so low. However, the average sales of stock has been 0.44% of GDP and the stock turnover ratio, which indicates the financial market efficiency, was 1.58% in the same period and both have been declining over time. These are very low when compared to South Korea and the U.S. in the same period (see table 1 and figure 2). Rwanda's 2019 values on the stocks traded to GDP and turnover ratios are also lower than those of more comparable countries in terms of income level such as Kenya and Bangladesh.

Table 1: Stock market depth and access indicators

	Rwanda (2011-2019)	Korea (2011-2018)	U.S. (2011-2018)	Rwanda (2019)	Kenya (2019)	Bangladesh (2019)
Market capitalization of listed domestic companies (% of GDP)-right scale	32.2	87.8	138.2	33.48	26.2	28.2(2018)
Stocks traded, total value (% of GDP)	0.4	120.1	212.6	0.1	0.5	4.3
Stocks traded, turnover ratio of domestic shares (%)	1.6	138.0	150.8	0.2	1.9	20.4

Source: Own calculations using NBR statistics and World Bank Indicators

Figure 2: Stock market trends: Depth and efficiency



Source: Authors' own calculations using NBR statistics

4. MODEL AND VARIABLE SPECIFICATION

4.1. Model specification

With reference to the empirical studies mentioned above and other relevant literature, the relationship between financial development and economic growth can be summarized in the regression model below;

$$Y_t = \beta_0 + \beta_1 FD + \beta_2 FD^2 + \beta_3 X_t + e_t$$

Where Y_t represents the growth variable, which in most cases is GDP per capita, GDP per capita growth or their logs. β_0 represents the constant and e_t the error term. FD represents a financial development indicator, whose relationship with economic growth will be indicated by β_1 and β_2 while X_t, stands for control variables.

FD^2 has been introduced in more recent literature where it is argued that the relationship between financial development and economic growth is better represented with a quadratic function since it is non-linear. β_1 & β_2 then answer our main question of whether the relationship is causal, whether it is parabolic and whether it is positive.

4.2. Financial development variables

Many authors in earlier studies primarily used bank credit to the private sector and monetary aggregates (M2, M3) as indicators of Financial Development because of data availability; see Calderon & Liu (2002), Apergis et al (2007) and Arcand et al (2012), among others. M3 is described as a better measure than M2 because it includes a broader range of institutions (Apergis et al). Caldreon & Liu, Arcand et al, Khan, and Senhadji (2000) argue that credit to the private sector is a better measure of financial depth than monetary aggregates because it presents the actual funds that go into the private sector which are more efficiently used for investment. Monetary aggregates really just show the ability of the financial system to facilitate transactions rather than channel funds from savers to borrowers and that an economy can have low financial development but have high liquid liabilities to GDP.

Another indicator that has been used in literature for financial development depth is financial system value added which apparently has stronger results that support the hypothesis of financial development positively affecting growth (Levine, 1997). Deposit money bank assets divided by deposit money bank assets plus central bank assets (Moral-Benito & Allison, 2018) and deposit bank liabilities divided by GDP have also been used to represent financial development (Okello et al, 2015).

However, most of the above indicators only measure one aspect of financial development; depth and only that of financial intermediaries. Other authors have used measures that include the financial markets' development because of their great importance for the developed economies' financial systems and their rising importance in emerging and developing countries. Measures of other forms of financial development, i.e financial access and financial efficiency, have also been used in more recent studies.

Financial market measures for depth commonly used include stock market capitalization to GDP ratio or stock market value traded to GDP (Levine, 1997; Khan

and Senhadji, 2000; Levine and Zervos, 1996). This data is mostly available for advanced economies because of the uncommonness of the stock markets in developing countries.

Some studies have used measures that have combined both financial intermediary and financial market indicators and/or combined indicators representing financial system access, depth, efficiency and development. For instance, Khan and Senhadji (2000) have added stock capitalization, credit to private sector and public market bond capitalization to GDP ratio to cover both financial intermediaries and financial markets in one of their indicators. Hossain et al (2017), in an attempt to use all the dimensions of financial development, condensed six indicators into two factors using factor analysis, one for the efficiency/Accessibility dimension and the other for depth/stability. The original indicators were credit to the private sector (depth), market capitalization (depth), listed companies per million (access), interest rate spread (efficiency), stock market turnover ratio (efficiency), and Bank non-performing loans (stability).

Svirydzenka (2016) recently introduced a financial development measure that incorporates financial access, depth and efficiency for both financial markets and financial intermediaries in one index. The main reason is that the traditional indicators do not represent the vastness and dynamics of financial development. She uses an exhaustive set of 20 variables which she standardizes and aggregates into a few subindices by weighting them using principal component analysis and then finally aggregating them into one index, the financial development index. For financial institution depth, some indicators that she has used that are not common to literature are sizes of the pension fund, mutual fund and Insurance premiums. Arcand et al (2012) also incorporated the credit by non-bank institutions in their credit to private sector measures due to their general increasing importance in financial systems. For financial institution access, whose data was limited to banking access, Svirydzenka used a bank branch and ATM per 100,000 adults. Financial institution efficiency was represented by six indicators that covered operating, profitability and efficiency in intermediating savings to investment.

For financial market measures, five indicators for stock and debt securities sizes were used for depth while percentage of market capitalization out of the top 10 companies

and number of debt issuers were used for market access whereas the stock turnover ratio was used for efficiency.[15]

4.3. Control variables.

In order to avoid omitted variable bias, other explanatory variables that have been proven to have relationship with economic growth and financial development are included in the finance growth analysis model. For instance, the majority of studies have used initial GDP per capita to control for catch-up growth which means that lower income countries will have faster growths than higher income countries, according to the conditional convergence theory (Khan & Senhadji, 2000; Apergis et al, 2007). Another common control is the openness to trade which is believed to facilitate growth through quality imports, wider markets for exports, transfer of technology and know-how, among others (Billmeier & Nannicini, 2007; Apergis et al, 2007).

Government expenditure is also used as a control variable. It is argued that government spending's effect on growth depends on the type of spending. It however, causes a crowding-out effect on the economy's resources and it will use the resources less efficiently than the private sector and hence slow growth (Apergis et al, 2007). Diamond (1989) contends that government spending, on the aggregate, does not have an effect in the long run for developing countries including that of capital infrastructure expenditure which he even finds to be negative. He however finds social capital expenditure on health, housing and welfare and current expenditure on directly productive sectors to be positively linked to growth.

Most studies have also included proxy measures for capital stock and labor levels as they are fundamental drivers of growth according to the Solow growth model. The quality of labor i.e., human capital, has been measured using indicators such as average years of schooling, initial levels of human capital, average years of secondary schooling el ac. Indicators used for capital stock include initial physical capital, gross capital formation, output share of investment etc. (Moral-Benito and Allison, 2018; Beck, 2008; Apergis et al, 2007; Adu et al, 2013).

[15] See Annex 1 for more detailed explanation of the FD index construction

4.4. Data and variable specification

In this study, we use time series annual data from 1980 to 2018 for all variables.

To measure financial development, we use the financial development index (FD index-fd), extracted from the IMF database, as the main indicator as it represents many dimensions of financial development. We then analyze which particular dimension drives the relationship with economic growth in Rwanda's case using the FD index's subindices: financial institution index (fi), financial markets index (fm), financial institution depth (fid), financial institution access (fia) and financial institution efficiency (fie). We finally then compare the results with traditional indicators used in previous studies in Rwanda, particularly those used by Kigabo et al (2015) and Okello et al (2015) i.e. banking system deposit liability to GDP ratio(systdeposit), and credit to private sector to GDP ratio(priv_cred) and M3 to GDP ratio(M3). We extract data of the traditional indicators from the Global Financial Development Database in the World Bank Group.

To measure economic growth, we use log real GDP per capita growth (gdpna_gr). We chose per capita growth over real GDP due to its better indication of the citizen's welfare development than the overall GDP. Based on availability of data, we use the following controls; log population growth to represent labor (pop_gr), capital formation to GDP ratio to represent capital stock (capital), trade openness to GDP ratio (trade) and government consumption to GDP (gov_cons). Both economic growth and control variables' data are extracted from the Penn World Tables which uses 2011 constant values (Feenstra et al, 2015).

We do not include any quadratic functions as part of the explanatory variables for the financial development as Rwanda's financial development is still quite far from the levels suggested by studies that start becoming harmful to growth e.g. those previously mentioned in this study. For instance, Rwanda's credit to private sector ratio to GDP in the last five years in the data was about 20 percent while the turning point for this indicator has been said to be about 80 to 100 percent. The FD index indicator in the same period was 0.10, yet the study by Sahay et al (2015) finds the turning point to be between 0.4 and 0.7, across countries from all income-levels.

4.5. Methodology

This study has adopted the modified Granger causality test suggested by Toda and Yamamoto (TY) (1995) that uses an augmented Vector Autoregression model. This causality test is applied on the variable levels which reduces bias that would come with wrongly identifying their respective levels of integration and can be used on analyses of data which have different orders of integration, which is not the case for the Granger causality test. Another advantage over the Granger causality test is that it does not depend on pre-testing for cointegration which can be tedious and a cause for another bias when a wrong cointegrating relationships are identified. Finally, the F-statistic used in testing granger causality is not appropriate when the series are integrated or cointegrated as the test will not have standard distribution.(Muhammed et al, 2014; Umar and Bakar, 2015; Dristsaki, 2017).

The first step of our procedure is to assess whether the variables are stationary i.e., their variances and means are not dependent on time. This is assessed using graphs for visual analysis and the Augmented Dicky Fuller test where the null hypothesis is the presence of a unit root i.e. it is non-stationary. From this step, we shall note the maximum order of integration among the variables (i^{max}), which will be used in feeding the augmented VAR model.

The next step will be to estimate a VAR and select its optimal lag length (l). The selection will be aided by the Akaike Selection Criterion (AIC) and judgment of the lag that maintains the model's stability. We then estimate a ($l + i^{max}$)th order(k) VAR model, which is the augmented version, with the last lagged vectors being introduced as exogenous variables. The Wald procedure is then used to test the augmented VAR for causality. This Wald statistic will be valid as long as the order of the integration will not exceed the lag length of the VAR model. This will be applied to all financial development indicators.

The augmented VAR model for which the TY Granger test will be applied on is denoted as follows;

$$\left(gdpna_{gr}\ FD\ indicator\ capital\ \ pop_{gr}\ trade\ \ gov_{cons}\ \ \right) = (a_1\ a_2\ a_3\ \ a_4\ a_5\ \ a_6\ ) +$$

$$\left(\delta_{11,1..l}, \delta_{12,1..l}, \delta_{13,1..l}, \delta_{14,1..l}, \delta_{15,1..l}\delta_{16,1..l}\ \ \delta_{21,1..l}, \delta_{22,1..l}, \delta_{23,1..l}, \delta_{24,1..l}, \delta_{25,1..l}\delta_{26,1..l}\ \ \delta_{31,1..l}, \delta_{32,1..l}, \delta_{33,1..l}, \delta_{34,1..l}, \delta\right.$$

$$\left(\delta_{11,k}, \delta_{12,k}, \delta_{13,k}, \delta_{14,k}\delta_{15,k}\delta_{16,k}\ \ \delta_{21,k}, \delta_{22,k}, \delta_{23,k}, \delta_{24,k}\delta_{25,k}\delta_{26,k}\ \ \delta_{31,k}, \delta_{32,k}, \delta_{33,k}, \delta_{34,k}\delta_{35,k}\delta_{36,k}\ \ \delta_{41,k}, \delta_{42,k}, \delta_{4}\right.$$

$$+(e_1\ e_2\ e_3\ \ e_4\ e_5\ \ e_6\ )$$

An example of the results we would be interested for one of the financial development indicators, the fd index series, is as follows.

$$gdpna_{gr_t} = a_0 + \sum_{n=3}^{l} \delta_{1\ldots3} gdpna_{gr_{t-1\ldots t-3}} + \sum_{n=3}^{l} \phi_{1\ldots3} fd_{t-1\ldots t-3} + \sum_{n=3}^{l} \alpha_{1\ldots3} X_{t-1\ldots t-3} + \sum_{k=l+1=4}^{l+i^{max}} \delta_4 gdpna_{gr_{t-4}} + \sum_{k=l+1=4}^{l+i^{max}} \phi_4 fd_{t-4} + \sum_{k=l+1=4}^{l+i^{max}} \alpha_4 X_{t-4} + e_t$$

where $gdpna_{gr_t}$,fd_t,X_t, are the gdp per capita growth, financial development index and control variables respectively while the coefficients δ , ϕ and α denote the relationship of their lags with the dependent variable. The Granger Causality test is then run to determine the direction of causality, if any.

4. EMPIRICAL RESULTS

5.1 Unit root test results

The first step's results of assessing the stationarity in levels are presented in figures 3 &4. Graphically, the gdpna_gr which is our main dependent variable and pop_gr seem to be stationary. The other variables seem to have drifts or trends and therefore are potentially non-stationary.

Figure 3: Graphical rep. of variables

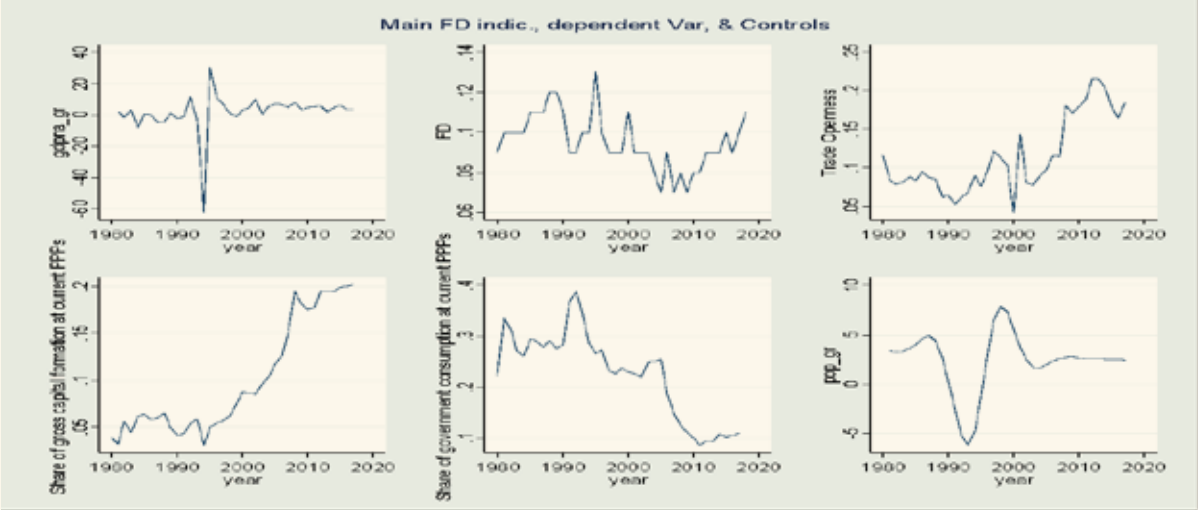
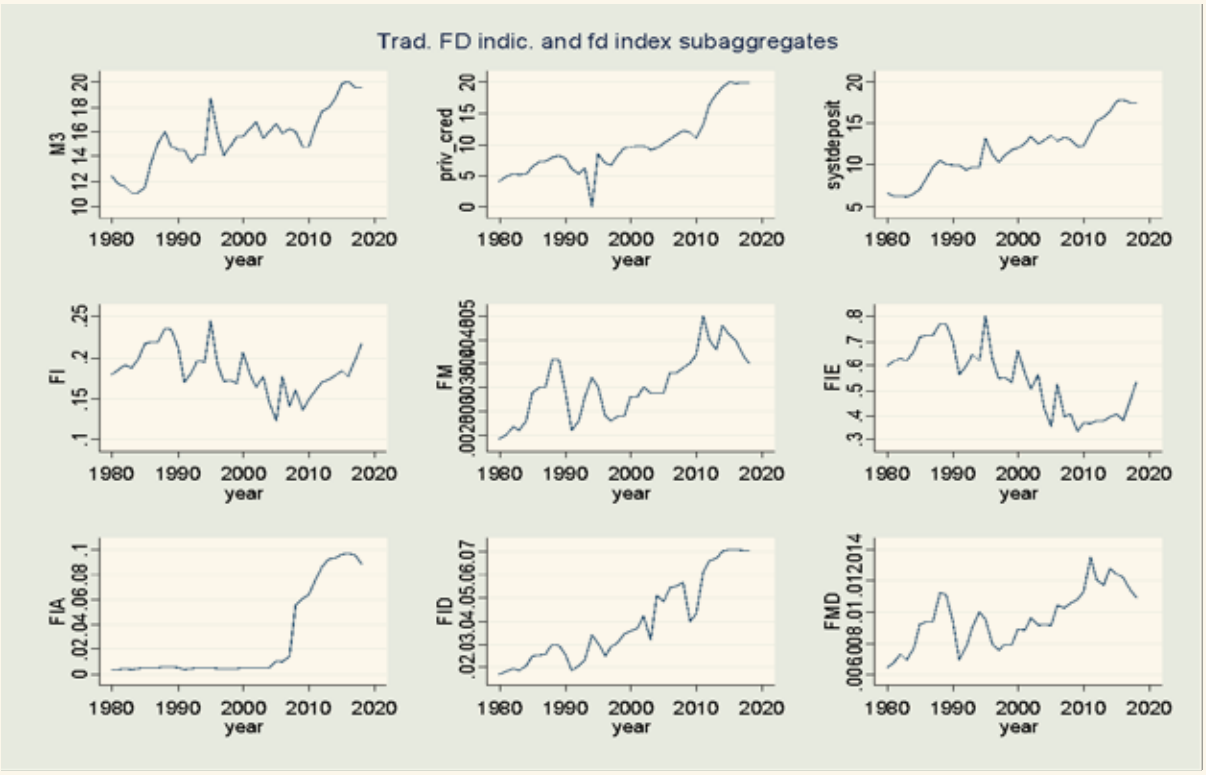


Figure 4: Graphical rep of variables



Source: Author's Calculations

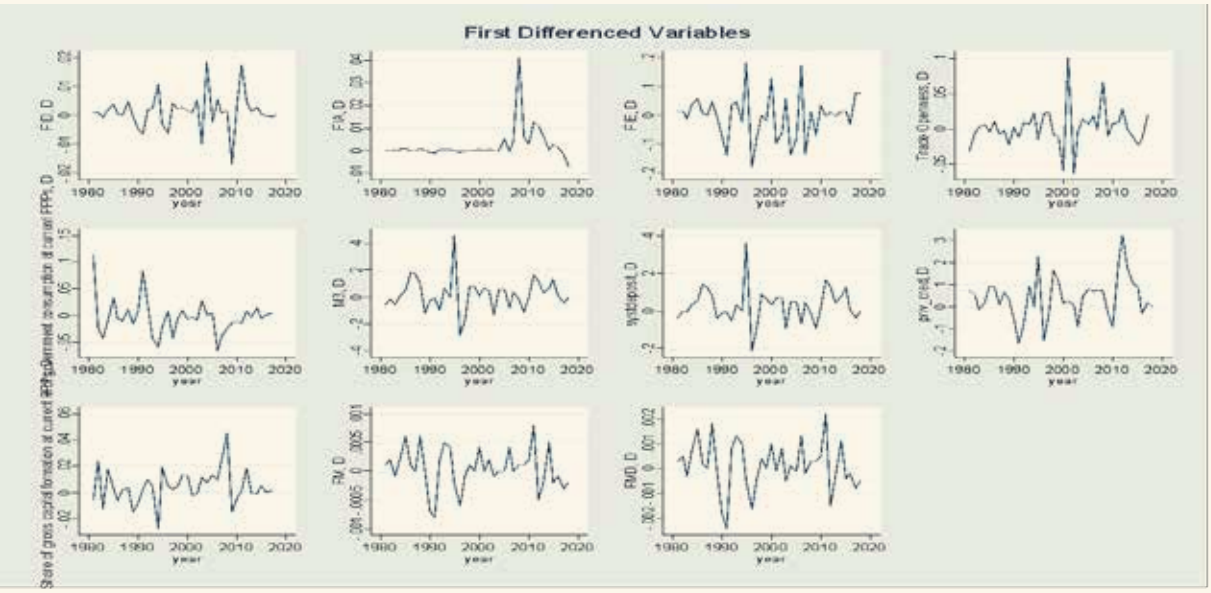
Using the Augmented Dicky Fuller Test, the unit root tests prove indeed that the gdpna_gr and pop-gr are stationary at levels i.e I(0) in addition to the fd index and fi subindex levels. The rest of the variables become stationary after the first differencing of the levels i.e I(1). This is then the highest order of integration,i^{max}(Table 1). The graphs of the differenced variables also reflect the same (figure 5)

Table 2: Unit root test results

ADF			
Variable	Level	First Difference	Order of Integration
	Test_Statistic		
FD	-1.984**	-	I(0)
fi	-1.913**	-	I(0)
fm	-3.139	-5.347***	I(1)
pop_gr	-8.526***	-	I(0)
gdpna_gr	-5.297***	-	I(0)
fmd	-3.099	-5.135***	I(1)
fid	-3.005	-5.776***	I(1)
fia	-1.395	-3.655***	I(1)
fie	-2.658	-5.654***	I(1)
trade	-2.227	-5.294***	I(1)
gov-cons	-1.226	-4.972***	I(1)
capital	0.069	-4.568***	I(1)
M3	-3.270	-5.315***	I(1)
systdeposit	-3.000	-5.106***	I(1)
priv_cred	-1.829	-4.460***	I(1)
*/**/*** indicates rejecting null hypothesis of unit root at 10%/5%/1% sig. levels respectively			

Source: Author's Calculations

Figure 5: Graphical view of differenced variables

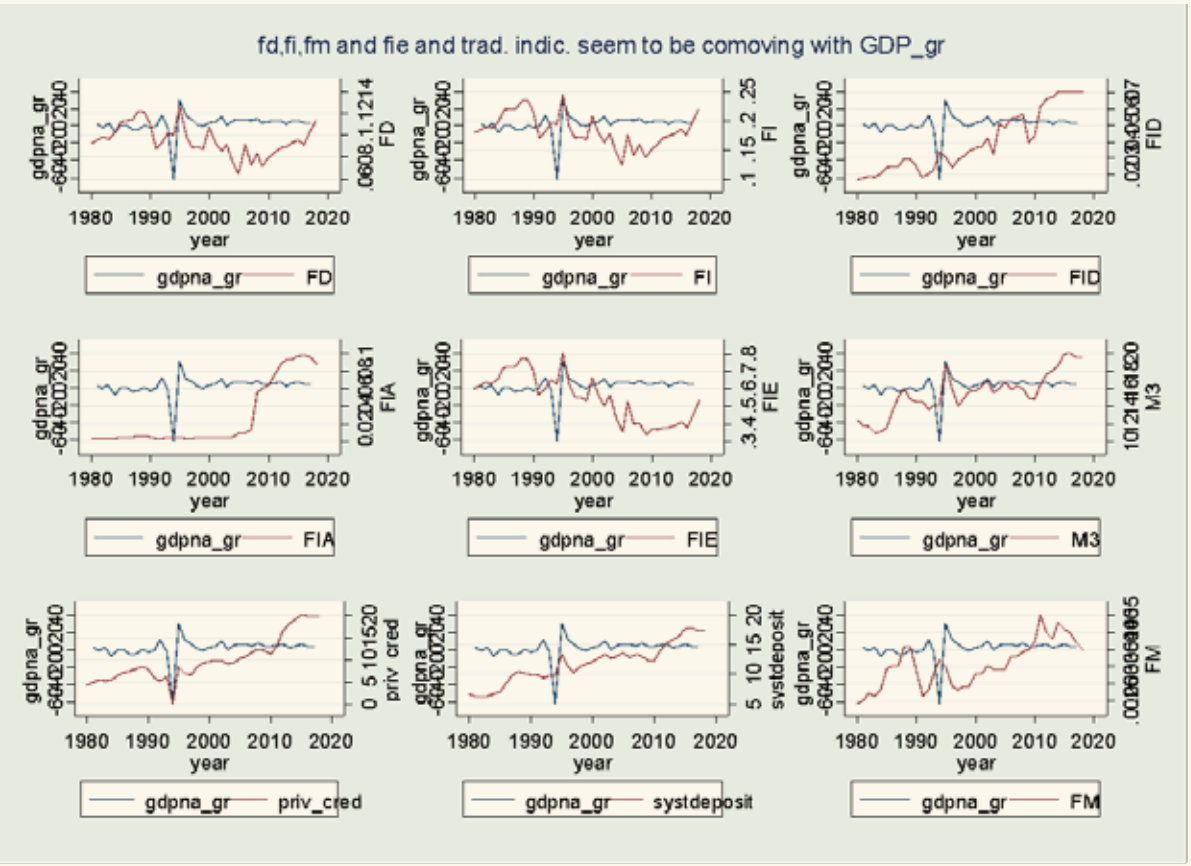


Source: Author's Calculations

5.2 Granger causality test results.

The relationship between the financial development indicators and economic growth can also be visually assessed using graphs. From figure 1, there is some degree of co-movement between the GDP per capita growth and the FD, FI, FM and FIE indices as well as the traditional financial development indicators.

Figure 6: Visual analysis of finance-growth correlation



Source: Author's Calculations

We then compare our graphical analysis with the TY Granger causality results. When using the fd index as the financial development indicator, table 3 shows that the null hypothesis that fd index does not granger-cause growth cannot be rejected meaning financial development does not granger-cause growth. The null hypothesis for non-causality of capital and trade openness on growth cannot be rejected as well[16].

On the other hand, the null of non-causality from economic growth to financial development is rejected at the 1% significance level. This proves a unidirectional causal relationship between finance and growth following the demand following theory.

[16] The results show that GDP growth instead causes capital growth at 1% sig. level. As for trade, the null hypothesis of non-causality in either direction cannot be rejected.

We go on and further analyze which part of Rwanda's financial system drives this growth to finance relationships. Table 4 (a) shows the results from granger causality tests where the financial development indicator is either the financial institution sub-index or the financial market sub-index. We find that the financial institutions(fi) mostly drive the growth to finance relationship as the non-causation from growth to finance cannot be rejected but that from finance to growth is rejected. As for the financial markets(fi) and growth, they have a bi-directional relationship with each other.

We then investigate which of the three subindices of the fi and fm index drive their relationships (Table 4 b). For the fi, fie, fid and fia are used in the same VAR model because of their high correlation (see Annex 2). We find that fie has a two-way causality relationship with growth. Fia on the other hand granger causes GDP while GDP granger causes fid.

For the fm subindex, the trend is identical to the fmd subindex because both the fma, fme have values of 0 for all years therefore its results are really driven by the performance of the fmd. From this, it can be concluded that the relationship of the aggregate fd index and gdpna_gr direction is mostly driven by fid and partly by fie and fmd.

Table 3: TY granger causality results for the FD index (Chi square statistics)

Y var \ X var	gdp_gr	fd	capital	trade	gov_cons	pop_gr	All
gdpna_gr	_	**2.179**	**4.565**	**7.257**	**13.041***	**18.556***	**113.04***
	_	**[0.536]**	**[0.207]**	**[0.064]**	**[0.005]**	**[0.000]**	**[0.000]**
fd	**8.648***	_	6.472	51.613*	52.889*	23.307*	142.15*
	[0.034]	_	[0.091]	[0.000]	[0.000]	[0.000]	[0.000]
capital	**11.835***	29.654*	_	7.700*	9.348*	9.534*	64.479*
	[0.008]	[0.000]	_	[0.053]	[0.025]	[0.023]	[0.000]
trade	**3.526**	7.363	11.265*	_	54.936*	31.786*	140.8*
	[0.317]	[0.061]	[0.010]	_	[0.000]	[0.000]	[0.000]
gov_cons	**11.157***	15.181*	38.694*	8.561	_	36.141*	107.76*
	[0.011]	[0.002]	[0.000]	[0.036]	_	[0.000]	[0.000]
pop_gr	**47.777***	41.578*	21.223*	48.057*	28.872*	_	276.84*
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	_	[0.000]

Ho=X does not granger cause Y, P-values are in brackets

** indicates rejecting null hypothesis of granger non-causality at 5%/1% sig. levels*

Optimal Lag=3 lags

Table 4: TY Granger causality results for the FD sub aggregates (Chi-square statistics)

a) Y var \ X var	gdp_na	fi	fm
gdp_na	-	**2.003**	**58.227***
	-	**[0.572]**	**[0.000]**
fi	**8.703***	-	-
	[0.0134]	-	-
fm	**24.973***	-	-
	[0.000]	-	-

Ho=X does not granger cause Y, P-values are in brackets

** indicates rejecting null hypothesis of granger non-causality at 5%/1% sig. levels*

Optimal Lag=3 lags

b) Y var \ X var	gdp_na	fid	fia	fie	fmd
gdp_na	-	**3.386**	**19.689***	**36.478***	**53.593***
	-	**[0.184]**	**[0.000]**	**[0.000]**	**[0.000]**
fid	**10.474***	-	24.257*	1.270	-
	[0.005]	-	[0.000]	[0.530)	-
fia	**4.632**	5.201	-	54.216*	-
	[0.099]	[0.074]	-	[0.000]	-
fie	**58.399***	11.469*	6.7276*	-	-
	[0.000]	[0.003]	[0.035]	-	-
fmd	**32.906***	-	-	-	-
	[0.000]	-	-	-	-

Ho=X does not granger cause Y, P-values are in brackets
** indicates rejecting null hypothesis of granger non-causality at 5%/1% sig. levels*

Optimal Lag(FI indices)=2 lags, Fmd=3lags

Source: Author's Calculations

Finally, as can be seen in table 5, the TY Granger test results of the traditional indicators are pointing to a two-way causality between financial development and growth. This is partly in line with the previous studies in Rwanda by Kigabo et al (2015), Okello et al (2015), Karangwa and Gichondo (2016) and Nyalihama and Kamanzi (2019).

Table 5: TY Granger causality results, Trad. indicators (Chi-square statistics)

Ho \ Var	priv_cred	M3	Systdeposit
Fin. dev does not granger cause GDP gr.	**42.154*** [0.000]	**23.483*** [0.000]	**16.611*** [0.001]
GDP_gr does not granger cause Fin. Dev	**17.298*** [0.001]	**58.905*** [0.000]	**67.999*** [0.000]

** indicates rejecting null hypothesis of granger non-causality at 5%/1% sig. Levels*
Optimal Lag= 3 lags, , P-values are in brackets

Source: Author's Calculations

5. CONCLUSION AND POLICY RECOMMENDATIONS.

This study reviews different literature with differing schools of thought regarding the finance and growth link; the supply leading hypothesis, the demand-following hypothesis, the bidirectional- causation hypothesis or the hypothesis that there is no link between the two. An empirical analysis is then made on Rwanda to find out which finance-growth nexus hypothesis is applicable to Rwanda using the Toda and Yamamoto Granger causality test for the years between 1980-2018. It uses the financial development index as the main measure for financial development. Due to the fd index encompassing different dimensions of financial development such as access, depth and efficiency for both financial institutions and financial markets using 20 different indicators. It is a better measure than traditional indicators that have been used in previous studies that would mostly only represent the depth dimension such as bank credit and money aggregates (M2/M3). Results show that Rwanda's finance-growth association is explained by the demand-following theory whereby financial sector services and infrastructure expand or get innovated as the economy grows due to more demand for financial services.

Further analysis shows that this relationship is mostly driven by the financial institutions' relationship with growth, which also supports the demand-following theory. Finding out why the financial institution index particularly that of depth, does not follow the supply-leading hypothesis is an area for further analysis. The policy implication for this is that more efforts should be directed in finding non-finance factors that boost economic growth and finding out ways to make the financial institutions become more beneficial to the overall growth process, since they make a bigger part of Rwanda's financial system as the usage financial markets to finance the private sector is relatively still in its infantry levels.

Another result from the study is a bidirectional relationship between financial markets and growth. This implies the growth of the economy will lead to more demand for the financial markets' services and the financial markets growth will lead to even further growth. Since Rwanda's financial market is still small and has a big room of growth, the government should continue in its efforts to facilitate firms to list their shares in the Rwanda Stock Exchange and establish financing by debt securities such as corporate bonds. The government so far has already set some incentives to encourage participation in the financial markets such as zero tax for venture capital firms that are registered with the Capital market Authority (CMA) for the first 5 years, exemption from capital gains for secondary market transactions for listed companies. There is also a plan to establish a corporate bond market, among others (Kigabo, 2021).

Among the control variables, we found a bi-directional causal relationship between growth and government consumptions and population growth. These are therefore some of the non-financial factors that can be leveraged on to boost Rwanda's economic growth. For example, government consumption could be boosted by its borrowing through bonds in the financial markets. The government bonds still have room for growth, because according to Kigabo(2021), the demand for bonds is very high. The oversubscription to listed bonds was 180.3% between 2014 and 2019.

Kigabo (2021) highlights the challenges that are limiting the participation in the financial market to include lack of knowledge of these non-intermediary channels of financing or fear of losing control of their companies(in the case of selling shares). Therefore, for this market to grow, more awareness should be spread among the population on the same. The result of this would be further growth of the economy

which in turn would lead to development of the financial institutions which depend on it and financial markets which have a chicken-egg relationship with growth.

Results from the traditional indicators (M3, credit to private sector and system deposit liabilities) display a bi-directional relationship between finance and growth. This means that policies that boost both growth and these indicators should be adopted concurrently in order for both to grow.

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Annex 1: The FD Index construction

As explained by Svirydzenka (2016) The FD index was constructed using a set of 20 indicators that were first normalized between 0 and 1, aggregated into subindices that captured financial institutions' and markets' depth, access and efficiency and then aggregated into the final financial development index. The variables were selected based on their availability in the majority of the countries across a long time period. Data from a total of 189 countries is used. The indicators are listed in the table below.

FINANCIAL INSTITUTIONS	
• Depth	Private sector credit to GDP, Pension fund assets to GDP, Mutual Fund Assets to GDP, Insurance Premiums, life and non-life to GDP.
• Access	Bank Branches per 100,000 adults, ATMs per 100,000 adults.
• Efficiency	Net interest margin, Lending-deposit spread, Non-interest income to total income, Overhead costs to total assets, return on assets, Return on equity
FINANCIAL MARKETS	
• Depth	Stock market capitalization to GDP, Stocks traded to GDP, International debt securities to GDP, Total debt securities of financial corporations to GDP, Total debt securities of non-financial corporations to GDP.
• Access	Percent of market capitalization outside of top 10 largest companies, Total number of issuers of debt (domestic and external, nonfinancial and financial corporations)
• Efficiency	Stock market turnover ratio (stocks traded to capitalization)

Source: Svirydzenka (2016)

These indicators were not free of limitations such as missing data especially for low income developing countries. For example, 32 percent of the sample had missing markets. The main approach used to deal with the data was splicing which solved for changes in the indices caused by introduction of new series in later periods.

The indicators were then winsorized at the 5th and 95th percentiles which helped avoid a scenario where extreme values of the indicator would cause other values to concentrate around 0 or 1 once normalized.

After winsorizing, the indicators are then normalized to values between 0 and 1 using the formulas below. $I_x = \frac{x - x_{min}}{x_{max} - x_{min}}$ where x is the raw data, and I_x the normalized data series. x_{min} is the global minimum across countries and time and x_{max} is the global maximum. The value 1 is therefore equal to the highest value of data across time and countries while 0 is given to the lowest.

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For indicators where a higher value points to worse performance, such as 'net interest margin, lending-deposits spread, noninterest income to total income, and overhead costs to total assets', this formula is applied; $I_x = 1 - \frac{x - x_{min}}{x_{max} - x_{min}}$ so that a higher value would indicate better performance.

The 20 now normalized indicators were aggregated into 6 subindices; financial institution depth (FID), financial institution access (FIA), financial institution efficiency (FIE), financial market depth (FMD), financial market access (FMA) and financial market efficiency (FME). They are aggregated through a weighted linear average where the weights are attained through principal component analysis.

The 6 subindices are then normalized to values between 0 and 1 using the first normalization formula and aggregated further into the Financial Institution Index (FI) and Financial Market Index (FM). These two indices then undergo the same procedure of normalization and aggregation to obtain the final Financial Development Index (FD).

Annex 2: The fie, fia and fid correlation

```
. pwcorr fie fid fia, star(0.05) sig
```

	fie	fid	fia
fie	1.0000		
fid	-0.7397*	1.0000	
	0.0000		
fia	-0.6825*	0.8611*	1.0000
	0.0000	0.0000	

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