NATIONAL BANK OF RWANDA
BANKI NKURU Y' U RWANDA

BNR ECONOMIC REVIEW

Vol. 7

August 2015

ISSN 2410-678X

ISSN 2410-678X

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Foreword

In line with the BNR ongoing efforts to disseminate knowledge and other information on the Rwandan economy, this seventh volume of the BNR Economic review publishes six articles. The first paper probes the economic promise of women financial inclusion. The article sheds more light on the concept of women financial inclusion, highlights its economic value to different stakeholders and clarifies the conditions, parameters, roles and responsibilities that underpin the inclusion process. Indeed, the paper leaves the reader with a sense of call to promoting women financial inclusion.

Competition and financial stability in Rwanda is explored in the second paper which reveals that there is monopolistic competition in the banking system and that competition has been increasing especially since 2010. The study supports the view that up to a certain level more competition would contribute to the buildup of vulnerabilities in the banking system. On this regard, the authors of the paper advise BNR as a regulator to keenly monitor the evolution of competition in the banking market.

The third paper investigates the exchange rate pass-through (ERPT) to inflation for the case of Rwanda. The findings reveal that ERPT in Rwanda is low but significant with a dynamic exchange rate pass through elasticity of 0.28. This defies conventional wisdom in the literature that ERPT is always substantially higher in developing and emerging economies than in developed economies. This result looks plausible for Rwanda because Rwanda has registered stable exchange rate and inflation over the sample period.

The fourth paper shows the linkages between financial development, monetary policy and economic growth in Rwanda. The results indicate positive and significant impact of credit to the private sector on the economic growth in Rwanda. They also indicate a negative link (even if it still very low) between interest rate spread and economic growth showing how high lending rate may discourage investment with its impact on economic growth. Furthermore, the paper indicates that BNR influences bank's decisions of financing the private sector, which is an improvement in monetary policy transmission mechanism in Rwanda.

The fifth paper is entitled "The forecasting and policy analysis systems (FPAS) macro-model for Rwanda". The model adequately explains the historical developments in GDP growth, inflation dynamics and exchange rate movements between 2008 and 2014-15. The good performance of the current model and the expected future improvements will strengthen the operationalization of the model to produce forecasts for key macroeconomic variables aimed at guiding monetary policy discussions.

Somehow linked to the fifth paper, this article estimates the Rwandan GDP using the famous dynamic factors model (DFM) developed by Stock and Watson (1991). To cope with the forward looking monetary policy framework, the DFM uses high frequency data on some indicators used to compute the real Composite Index of Economic Activities (CIEA) to estimate real GDP growth rate which comes with at least a one quarter lag. Results of the paper show a very good fit to historical data and outperforms the results of the univariate AR model, which is often considered as a benchmark model, especially in the short-run.

In conclusion, it is worth mentioning that the reprint of any figures or statements contained herein is permitted on condition that proper citation and/or referencing is given to the National Bank of Rwanda's Economic Review. However, the National Bank of Rwanda assumes no responsibility for the views expressed by the authors of the aforementioned papers.

Comments and questions can be sent to the Office of the Chief Economist (tkigabo@bnr.rw or thkigabo@yahoo.fr) and/or the Monetary Policy and Research Department, KN 6 Avenue 4, P.O Box 531 Kigali-Rwanda, Monetary_Policy_Res_Group@bnr.rw.

John Rwangombwa

Governor

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The economic promise of women financial inclusion

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1. Introduction

A new women initiative came to the Rwandan public domain lime light as New Faces New Voices Rwanda Chapter was launched on 10 June 2015. The "Transformative Financial Solutions for Women Conference" that was organized on the occasion and the media interest the event generated stimulated a debate on the value of including women financially. But the concept meant so many things to different people, shaped diverse expectations, and left some unanswered questions as well, that it triggered the writing of this article. In the minds of some people, including women financially was limited to getting access to cheaper loans, and that was the business of financial institutions and their regulator to guarantee. Yet there is more to the concept than just credit, and more role players, including the women themselves and society. Some other minds wondered about the genuine value of including women financially beyond being "fashionable"; is it a panacea to the plight of the many poor women who have no access to income generating activities? What is the effort likely to return to the economy in general?

This article aims at shedding more light on the concept of women financial inclusion, highlighting its economic value to different stakeholders and clarifying the conditions, parameters, roles and responsibilities that underpin the inclusion process. The ultimate goal is to leave the reader with a sense of call to promoting women financial inclusion from his/her position since there is a role to be played by everyone and the rewards accrue to all of us.

2. Why financial inclusion and why women?

A positive relationship between finance and economic growth has been recognized (Agenor and Montiel 1999: 671, Beck et al. 2000). Beyond its positive impact on the aggregate economic growth, financial development plays an important role in the reduction of poverty and inequalities while putting a disproportionately positive advantage on the relatively poor (Beck et al. 2007: 4-5).

Being a realm of monetary financial institutions (such as banks and microfinance institutions) and non-monetary financial institutions (such as insurance corporations, pension funds and other financial intermediaries), financial intermediation enables

economic growth and development through "reconciling the different desires of savers and borrowers in terms of maturity and returns" (ECB 2012:59). The services offered by financial intermediaries include maturity transformation, liquidity transformation, payment services, information processing and transaction cost reduction, to name but a few. Therefore, by pulling savings, allocating these to borrowing for investment and consumption, allowing redistribution of resources through transfers, enabling intertemporal choices and helping in managing risks (UKaid and GIZ 2013:4), financial institutions play a vital role at individual and economy-wide level.

Financial inclusion therefore is a normative concept that relates to a situation whereby the benefits of financial intermediation are enjoyed by all individuals, households and business entities. Its point of departure is a setting where constraints still exist, mainly in relation to the level of income, geographical location, type of activity, or gender.

Financial inclusion often refers to access to a formal financial institution, i.e. having an account with that institution; access being a function of proximity, eligibility and affordability. However, more meaningful is a measure of actual uptake of the services offered by the institution, or, even better, the usage of the service (Nsanzabaganwa 2014: 2).

A body of empirical research shows that rural population tend to be less financially included compared to urban; that SMEs face more challenges to access to finance than large firms; that women tend to be less financially included than men; etc. The following table providing the latest numbers on accounts holding in different parts of the world shows that adult women, poorest, younger adults and rural adult levels of access are below average.

Table 1 Financial access by account holding

Region	Adults >15 Yrs	Women	Poorest 40%	15-24 Yrs old	Rural
World	61.5	58.1	54	46.3	56.7
OECD	94	93.8	90.6	84.1	93.8
South Asia	46.4	37.4	38.1	36.7	43.5
Sub-Saharan Africa	34.2	29.9	24.6	25.9	29.2
Rwanda	42.1	35.3	18.3	23.3	37.9

Source: The 2015 Little Data Book on Financial Inclusion

Yet Narain (2009: 24) points out that Uganda has foregone 2% of GDP growth per year due to policies restricting women's full participation in the economy, according to a gender growth assessment. Excluding women may reduce by half the poverty reducing or growth promoting potential of finance. Indeed women form half, if not more, of the population of any developing country. In most of the cases, they engage more in agriculture and small trade thus playing a bigger role in sustaining the livelihoods of their communities and families through the provision of basic needs and supply of goods and services to local markets than men would do. A study by International Capital Corporation (2014: 8) shows that Mozambican women tend to save more than men for family basic needs such as health, education, and house improvements.

UKaid and GIZ (2013: 13) argue that women deserve deliberate remedial action with regards to their financial inclusion since, as farmers, women tend to dominate the subsistence food crop agriculture than cash crops; as entrepreneurs, they tend to be less productive; as income earners, they are in low-paid employments; as holders of assets, they are less likely to own land, and if they do, cultural barriers would still be a barrier to enjoying the right fully; and as consumers, they tend to spend on different items and in different proportions.

A similar study commissioned by GIZ/Making Finance Work for Africa on six countries (Botswana, Malawi, Namibia, Rwanda, Uganda, and Zambia) identified that "in all six countries women tend to have smaller businesses and operate in sectors, such as retail and services that require little initial capital. Many women seem also more inclined to grow their businesses slowly and over time, with less outside capital. They tend to be more risk-averse and less eager to borrow from formal financial institutions for fear of losing collateral because they overwhelmingly bear financial responsibilities for their families. That may also explain women's preference for informal savings and credit cooperatives. After all, ease and convenience matter for women when choosing where to save and borrow, as they are often more time-constrained than men" (GIZ 2012: 1).

The reality of the facts therefore calls for specific efforts in addressing women financial inclusion.

3. Charting a conceptual framework for women financial inclusion

Financial inclusion goes beyond microfinance

Making Finance Work for Africa (2012: 3) defines women's financial inclusion as "a state in which women, as individuals, members of households and entrepreneurs, have access to the full range of financial products and services from convenient responsible formal service providers, offered effectively, responsibly and sustainably and at a reasonable cost to clients". The range of services include savings, credit, leasing and factoring, mortgage, insurance, pensions, payments, local money transfers, international remittances, and equity (investment) finance.

Women financial inclusion is more than just microfinance. It involves actions in the policy, legal and institutional areas. It will also include insurance, financing, cash transfers, mobile financial services, branchless banking, microfinance, etc. Women financial inclusion is part of a broad gender equality, especially the women's economic empowerment in so far access to income, opportunities, assets and decision-making authority is concerned (UKaid and GIZ 2013: 9).

In line with the above, New Faces New Voices[1] framework directs the focus on three important axes, namely, access to financial products and services, capabilities in handling business and financial matters, and representation of women in decision-making positions in financial institutions. Narain (2009: 37) highlights the positive impact of increasing the voice and participation of women in top management positions of a financial institution on understanding and responding to customer needs as well as the ensuing performance of the institution.

[1] New Faces New Voices is a Pan African movement that advocates for women in finance. It was founded by Graca Machel in 2010 and operates through country chapters and the Headquarters. It has been playing leading role in research, advocacy, and participation at global and regional fora where the promotion of women financial inclusion is at the center. These include the G20 Global Partnership for Financial Inclusion, the Alliance for Financial Inclusion, the World Women's Banking African Advisory Council, Making Finance Work for Africa, and the work of the African Development Bank Office of the Envoy on Gender among others.

Understand the women through the lenses of men

Dealing with women financial inclusion starts with understanding the reasons behind their exclusion, which itself cannot be fully appreciated outside the comparison to men's attributes and behaviors. Constraints are often presented in two categories, i.e. supply side and demand side, the former taking the perspective of financial institutions while the latter considers the attributes of the women as customers of the financial institutions. But there are also constraints that pertain to the legal, regulatory, policy, cultural norms and other institutional aspects in the environment where women live.

Supply side and demand side constraints

A trend seems to emerge out of the several case studies[2] that demand side constraints include low levels of education, economic opportunity, financial literacy, self-confidence and information. But research done by Rwanda Accuracy Development Consult on behalf of Rwanda Gender Monitoring Office (GMO 2014) has revealed that at certain age, education, like staying in marriage, is associated with less sophistication in up-taking financial products and services. Supply side constraints often allude to poor design and delivery of financial products and services. Institutional aspects include the social norms such as gender roles, the legal rights on assets ownership (both de jure and de facto), perception, etc (Demirguc-Kunt et al. 2013).

Be mindful of informality

A distinction is always made between formal and informal financial inclusion. In fact, women tend to have more appetite than men for informal savings and credit arrangements such as village savings and loans associations (VSLAs). According to the World Bank's Global Findex, 30% of women savers, compared to 20% men savers, use informal community-based saving method in Sub Saharan Africa (Klapper 2012).

[2] Examples include country case studies done by Making Finance Work for Africa in partnership with New Faces New Voices and GIZ, and the Financial Landscape Study conducted by Monitor Deloitte on behalf of New Faces New Voices Rwanda Chapter.

These informal settings are perceived by women as offering more discretion (women would not be looked down upon for their small amounts saved or asked in loan), convenience (proximity and less paper work or none at all), simplicity (in fact, some concepts used in formal institutions, such as interest, are quite confusing to uneducated women who understand easier the use of an absolute figure rather than a percentage), and even friendship and social support. Rwanda Finscope (AFR 2012) cites the social network among main reasons Rwandans, and women in particular, prefer informal savings and loans association over formal financial institutions. So does the GSMA mWomen Programme study conducted in 2012 speak to the same specific needs of women: convenience, reliability, security, and privacy (GSMA 2012). A study commissioned by GIZ/Making Finance Work for Africa on six countries (Botswana, Malawi, Namibia, Rwanda, Uganda, and Zambia) arrived at the same conclusion of preference for convenience, but also avoidance of fees and transaction costs as well as the nature of women as more collaborative and more trusting than men (GIZ 2012:1; 16).

Yet the informal mechanisms are lacking in scale and efficiency, sustainability and reliability (Making Finance Work for Africa 2012: 3). A study commissioned by UKaid and New Faces New Voices on "Women's Access to Financial Services in Mozambique" (International Capital Corporation 2014:1) found that women tend to use informal sources for all types of needs (life cycle, opportunity and emergencies needs), irrespective of their inappropriateness. There is enough room for formal institutions to tap this opportunity, through product design, diversification, financial literacy and improved convenience in transactions.

Understanding the commercial value of the women market segments

Most of the demand side constraints could be easily alleviated if financial institutions fully internalized them, i.e. addressed the supply side constraints. Unfortunately these institutions are also faced with some limitations in understanding women needs very well. There seems to be lack of information on the niches where women are vibrant, or the periodicity of their income streams and expenses that is often irregular. For instance, business women may prefer growing their SME business organically without a loan, and only have access to bridge loan in case of unexpected disruption in the

regular flow of income; they might fear to commit for a long time (Making Finance Work for Africa 2012:5). In addition to a loan, they may require package of services or bundled products, including insurance and business coaching or linkage to market, to make them feel totally comfortable.

In extreme cases, the value of banking with women (good savers, risk-averse therefore higher quality of portfolio) is not well apprehended due to lack of statistics. There is a business case in banking with women. Not only they are an "untapped, profitable and growing market", but they also command better payback rates (Narain 2009: 25). As such financial institutions loose the sight of benefits that banking women would bring to the bottom line of profit. Some even consider women programs under Corporate Social Responsibility and not the "main market"[3].

A GSMA Mobile Money for the Unbanked (MMU) study conducted in 2013 revealed that only 32% of the 92 respondent operators knew the gender composition of their customer base (Scharwatt and Minischetti 2014: 4). The same study puts emphasis on the women as mainly being on the receiver end, yet operators tend to focus on sender side, forgetting that the recipients side is key for the success of their network.

A research commissioned by the European Bank for Reconstruction and Development and conducted by Women's World Banking tips financial institutions on six best practices in banking women-led SMES. In fact, "women don't necessarily want differentiated financial products but they do want to be served differently and treated with respect…" (Women's World Banking 2014:6).

Gender performance indicators in financial inclusion

Women's World Banking (2014) has documented six global best practices to serving women as follows:

I. Know your market: data analysis and research to understand sub-segments in the women's market, trends in demographics, attitudes, etc.;

[3] Motivational speech delivered on 11 June 2015 by Audrey Mothupi at the Transformative Financial Solutions for Women Conference held in Kigali on 10-11 June 2015.

II. View women as a distinct group: Reviewing marketing tools and including women-to-women communication, training relationship managers in psychology and interpersonal skills to better serve women, and tailoring the brand strategy to resonate with women-led SMEs are the main insights offered by the report;

III. Build internal capacity which starts by a buy-in by the Board and Executive Management and includes identifying an internal champion who will rally the organization on the power of the women market, raising gender awareness and developing internal women leadership;

IV. Adapt your credit processes, methodologies and delivery models to suit women's need, including designing collateral free products to overcome the issue of legal rights or traditional norms, and assigning women relationship manager, for instance;

V. Offering women a comprehensive mix of financial services and non financial services as women prefer bundled products (insurance, advisory, asset management, etc. through strategic collaboration with other players in the market);

VI. Invest in proving the business case through disaggregated data

Five indicators recommended by Women's World Banking (Berfond et al. 2014: 10) are:

1. Percentage or women new borrowers;
2. Average loan size per woman borrower;
3. Women borrower retention rate;
4. Women's portfolio risk; and
5. Women staff retention rates.

4. The policy and business response: initiatives for women in finance

Founded on the premises that gender plays a role in sustainable economic development, a number of commitments and initiatives have been taken at global and regional levels as they were emulated through national programs. An interested reader is directed to the following few ones:

- The Convention on the Elimination of all forms of Discrimination against Women CEDAW
- The G20 commitment to financial inclusion, mainly the Global Partnership for Financial Inclusion (GPFI) founded in 2010 which, in its 2011 progress report presented at Cannes, France, recommended that global leaders commit to policy recommendations addressing challenges facing women entrepreneurs and reiterated the partnership with the private sector to achieve the same (Culpeper 2012: VII-IX). The initiative focuses on key areas: enabling environment, emulating successful models and achieving gender disaggregated statistics (UKaid and GIZ 2013:12)
- The Maputo Protocol to the African Charter on Human and People's Rights on the Rights of Women in Africa
- The Beijing Declaration of 1995, and the United Nations Conference on the Status of Women (CSW) 2015 which was dedicated at evaluating Beijing 20 years on (UN Women 2015)
- The Alliance for Financial Inclusion and especially its focus on African women financial inclusion as exemplified with the Yamoussoukro conference held in July 2015 (www.afi-global.org)
- The African Development Bank Group's Africa Gender Equality (African Development Bank Group 2015)
- Making Finance Work for Africa (MFW4A) Partnership, a platform for African governments, the private sector and development partners to coordinate financial sector interventions across Africa. MFW4A is hosted at the African Development Bank.
- The Women's World Banking (WWB) African Advisory Council, created in 2014 to support the work of WWB in Africa with strategic guidance. WWB is a non-profit organization that provides strategic support to financial institutions to show them the benefit of investing in women as customers, and as leaders. WWB has partnered with Financial Deepening Africa on the African program.
- New Faces New Voices founded in 2010 as a call to Africans to be at the table where global leaders (the G20 and its Global Partnership for Financial Inclusion initiative) were trying to shape the financial landscape after the 2008 financial

crisis. NFNV is "a Pan-African advocacy group that focuses on expanding the role and influence of women in the financial sector" (www.nfnv.org). Its main angles of focus are three: access, financial and business capabilities, and representation of women in decision making positions in financial institutions. New Faces New Voices has a network of country chapters across Africa, and Rwanda is one of them.

5. Women financial inclusion and the work of New Faces New Voices Rwanda Chapter

Rwanda has made tremendous strides in empowering women (MIGEPROF 2014). It ranks second (after South Africa) on the Africa Gender Index overall score on economic opportunities, human development and equality in laws and institutions (African Development Bank Group 2015: 7). Even then, there is still room for further improvements, especially on economic opportunities. Though still among top ten countries, Rwanda ranks 5th on economic opportunities, after Malawi, Botswana, Gambia and the Central Africa Republic (African Development Bank Group 2015:10).

Looking at financial inclusion specifically, the 2012 Finscope study ranked Rwanda again second after South Africa on the least total exclusion (27% for South Africa and 28% for Rwanda). However, reliance on sole informal financial inclusion was higher in Rwanda (30%) compared to South Africa (5%). Formal financial inclusion in Rwanda stood at 42% overall, and at 36% for women (AFR 2012: 22-23).

With regard to women capabilities, though female education ranks among the highest on the continent, women still face issues of lack of information on financial products for instance. Since there still exists differences between men and women as far as economic opportunities are concerned, focusing on women financial inclusion is important in redressing the balance. According to the 2012 census and Household Survey (EICV), 82% of Rwandan women of working age are engaged in subsistence agriculture compared to 63% of working-age men while the gap in wage employment between men and women widened to 24 percentage points from 9 between 2005 and 2011 (NISR 2012a, 2012b). A similar picture can be depicted if you consider business

enterprises. A study by a World Bank team showed that women have a 12 to 20% gap in managerial experience in Rwandan informal firms compared to men (Kushnir and Amin 2013). All this evidence confirms the need to build skills and make finance work for women so they modernize their activities, link to markets, be able to save for small and big investments, and have access to a wide range of financial solutions they need to transform the structure of their economy.

Primary research conducted on behalf of New Faces New Voices Rwanda Chapter came with a list of issues that were more or less facing all Rwandan women across clusters (Monitor Deloitte 2015b, 27-30). They include:

- Education and information deficiency that limit their capacity to absorb complex information, their awareness and their confidence;
- Cultural issues, such as traditional gender roles and risk aversion;
- Inadequate financial products, notably collateral and/or business plan requirements that are found hard to meet;
- Skills and training gaps, especially in business and finance management;
- Complicated bank processes;
- Lack of mentors and role models and hence lack of inspiration and coaching;
- Reluctance to formalize and grow, especially by fear of tax implications;
- Proximity of financial institutions is still felt inadequate, despite Umurenge SACCOs. Although Rwanda was praised by Alliance for Financial Inclusion for having more than 90% of the population living within the 5km radius, many are still beyond 3km, which is felt too long a distance to work for a house wife busy with many activities;
- Corporate pressures expressed in terms of short maternity leave, less flexible working hours and the need to work much harder than a male colleague to attract any recognition;
- Perceived barriers to gender equality especially gender bias in the workplace, in procurement, in business dealing, etc.; and
- Limited private sector growth which results in less jobs and capacity to earn an income.

From the supply side, the financial landscape study pointed out that "though banks are actively targeting women, few are tailoring products and services to women and though financial institutions recognize the importance of financial and business literacy as a priority for obtaining finance, they do not provide training in this regard for their clients" (Monitor Deloitte 2015b: 34)

On influence or voice and representation grounds, the financial landscape survey conducted on behalf of New Faces New Voices Rwanda Chapter pointed out that "corporate pressures limit the ability of professional women, especially senior women, to move up the ranks to achieve more senior and more influential positions" (Monitor Deloitte 2015a:41). As such, women represented 25% both in Boards and senior management positions in banks, and less for insurance companies, against a policy target of 35%.

New Faces New Voices Rwanda chapter established in 2012 and officially launched in 2012 sought to contribute to resolving these and more challenges which were highlighted in its Financial Landscape Study and the strategy and business model it informed (Monitor Deloitte 2015a; 2015b).

Unlike many country chapters, New Faces New Voices Rwanda opted for a business legal status, consistent with its vision to strive for "a Rwanda where women co-create their full financial inclusion and reach their economic potential" and its mission to "serve its members and women through the value chain by increasing their access to finance directly and through new investment initiatives" (Monitor Deloitte 2015b: 36).

The women in the value chain are clustered in six target groups ranging from the low-income women at grass-root, to women in occupational cooperatives, women owners of informal micro-enterprises, women emerging entrepreneurs, women junior and middle professionals, and women at the top as senior professionals or established entrepreneurs.

New Faces New Voices Rwanda aims at working with players in the financial landscape of Rwanda (Rwanda women themselves, financial institutions, policy makers and development actors) to advance women on the three grounds of access, capabilities and representation. The chapter's work will cover four business lines.

Firstly, there is networking/advocacy, with a strong focus on mentorship and pulling resources to raise the negotiating position of women. In second position come financial information services, to bridge gaps in financial literacy. Third is programming whereby partnerships will be sought with different agencies to mobilize projects working to empower women especially in lower parts of the pyramid. A consortium partnership exists already between New Faces New Voices Rwanda and the IFC and UN Women. Last but not least, New Faces New Voices Rwanda will promote investments, where women can channel their savings for a return. To start with, a Women Investment Fund is expected to be launched by end 2016 whereby broad base women membership will mobilize 25% and the rest will be raised in matching funds from government, foundations and international financial organizations. The hybrid capital venture/private equity fund will be invested in big ticket (USD 50,000 to 1million) women-owned businesses or businesses qualifying on other criteria advancing women, such as job creation). The fund will also have appropriate corporate governance structures and investment policies and will be managed by a professional fund manager.

6. Conclusion

Women financial inclusion is not only an individual human right, but it plays an important socio-economic role at the macro level (economic growth, the reduction of poverty and inequalities, social impacts such as education and health) and at firm level (positive impact on the bottom line of financial institutions). Therefore, its attraction of policy makers, regulators, development organizations, and businesses' attention is legitimate and rational. In fact, more innovative approaches customized to the diverse needs and conditions of women (there is no such thing as a women market, but many segments in that market) are called for.

Understanding informal mechanisms preferred by women and taping into them by creating linkages to formal institutions is paramount, and mobile technology stands a chance to achieve that quicker.

There is room for more collaboration between banking institutions, mobile network operators, insurance companies, pension funds and business development services providers to offer bundled financial products highly preferred by women.

These institutions will also gain from training their staff and female customer base while raising the percentage of women champions across the functions of the institutions.

All in all, as a certain inspirational leader once said, if you do not measure it, you cannot care; gender disaggregated statistics are instrumental in the identification of gaps and opportunities for more action.

New Faces New Voices Rwanda value proposition to the market stakeholders, including the women themselves, is to be a framework where concerted effort can be harnessed and channeled to unleash the economic potential of Rwandan women.

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Competition and financial stability in Rwanda

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Abstract

The relationship between competition and stability in the banking sector has attracted interest from researchers and the existing literature is divided under two alternatives namely competition stability view that intense competition in the banking sector would contribute to its stability or alternatively, competition fragility view that more competition would contribute to the buildup of vulnerabilities in the banking system. The present study empirically investigates this relationship using data of 6 commercial banks in Rwanda from 2006 to 2013. Firstly, empirical measures of competition (Lerner index, Panzar Rosse H statistics) indicate that in Rwanda, banks are operating in monopolistic competition and competition is increasing especially since 2010. Secondly, results from Arellano Bond GMM estimation tend to support the competition fragility view as market power was found to be associated with less risk exposure in the banking system. However, by including the quadratic term to allow non-linearity in this relationship, the results also indicates that this relationship will hold up to a certain point where more market power may lead to more risk exposure in the banking system. Therefore, BNR as a regulator should keenly follow how the degree of competition is evolving on the banking market in Rwanda.

Key Words: Bank competition, Banking system Stability, Lerner Index, H statistics, Rwanda

JEL Classification: G21, L11

1. Introduction

Banking sector stability has been a matter of concern for policymakers given its role in the stability of the whole economy and its prominence in policy transmission especially monetary policy. Actually, banking sector is a key channel through which instability may be transmitted to other sectors in the economy by disrupting the interbank lending market, payments system and market for credit and deposits (Berger et. Al 2008). This is because of its critical role on financing economic activities. Besides, the negative effect from previous banking and financial crisis on the global economy has put the issue of financial stability at the center of policy debate.

Competition in the banking sector also has attracted interests from researchers given its impact on the stability and efficiency of the whole banking system and social welfare. Banking competition is expected to lower monopoly power of banks and reduce banking prices, which in turn will impact positively on investment and economic growth. These expected gains are important in countries where bank credit represents the largest source of external financing for firms (Pruteanu-Podpiera, 2007). High competition should also encourage banks to reduce their operation costs (costs of inefficiencies, because in a competitive market, no single bank will be able to change market price).

On the other side, following globalization phenomenon and foreign bank entry in emerging and developing countries, bank concentration and consolidation resulted to bigger institutions and complexities in the system and this raised concerns as it might undermine proper regulations and supervision, eventually leading to the "too big to fail" phenomenon (Beck, 2008). Thus, whether competition on the banking market would favor or not financial stability is an empirical question

In fact, the existing literature and regulatory practice is divided on whether intense competition in the banking sector contributes to its stability or leads to the buildup of vulnerabilities (Schaek et al. 2006). Competition is a socially optimal target for policymakers aiming at reducing the cost of financial intermediaries and increasing the quality of banks services (Simpasa, 2013). However, too much competition may negatively affect banks margins and lead to excessive risk taking by banks with

negative impact on the stability of the banking sector (Allen and Gale. 2003, Carletti and Hartmann 2002). In addition, this debate was made more difficult by the issue of finding appropriate measurement of competition in the banking system and/or stability in the banking system.

The banking sector in Rwanda has evolved in recent years with the entry of new banks especially from the East African region, the number of banks as well as the size of the banking sector have expanded significantly amid banks efforts to increase their outreach. The Rwandan Government drive to enhance financial inclusion also contributed to this positive evolution.

To our knowledge there is one paper published by Sanya and Gaertner (2012) assessing bank competition in East African community using Lerner index and H statistics on data covering the period from 2001 to 2008 which concluded that banking market in Rwanda was less competitive than its neighbouring EAC countries (Kenya, Uganda and Tanzania). However, since 2008, many developments were observed in the banking sector in Rwanda with entry of new foreign banks especially from EAC. In addition, the size of the banking sector has expanded significantly.

The main objective of this paper is to assess the development in the banking sector competition in Rwanda and its possible impact on the stability of the sector.

This paper is organized as follows: the next section reviews the existing literature on competition and financial stability; the third section describes in summary some facts about the banking sector in Rwanda. The fourth section describes the methodology and data to be used in empirical analysis. This includes empirical estimation of competition measures using Lerner Index and Panzar and Rosse H statistics, the most used indicators in empirical studies on competition. The fifth section discusses empirical results and the final section concludes.

2. Literature review

Predictions from theoretical models on relationship between bank competition and stability have diverged. According to Beck (2008), "these predictions might differ in static and dynamic models and have important interactions with elements of the regulatory framework". There are two competing hypotheses namely competition fragility hypothesis and competition stability hypothesis.

According to competition fragility hypothesis, competitive environment can lead to less stability in the banking sector. Beck (2008) identified several channels through which competition may affect banks' stability.

Beck (2008) singled out some models (Marcus' model in 1984, Chan, Greenbaum and Thakor's model in 1986, and Keeley's model in 1990), which predict that more concentrated and less competitive banking systems are more stable, as profits and capital cushions provide a buffer against fragility. This provides incentives against excessive risk taking with a positive effect on financial stability whereas in a competitive environment, banks have strong incentives to take more excessive risks due to pressure on their profits and this result in higher fragility.

The interbank market is another channel by which contagion can spread through the whole financial system. In this model, less competition may lead to more financial stability as perfect competition can prevent banks to provide liquidity to a peer that is experiencing a temporary liquidity shortage. In competitive market where banks are price takers, there is no incentive for bank to rescue its peer by providing liquidity and definitely the failure of that bank with liquidity shortage will negatively affect the whole sector(Allen & Gale, 2003).

Furthermore, it is argued that banks in a more concentrated banking system are likely to be larger, diversify their portfolio and enjoy economies of scale thereby sustaining their stability. However, as put by Beck (2008) this argument, so called competition fragility hypothesis, is about the market structure in banking, not the competition that this implies.

According to competition stability hypothesis, competition will lead to more stability in the banking system. Boyd and De Nicolo (2005) insisted on the potential impact of bank's market power on their behavior. Market power allows banks to charge higher interest rates on loans granted to firms and these may induce the firms to undertake risky activities which results in a higher probability that loans granted turn non-performing.

Another argument for competition stability hypothesis is that policy makers are more concerned in environment of concentrated banking system with fewer banks and this may favor the "too big to fail" policies, which increases incentives for risk taking and banking system fragility (Beck, 2008). Furthermore, larger banks in a concentrated banking system can increase the contagion risk. In addition, these banks are complex and harder to monitor than small banks (Beck, 2008).

While there is still debate on the relationship of the degree of competition in the banking system and banking system stability, the measurement of both bank competition and bank stability has not be similar across all theoretical and empirical studies.

Bank stability is generally measured by considering individual or systemic bank distress. Distress from an individual bank is important as it can spillover the whole banking system. Z score is used in many empirical studies as an indicator of the proximity to the bankruptcy. In some studies the non-performing ratio is also used as a proxy of bank stability (e.g. Boyd et al., 2006).

About measuring competition, the literature is divided into two major groups: the structure conduct performance paradigm using market concentration such as Herfindahl Hirschman Index (HHI) as a proxy of competition. To take into consideration deficiencies in the structural approach, non-structural approach were developed and used to directly assess the competitive conduct of the firms. Lerner index and Panzar Rosse H statistics are good example of this approach.

Some studies have used bank concentration (mostly Herfindahl Hirschmann index) as a proxy for competition. Yet, it is argued that concentration is not an appropriate

measure to gauge the degree of competition have been shown to be ambiguous indicators (Berger et al., 2008). Claessens and Laeven (2004) find no supportive empirical evidence for the intuitively anticipated inverse relationship between concentration and competition.(Schaek et al., 2006) thus the degree of concentration may not be the appropriate indicator for the competitiveness on banks market since concentration does not necessarily imply the lack of competition, as there are other factors which may drive concentration.

The shortcomings of concentration measures reside in the fact that they don't measure the competitive behavior of banks. Alternatively, there are measures of competitiveness such the Lerner index which measures the ability of a given bank to charge the price above the marginal cost. In perfect competition, price and marginal costs should be equal but diverge in less competitive environments, with the prices adjusted for lending risks (Beck 2008). Another measure of competitiveness is the Panzar Rosse H statistics which measures the reaction of output to input prices but this measure requires the state of equilibrium on the market (Sanya and Gaertner, 2012).

As mentioned, there is no consensus on the link between competition and banking system stability as some studies support competition stability hypotheses while others support competition fragility hypotheses. According to Beck (2008) there are some key issues to be taken into account. First, more market concentration does not necessary imply less competition. Therefore testing the relationship between market structure and stability in one hand and competition and stability on the other hand does not necessarily yield the same results. Second, regulatory and supervisory framework can affect this relationship between market structure and/or competitiveness in one hand and banking system stability on the other hand.

Starting with empirical studies on developed countries, Jimenez et Al (2010) studied the case of Spain to assess whether bank competition lead to risk taking as suggested by franchise value paradigm or that market power could lead to risk shifting and less stability (Boyd and de Nicolo model) or if the relationship is U shaped. Using data from more than 100 Spanish banks over the period1988-2003 with Non-performing loans

(NPLs) as a measure of stability and its one period lag, current and lagged real GDP growth, return on assets, size and loan ratio and competition indicator (Lerner index or HHI) as explanatory variables, results from GMM estimation with variables in first differences (to correct for endogeneity) supported the franchise value paradigm that when bank market power increases, bank risk taking decreases. There was little evidence of U shaped relationship (i.e. initially increase in competition reduces risks but if it continues eventually leads to increase in risks) while no evidence for risks shifting paradigm was found.

Similarly, concentration-stability view was supported by empirical findings by Beck, Kunt and Levine (2006), using data on 69 countries over the period 1980-1997 and a logit probability model with various data capturing concentration, bank regulations and macroeconomic conditions as control variables. Their results indicate that more concentrated banking systems are less prone to banking crises. The negative relationship between concentration and crises also holds when conditioning on macroeconomic, financial, regulatory, institutional, and cultural characteristics. Nevertheless, as suggested by Claessens and Laeven (2003), results show that concentration may not be an appropriate measure of the competitiveness of the banking system.

Furthermore, Berger, Klapper & Turk Ariss (2008) had used a database of 8235 banks from 23 industrialized countries. They considered loan risks (NPLs ratio), bank risks (Z-index) and bank equity capital (equity to assets ratio) as proxies of financial stability and include multiple measures of competition such a Lerner index and HHI to check for robustness of the findings. Their study allowed nonlinear relationship between financial stability and market structure, and control for possible endogeneity of the measures of the degree of market power using GMM estimator. Activity restrictions, banking freedom, and the percent of foreign- and government-owned banks were used as instruments to take care of that possible endogeneity of degree of market power. The results obtained also supported competition fragility view as banks with higher market power were found to be less exposed to overall risks. Nonetheless, market power was found to increase loan risks.

On the other side, various empirical studies have supported competition stability hypotheses using different methodologies to measure financial stability. Schaeck and Cihak (2008) and Berger et al. (2008) considered Z-index whereas the recent study by Anginer et al. (2012) consider the co-dependence of banks default risks which reflect systemic stability rather than the individual bank risks. Banks default risks were measured using Merton contingent default framework computed as the difference between the asset value of the firm and the face value of its debt, scaled by the standard deviation of the firm's asset value. Another difference is in Schaeck et al. (2006) who used parametric duration models.

The degree of competitiveness also was measured differently although most of the studies used the Lerner index. Schaeck and Cihak (2008) adopted a different approach by using the Boone indicator which is measure of competition that focuses on the impact of competition on performance of efficient banks. In their approach, they tried to relate competition with banks' efficiency. Two dataset covering the period from 1995 to 2005, one for European banks and another r for US banks were used and results obtained from Granger causality tests confirmed a positive relationship between competition (measured by Lerner index) and efficiency in both European and US banks. Secondly, results from panel model suggest a positive effect of competition (measured by Boone indicator) on banks soundness (measured by Z score) especially in Europe while in US, the effect is weak. In general, results suggest that competition increases banks efficiency and also banks soundness.

Previously, Schaeck, Cihak and Wolfe (2006) had examined the effect of competitiveness in banking sector on its stability in a cross-country setting and how the regulatory environment affect the likelihoods and timing of systemic banks crises. The difference with other studies is the use of parametric duration models with time-varying covariates to examine the timing of systemic banking crises while previous studies had used discrete choice models which simply compute the likelihood of a crisis at some unspecified point in time Using data on 38 countries from 1980 to 2003, including Kenya, the studies support the competition stability hypothesis as competition (measured by Panzar and Rosse H- statistics) significantly decrease the

probability of banks systemic problem and increases the survival time of the banking system, controlling for concentration and regulatory variables.

Recently, Anginer, Demirguc Kunt and Zhu (2012) investigated the empirical relationship between competition and systemic stability, using a different measure of stability as they didn't consider the individual bank risks rather the co-dependence of those risks which reflect systemic stability. The main explanatory variable was the Lerner index as a measure of competition while bank concentration, state policies that restrict competition and state ownership of banks were considered as alternative measures. Bank level (size, leverage, ROA, etc.) and country level (per capita GDP, GDP growth, etc.) control variables were also included. Data were obtained from a sample of 1,872 banks in 63 countries over the period 1997 to 2009. Empirical findings ruled out a tradeoff between competition and systemic stability as concentration and market power, were found to be associated with more systemic fragility. Institutional and regulatory environment were also found to be very important in this relationship as lack of market power has more adverse effect in countries with weak supervision or generous safety nets. Besides, allowing entry, activity restrictions and diversification guidelines reduces systemic fragility particularly in less competitive banking environments.

In emerging countries, Maghyereh and Awartani (2013) investigated the relationship between competition and banking sector stability in Gulf cooperation council countries (GCC), particularly the influence of market structure on risk taking behavior and stability in banking sector, using data from 70 banks spanning from 2001 to 2011. Their study supported a nonlinear relationship between competition and banks stability as market power increases stability up to a certain threshold beyond which this positive relationship reverses. Besides, looking at the interaction between regulation and competition, results suggest that strict regulations would mitigate negative effect of competition on banks stability.

Iskenderoglu and Tomak (2013) investigated the relationship between competition and banking system stability in Turkey using bank level quarterly data from 2002 to 2012. Z index and NPLs ratio were used as measures of banks stability while independent

variables included banks specific variables (assets composition, deposits ratio and bank size) and competition was proxied by Herfindahl Hirschman index for loans, deposits and assets. Their results didn't indicate a clear cut evidence of any influence of competition on banks stability.

Fungacova and Weill (2010) studied the case of Russian banking system and their study concluded to a negative effect of high competition on banking sector stability. Using quarterly bank level data from 2001 to 2007, these results were obtained from a panel logit regression on lagged explanatory variables including Lerner index as a measure of competition, measures of banks size, loans to assets ratio, deposits to assets ratio, government bonds to assets ratio and dummy variables. In addition, using HHI, the study confirmed that concentration reduces the probability of banks failure.

Regarding EAC countries, we have some cross countries studies (e.g. Schaeck et al. 2006; Ruiz-Porras, 2007) including the Kenyan banking sector. As previously mentioned Schaeck et al. (2006) considered the period 1980 and 2003 and used H statistic as a measure of competition for the case of 38 countries including Kenya. The study indicates that more competitive banking systems are less prone to systemic crises (using logistic probability analysis) and that time to crisis is longer in a competitive environment (using duration analysis), even when controlling for concentration and the regulatory environment.

A recent study by Sanya and Gaertner (2012) attempted to empirically measure the degree of competition and assess the factors behind it. They estimated both Lerner index and Panzar Rosse H statistic for Kenya, Uganda, Tanzania and Rwanda for the period 2001-2008 and concluded that the structure of the EAC banking systems can be considered as a monopolistic competition. They found that Kenya has the most competitive market followed by Tanzania, Uganda and Rwanda. In addition, they found that in EAC banking system, competition is linked to the level of economic development, the contestability of markets and the quality of institutions. Market concentration reduces competition whereas institutional development (proxied by index of property rights enforcement) increases competition. Bank lending and market

size (proxied by population) also positively affect competition while bank size, foreign owned banks, state owned banks and liquidity preferences negatively affect competition. Besides, banks in EAC are less competitive in higher inflation environment while higher GDP per capita favours competition.

In summary, reviewed empirical studies have given mixed results, some supporting competition stability view others competition fragility view. In addition, we have noticed differences in methodologies, particularly about the measurement of competition and stability of the banking sector. Two measures of competition have been extensively used; the Lerner index and H statistics. To check the robustness of results some studies have used HHI and Boone indicator. Measurements of financial stability Z- index or non-performing ratio have been widely used. Some studies have also used a discrete measure of whether or not a banking crisis happened or not. In terms of estimation techniques, some studies used GMM panel estimation while others used logistic probability analysis or duration analysis. Lastly, some studies have focused on the role of the quality of institutions (e.g. legal and regulatory framework) in the relationship between competition and financial stability.

3. Banking sector in Rwanda

Following the financial liberalization which started in early 1990s but became fully-fledged in 1995, the Rwandan banking sector has been evolving in a positive direction.

Table 1: Banking institutions in Rwanda

Institution	Number of Institutions
Banks	**16**
Commercial banks	10
Development banks	1
Cooperative banks	1
Microfinance banks	4
Microfinance institutions	**491**
UMURENGE SACCOs	416
Other SACCOs	62
Microfinance institutions LTD	13

Source: BNR, Financial Stability Directorate

Looking at the number of banks, prior to1995, there were only five banking institutions (BCR, BK, BACAR, Caisse d' Epargne du Rwanda and BPR) and one development bank (BRD). Currently the number of commercial banks has doubled to 10. In addition there are one development bank, one cooperative bank, 4 microfinance banks and 491 microfinance institutions.

The banking sector accounts for the biggest part of the whole financial sector with 66.9% of the total financial sector assets. Following various reforms in financial sector, the outreach of the banking sector has been expanding as shown by the evolution of the financial deepening indicators such as broad money to GDP, credit to private sector GDP and deposits to GDP. These have grown from 18.7%, 12.3% and 15.6% in 2006 to 22.7%, 16.8% and 20.5% in 2014 respectively.

3.1. Banking market structure and concentration

With financial liberalization and entry of new banks on the market, the banking market structure also evolved. The share of 3 largest banks in terms of assets, deposits and loans of the three largest banks, significantly reduced in the last eight years to around 50% in 2014 from 65% in 2006.

Similarly, looking at concentration in the whole commercial banking sector as measured by Herfindahl Hirschman index (HHI), this has improved over time. Since 2009, the market is less concentrated (HHI for assets loans and deposits around 0.13 in 2014) and approaching "high competition" (Karangwa & Nyalihama, 2014). This improvement is due various factors including entry of new banks (including foreign-owned ones) in the banking industry.

Regarding the banking system soundness, the Rwandan banking system has generally been healthy and sound. Financial soundness indicators such capital adequacy has remained at a satisfactory level while other such as non-performing ratio significantly improved. On this, the non performing ratio fell from 23.4% in 2006 to 6.4% in 2014. The profitability indicators have generally remained steady in recent years. On average in the last three years, the return on assets ratio (ROA) was around 2%, return on

equity (ROE) at around 12.5% and net interest margin at around 9.5% in the commercial banks sector.

4. Methodology

In this study, we analyze the impact of the banking sector competition on the sector stability in Rwanda using quarterly data covering the period from 2006 to 2013. Before we analyze the effect of competition in banking sector to financial stability, we first discuss methodology of computing indicators of competition and stability of the banking sector.

Following Schaek and Cihak (2008) and Berger et al (2008), we use Z-index as proxy of bank sector stability in Rwanda. Z-index is an inverse proxy for the firm's probability of failure. According to Boyd et al. 2006, "Z-index represents the number of standard deviations below the mean by which profits would have to fall so as to just deplete equity capital". It is a single measure which combine profitability, leverage, and return volatility and is usually derived as follows:

$$Z_i = \frac{ROA_i + E/TA_i}{\sigma_{ROA_i}} \qquad (1)$$

Where

ROA_i is the period average return on assets for bank I which is an indicator of bank profitability and is calculated by dividing net profit after tax by average value of total assets.

E/TA_i is the period equity to total assets ratio for bank i; which is obtained by dividing the period total shareholders' funds (paid up capital, share premium, total reserves) by period banks' total assets and can be an indicator of overall bank risks.

σ_{ROA_i} is the standard deviation of return on assets over the period under study. It measures volatility in banks' returns.

Z index increases with higher profitability and capital level, implying more stability at bank level, it decreases with high volatility in banks earnings.

About measurement of banking sector competition, in this paper we use non-structural measures of competition such as Lerner index and Panzar Rosse H statistics, because they help to understand the nature of competition by observing conduct directly as they measure reaction of banks output to changes in input prices. "The Lerner index or price cost margin is one of popular measures of market power in empirical research" (Leon, 2014). It measures the market power by measuring the divergence between the firms' price and its marginal cost. In a perfect competition, price and marginal cost should be equal and there will be a markup in a less competitive sector (Leon, 2014).

$$\text{Lerner}_{it} = \frac{(P_{it} - MC_{it})}{P_{it}} \qquad (2)$$

Where i denotes bank i, and t denotes period of time t. $P_{it}$is the ratio of total revenues (sum of interest income on advances, on government securities and other financial instruments, on placement and noninterest income such as commission, foreign exchange income, off balance sheet income and other income) to total assets for bank i at time t, and $MC_{it}$is the marginal cost for bank i at time t.

The index is known by economists since mid-1930s but started to be used in the banking sector during the last two decades due to the difficulty of measuring the marginal cost. Using the intermediation approach, cost function of banks was developed from a translog cost function using total assets as bank output and labor, deposits and physical capital as banks' inputs (Leon, 2014). The translog function is generally specified as follows:

$$\text{LnCost}_{it} = \beta_0 + \beta_1 \ln Q_{it} + \frac{\beta_2}{2} \ln Q_{it}^2 + \sum_{k=1}^{3} \gamma_{kt} \ln W_{k,it} + \sum_{k=1}^{3} \emptyset_k \ln Q_{it} \ln W_{k,it} + \sum_{k=1}^{3} \sum_{j=1}^{3} \ln W_{k,it} \ln W_{j,it} + \varepsilon_{it} \qquad (3)$$

Where Cost_{it} is the total operating cost plus interest expenses for bank i at time t. In details, this is a summation of interest expenses on deposits, other interest expenses,

provision for bad debts, salaries, wages and staff costs, premises, depreciation and transport expenses and other expenses;

Q_{it}, is total assets and is a proxy for the bank output;

$W_{k,it}$ is the price of a bank's three main inputs(labor, funds and fixed capital).

Input prices for labor, funds, and fixed capital are calculated as the ratios of personnel expenses to total assets, interest expenses to total deposits, and other operating and administrative expenses to total asset respectively (Sanya & Gaertner, 2012).

$$MC_{it} = \frac{cost_{it}}{Q_{it}}\left[\beta_1 + \beta_2 \ln Q_{it} + \sum_{k=1}^{3} \emptyset_k \ln W_{k,it}\right] \qquad (4)$$

The Panzar Rosse H statistics measures how much a change in input prices is reflected in revenue earned by a firm at the equilibrium. Under a monopoly, an increase in input prices will increase marginal costs, reduce equilibrium output and consequently reduce total revenues. Under perfect competition, an increase in input prices will increase both marginal costs and total revenues by the same amount as costs rise (Sanya & Gaertner, 2012). Thus, "a weak transmission of input prices on firms' revenues indicates market power in pricing while high values indicate more competition" (Leon, 2014). The H-statistic is estimated from a reduced form log-linear bank revenue equation as follows:

$$\ln(P_{it}) = \alpha + \beta_1 \ln(W_{1,it}) + \beta_2 \ln(W_{2,it}) + \beta_3 \ln(W_{3,it}) + \gamma_1 \ln(Y_{1,it}) + \gamma_2 \ln(Y_{2,it}) + \gamma_3 \ln(Y_{3,it}) + \delta D + \varepsilon_{it} \qquad (5)$$

Where:

P_{it}, $W_{1,it}$, $W_{2,it}$, $W_{3,it}$ are as defined previously;

$Y_{1,it}$ is the ratio of equity to total assets ;

$Y_{2,it}$ is the ratio of net loans to total assets which is proxy of credit exposure; net loans is equal to total loans and overdraft minus provision;

$Y_{3,it}$ is the total asset as proxy of bank size

D is a vector of dummy variables.

H statistics is the sum of the elasticities of the total interest revenues of banks with respect to their factor prices:

$$H = \sum_{i=1}^{3} \beta_i \qquad (6)$$

H statistics should vary between 0 and 1 with less or equal to 0 being a monopoly, between 0 and 1 as a monopolistic competition and 1 a perfect competition. However the H statistics is valid only when the market is in long run equilibrium. This is formally tested by using the following equation (e.g. Demirguc Kunt and Martinez Peria 2011).

$$\ln(ROA_{it}) = \alpha + \beta_1 \ln(W_{1,it}) + \beta_2 \ln(W_{2,it}) + \beta_3 \ln(W_{3,it}) + \gamma_1 \ln(Y_{1,it}) + \gamma_2 \ln(Y_{2,it}) + \gamma_3 \ln(Y_{3,it}) + \delta D + \varepsilon_{it} \qquad (7)$$

ROA is the average return on assets. As ROA can be a negative value, the dependent variable is computed as natural logarithm of (1+ROA). The test of long-run equilibrium involves testing whether E= β1 + β2 + β3 =0.

In order to assess the effect of banks competition on the financial stability we estimates the following model:

$$\text{Stability}_{it} = \alpha_0 + \alpha_1 \text{Stability}_{it-1} + \alpha_2 \text{competition}_{it} + \sum_{j=3}^{n} \alpha_j \text{ Bank specific}_{j\,i\,t} + \sum_{j=n}^{m} \alpha_j \text{ macro conditons}_{j\,i\,t} + \varepsilon_{it} \qquad (8)$$

For stability measures, we considered Z-index as in most of reviewed studies. As measure of competition we use Lerner index as well as the concentration index (HHI). Banks specific measures include size, assets share, efficiency and credit risk. The size is proxied by the total assets of each bank in natural logarithm. The assets share is each bank's assets proportion in total assets of the banking system. Efficiency is

proxied by the ratio of non-interest operating cost (sum of labor expenses and other expenses) over total income whereas credit risk is proxied by the ratio of provision for bad debt to total income.

Macroeconomic conditions include the measure of financial deepening proxied by the ratio of broad money to GDP and real GDP growth. An indicator of regulatory environment namely the indicator of strength of legal rights is also considered.

Most of data on legal and regulatory environment such as activities restrictions and banking freedom were not available for the whole sample period in Rwanda. The indicator of strength of legal rights was the only one available.

A sample of 6 commercial banks (BK, I&M BANK, ECOBANK, GT BANK, COGEBANQUE, ACCESS BANK) representing 75% of the total assets of commercial banking system was used and data were obtained from consolidated financial quarterly report from BNR Financial Stability Directorate, covering the period from 2006 to 2013 and data are annual. The remaining data were obtained from Monetary Policy Directorate and data on legal environment are from World Bank database.

In this section we analyze the evolution of bank level data and macroeconomic data used in the estimation of various models.

Starting with average return on assets by bank, this is calculated by dividing net profit after tax by average value of total assets and is an indicator of banks profitability. From 2006 to 2013, return on assets in sampled banks has not changed much overtime, averaging around 1.9% for the last five years and the disparities in profitability by bank has slightly waned from an average of 0.059 standard deviation between 2006 and 201n to 0.012 in 2013..

Banks' profits are the difference between total income and total expenses for a given period. Total income and total expenses components and their respective shares on average between 2006 and 2013 are displayed in the next table:

Table 2: Income and expenses components shares in 6 sampled banks (average from 2006 to 2013)

INCOME	Share	EXPENSES	Share
Interest Income/ Advances	0.46	Interest Expense – Deposits	0.19
Interest Income/ Govt Securities	0.04	Other Interest Expenses	0.02
Interest Income on placement	0.06	Provisions for Bad Debts	0.16
Interest Income - Others	0.00	Salaries, Wages, staff costs	0.27
Commissions	0.09	Premises, Depreciation, Transport	0.11
Foreign Exchange Income	0.16	Other Expenses	0.24
Income – Off Balance Sheet	0.01		
Other Income	0.19		

Source: BNR, Monetary Policy and Research Department

On income side, a half of banks' income source was from interest from loans and advances (46%) followed by income from forex operations (16%) whereas banks expenses seem to be relatively well distributed between key expenses items compared to income sources. Salaries and staff costs weigh more on banks costs with 27%, while interest expenses and provision for bad debts represents (19% and 16% of total cost respectively).

Equity to total assets ratio by bank is obtained by dividing the period total shareholders' funds (paid up capital, share premium, total reserves) by period banks' total assets and this is a measure of overall bank risks. On average, the risk in sampled banks has been gradually going up from 8.7% in 2006 to 13.6% in 2014.

The price is proxied by ratio of total income to total assets by bank. As shown in the previous table, total income is the sum of interest income on advances, on government securities and other financial instruments, on placement and noninterest income such as commission, foreign exchange income, off balance sheet income and other income. Between 2006 and 2013, the price proxy has marginally increased from 13.3% in 2006 to 14.5% in 2013 and averaged around 15% for the whole period. Disparities between banks have almost disappeared in recent periods.

The total operating cost plus interest expenses for sampled banks have been gradually expanding during the period under review. Total cost is a summation of interest expenses on deposits, other interest expenses, provision for bad debts, salaries, wages and staff costs, premises, depreciation and transport expenses and other expenses.

Similarly, total assets by bank which is a proxy for the bank output have been trending upward on average although the disparities between banks have persisted.

Regarding evolution in three main inputs prices by bank, both labor price (ratio of labor cost to total assets) and funds prices (ratio of funds cost to total assets) have moderately increased during the sample period averaging 3.4% and 3.1% respectively whereas fixed capital prices remained relatively steady. Disparities between sampled banks are not that significant.

The credit exposure also didn't move much during the period under review, averaging 46.9% and the difference between banks are small. Net loans are equal to total loans and overdraft minus provision.

Regarding banks efficiency, it has been quite stable around 52% on average and there has not been much improvement although some banks has performed well in recent period. The efficiency is proxied by the ratio of operating cost over income.

Regarding the credit risk which is calculated as ratio of provision to interest income, it averaged around 32% and the last three years were characterized by a gradual decline in credit risks as well as differences in credit risks across banks.

Regarding the macroeconomic indicators, financial deepening calculated as a ratio of broad money to GDP shows sign of progress, averaging 20% from 2006 to 2013 whereas real GDP growth averaged 7.8% and remained well high compared to Sub Saharan Africa average.

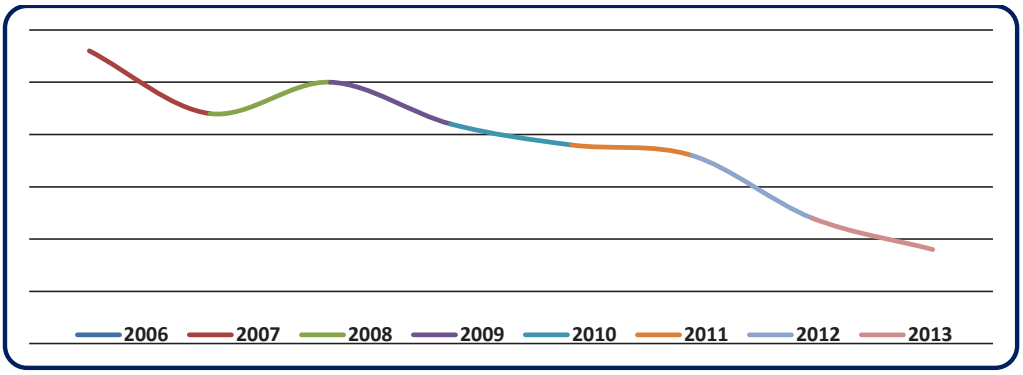
5. Empirical results

Firstly, the empirical estimation focused on measuring competition in the Rwandan banking sector using Lerner index and Panzar and Rosse H statistics.

Regarding Lerner index, equation 3 was estimated using annual panel data in order to obtain coefficients used in calculating the marginal costs, using bank specific fixed effects and period fixed effects. Although some coefficients were not statistically significant, other diagnostic test for the model were satisfactory. From the estimated

equation we have derived the marginal costs and the Lerner index were subsequently calculated for each bank. The following chart displays the evolution of the Lerner index and shows a declining trend, implying that the banking market has been becoming more competitive especially since 2008.

Chart 1: Evolution of Lerner index



Source: BNR, Monetary Policy and Research Department

Table 3: Lerner Index

Year	2006	2007	2008	2009	2010	2011	2012	2013
Lerner Index (average)	0.48	0.42	0.45	0.41	0.39	0.38	0.32	0.29
Standard deviation	0.12	0.17	0.14	0.12	0.18	0.12	0.12	0.06

Source: BNR, Monetary Policy and Research Department

Previously, Sanya and Gaertner (2012) had found Lerner index of 0.41 in year 2008 for Rwanda using data from 2001 to 2007. Our result clearly indicates a good progress in banking sector competition Rwanda since 2008.

We have also calculated Panzar Rosse H statistic from estimated coefficients in equation 5, using panel fixed effect. The results were expected as the increase in cost of inputs lead to a hike in banks prices. The main evidence to highlight is the significant and positive effect of labor cost and fixed capital cost on pricing behavior of commercial banks in Rwanda whereas the effect of funds cost is marginal. The increase in credit exposure also would lead to increase in prices charged by commercial banks.

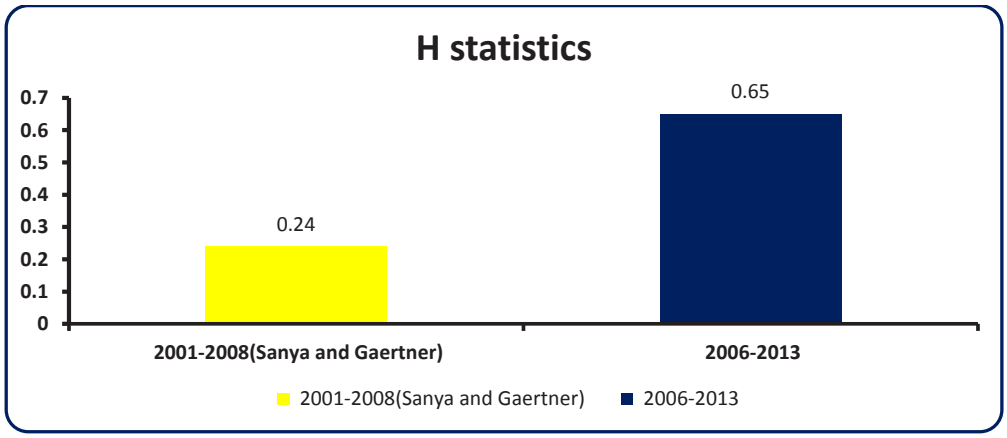
Table 4: Panel fixed effects results for equation 5(H statistics)

Dependent variable	Log Price		
Variables	Coefficients	Robust Std errors	Probability
labor price	0.154	0.043	0.001
Funds price	0.049	0.031	0.126
Fixed capital price	0.455	0.048	0.000
Size (ln assets)	0.073	0.044	0.110
credit exposure	0.136	0.046	0.005
Equity to assets ratio	-0.113	0.030	0.001
C	-0.195	0.464	0.677
R-squared	0.853		
Adjusted R-squared	0.809		

Source: BNR, Monetary Policy and Research Department

Recall that the H statistic is the sum of β1, β2 and β3 which are bank's revenue elasticity of labor input, funds and fixed capital respectively. The obtained H statistic for the period 2006-2013 is 0.65, higher than 0.24 previously obtained by Sanya and Gaertner (2012) for the period 2001-2008. Hence, the H statistic also confirms that competition has been increasing in the banking sector market in Rwanda. Secondly this value between 0 and 1 imply that banks are operating in monopolistic competition.

Chart 2: Evolution of H statistics



Source: BNR, Monetary Policy and Research Department

Following Demirguc-Kunt and Martinez Peria (2013), we estimate equation 6 to test for long run equilibrium and we use period fixed effects. The null hypothesis that the sum of β1 β2 and β3 obtained from estimation is equal to zero is rejected by Wald test at 5% level, with F statistics equal to 5.912 (p=0.02) and chi-square equal to 5.912 (p=0.015). Thus to test for the impact of banking sector competition on the banking sector stability, we use Lerner index a s a measure of competition.

Table 5: Panel fixed effects results for equation 7

Dependent variable	**Log ROA**		
Variables	**Coefficients**	**Robust Std errors**	**Probability**
labor price	0.024	0.010	0.021
Funds price	-0.017	0.011	0.125
Fixed capital price	-0.049	0.010	0.000
Size (ln assets)	-0.002	0.005	0.761
credit exposure	0.021	0.022	0.329
Equity to assets ratio	0.025	0.012	0.045
C	-0.053	0.063	0.400
R-squared	0.533		
Adjusted R-squared	0.355		

Source: BNR, Monetary Policy and Research Department

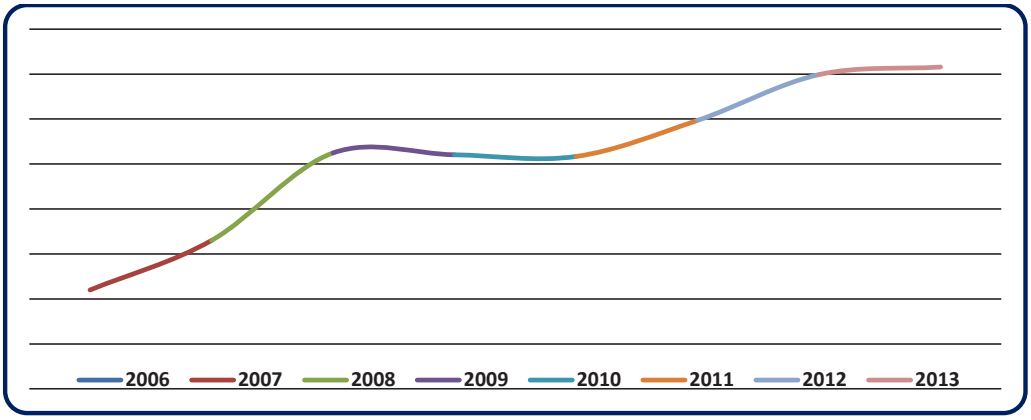
Table 6: Wald Test

Test Statistic	**Value**	**Probability**
F-statistic	5.912	0.020
Chi-square	5.912	0.015

Source: BNR, Monetary Policy and Research Department

Before assessing the impact of competition on stability in the banking sector, we first estimate the Z-index which is an inverse proxy for the firm's probability of failure. The next chart and table shows an increase in Z index, indicating an improvement of banking sector stability overtime. Nevertheless, disparities in degree of stability between banks have also amplified as shown by standard deviations.

Chart 3: Evolution of Z index



Source: BNR, Monetary Policy and Research Department

Table 7: Z- Index

Year	2006	2007	2008	2009	2010	2011	2012	2013
Z-Index (average)	8.4	10.6	14.5	14.4	14.3	15.9	18.0	18.3
Standard deviation	4.4	5.4	8.4	6.8	6.2	6.5	8.6	9.6

Source: BNR, Monetary Policy and Research Department

The equation 7 was estimated in order to investigate the relationship between bank competition and bank stability in Rwanda with the Z-index in logarithm as dependent variable, Lerner index as an indicator of competition and a set of bank specific variables including the bank assets share, the size and efficiency. In addition, the indicator of legal strength was included and the ratio of M3 to GDP as a macroeconomic variable. The Arellano Bond GMM estimation method was used as some variables were obviously endogenous and in order to capture dynamics. The Arellano Bond GMM estimation uses instrumental variables which are the lagged values of the dependent variable.

The results obtained[4] from Arellano Bond GMM estimation with robust standard errors indicated a positive relationship between the Lerner index and Z-index, implying that some market power would lead to more stability. Nonetheless, the effect

[4] These results were obtained after removing the macroeconomic variables as with the GDP or M3/GDP included, they were consistently dropped and Lerner index not statistically significant

from assets share is rather negative and small (-0.09). The remaining coefficients were not statistically significant. Regarding the diagnostic test, we couldn't obtain the Hansen J test for instruments validity as the constant were also dropped from results.

Table 8: Arellano Bond dynamic panel data estimation results

Dependent variable	**Log Z-index**		
Variables	**coefficients**	**Robust Std errors**	**Probability**
lZ_index(-1)	0.575	0.618	0.35
Lerner	1.967	0.951	0.039
Assets share	-0.09	0.02	0.000
Size	0.451	0.36	0.21
Legal	-0.062	0.04	0.11
Efficiency	-0.0008	0.003	0.80
Wald (chi 2)	578.9 , prob: 0.000		

Source: BNR, Monetary Policy and Research Department

Following Berger et Al. (2008), we allowed non-linearity in the relationship between competition and stability in the banking system by including the squared Lerner index in the model.

Table 9: Arellano Bond dynamic panel data estimation results (including Lerner squared)

Dependent variable	**Log Z-index**		
Variables	**Coefficients**	**Robust Std. Err.**	**Probability**
lZ_index(-1)	1.63	1.02	0.110
Lerner	11.1	5.92	0.060
Lerner squared	-13.5	7.15	0.050
Assets share	0.21	0.164	0.180
credit risks	-0.004	0	0.000
constant	-6.04	5.59	0.280
Wald (chi 2)	1258.23 , prob: 0.000		
Hansen J Test	prob: 1.000		

Source: BNR, Monetary Policy and Research Department

The results[5] obtained indeed confirmed that the relationship is non-linear as the coefficient of Lerner squared is statistically significant and negative, implying that even though some market power would promote stability, increase in market power beyond a certain inflexion point would at the end lead to fragility in the banking system.

The diagnostic tests of the model were satisfactory as the Hansen J test confirmed the validity of instruments used and there is no autocorrelation in first differenced errors.

In summary, the results obtained would suggest that in Rwanda, there are some evidences that some market power is associated with less risk exposure in the banking system, thereby supporting the competition-fragility view. In other words, market power leads to profits and capital cushions which provide a buffer against fragility in the Rwandan banking system whereas fierce competition in the banking system is likely to negatively affect their profitability and increase their overall risks exposure.

Nevertheless, the negative coefficient on the quadratic Lerner index in our results suggest that beyond a certain point (basing on the results obtained this would be around 0.41), more market power would increase the overall risks exposure in the Rwandan banking system. In other words, charging excessively higher prices would lead to build up of systemic fragilities in the banking system. This partially supports the competition stability view.

[5] This new estimation also excluded the macro indicators, the latter was included in first estimation and the results confirmed non-linearity, however, the Hansen J test couldn't be established

6. Conclusion and Policy implications

The objective of this study was to empirically investigate the relationship between bank competition and financial stability in Rwanda. There is no consensus in the existing literature on the effect of competition on financial stability as some theoretical and empirical studies have supported the competition fragility view that more market power leads to less stability in the banking system, while others concluded to the opposite, supporting competition stability view that more competition lead to more stability in banking system.

Firstly, the present study empirically estimates indicators of competition and bank stability. Regarding the degree of competition, the obtained Lerner index and Panzar Rosse H statistics as proxies of competition show that banks are operating in a monopolistic competition where they are able to set the price above the marginal cost. However, evolution of the Lerner index as well as the Panzar Rosse H statistics shows that competition has been improving overtime since 2008.

About the measure of overall stability in the banking system, the derived Z-index as a proxy of financial stability indicates an improvement in Rwandan banking sector stability overtime especially since 2010.

The relationship between competition and financial stability was empirically tested, using panel data from 6 commercial banks from 2006 to 2013. The results from Arellano Bond GMM estimation tend to support the competition fragility view as market power was found to be associated with less risk exposure in the banking system. However, by allowing non linearity in this relationship, the results indicate that this positive relationship will hold up to a certain inflexion point beyond which more market power may lead to more risk exposure in the banking system.

Therefore, it would be preferable in Rwanda that banks continue to operate in a monopolistic competition where they have some market power to charge more than their marginal costs. However, it is important that this market power should not be excessive as it can build up fragilities in the system. Understanding the link between competition and stability in the banking sector has become very relevant for the macro

prudential analysis of the banking sector, especially after recent financial crisis. Our results indicate that BNR as regulation of the banking sector should reinforce its macro prudential framework to continuously capture the impact of banks conduct on the stability of the sector.

Besides, given that the current level of pricing in banking sector is relatively higher, it is paramount for banks to be more efficient by progressively reducing their marginal costs. These would give banks a room to cut prices charged to their customers without putting into jeopardy the stability of the banking system.

Lastly, future research on this topic should include more banks in order to get comprehensive view on the effect of competition on bank stability. When data on regulatory framework are available, future research could also check the effect from interaction between competition and regulatory framework on banking sector stability.

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An empirical investigation of exchange rate pass-through to inflation in Rwanda

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Abstract

The paper examines the degree of exchange rate pass-through to inflation in Rwanda using structural vector autoregressive model (SVAR) based on data spanning the period 2000Q1 to 2014Q3. The empirical analysis starts with testing the stochastic properties of data and we find most variables integrated of order I (1) save for output gap. Accordingly, we proceed by estimating the SVAR model and the resultant impulse responses as well as variance decomposition.

The major finding reveal that exchange rate pass-through in Rwanda is low but significant with a dynamic exchange rate pass through elasticity of 0.28. This defies conventional wisdom in the literature that ERPT is always substantially higher in developing and emerging economies than in developed economies. This result looks plausible for Rwanda because Rwanda has registered stable exchange rate and inflation over the sample period. However, the dynamic pass-through elasticity of 0.28 still depict exchange rate as an important source of inflation in Rwanda. The policy implication arising from these findings is that the monetary authority (BNR) should be closely track exchange rate movements so as to take appropriate monetary policy action to limit inflationary pressure from the exchange rate depreciation.

Key words: Exchange rate pass through, inflation, SVAR Model, Rwanda

JEL classification: E31, F31, F42

1. Introduction

In open economies exchange rate fluctuations affect the behavior of inflation and this makes exchange rate pass through an important consideration with respect to monetary policy and macroeconomic stability in general. The impact of the exchange rate to inflation is broadly termed as the exchange rate pass through to inflation (ERPT).

The exchange rate remains one of the factors connecting national economies and has been among causes of some regional or global financial crises. One of the most challenging issues in the conduct of monetary policy in developing countries particularly small open economies like Rwanda is exchange rate pass- through given its expected impact on changes in domestic prices.

The thorough understanding of exchange rate pass-through is of particular importance for several reasons. The knowledge of the degree and timing of pass-through are essential for the proper assessment of monetary policy transmission on prices as well as for inflation forecasting. In addition, the degree of exchange rate pass-through has important implication for "expenditure-switching" effects from the exchange rate.

In Rwanda, the need to understand the exchange rate pass-through is underpinned by the fact that the Rwandan economy is open and as such shocks from global commodity markets have serious implications on the economy mainly through the cost of imports. In addition, the need to make the external sector competitive through appropriate exchange rate adjustment has made the study of exchange rate pass-through in Rwanda imperative.

Indeed, the relationship between exchange rate and prices has been extensively studied but few studies relate to sub-Saharan Africa (SSA). In general, country specific studies find low and incomplete exchange rate pass- through to inflation and the findings from these studies paint a mixed picture at best.

To the best of our knowledge, little has been done to estimate ERPT to domestic prices in Rwanda. However, Gichondo and Kimenyi (2012) in their effort to identify the main

drivers of inflation in Rwanda identified exchange rate depreciation as one of the causes of inflation in Rwanda.

The objective of this study is to estimate the degree of ERPT in Rwanda and understand how the exchange rate channel of transmission mechanism works taking into account the recent changes in macroeconomic environment.

The rest of the paper is organized as follows. Section II discusses an overview of nominal exchange rate and inflation developments in Rwanda. Section III reviews the related literature. Section IV discusses the data and methodology. Section V presents the empirical analysis and Section VI presents conclusion and policy recommendations.

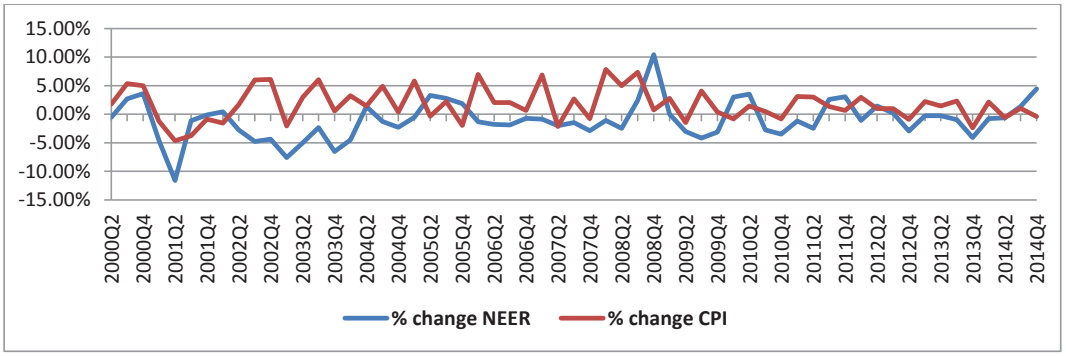
2. Overview of nominal exchange and inflation developments in Rwanda

The exchange rate policy in Rwanda is broadly characterized by two distinct periods; the period of fixed exchange rate system and the period of a more flexible exchange rate system.

During the fixed exchange rate system from 1964 to 1990, foreign currencies of the banking system were held by the central bank, it was the sole institution authorized to carry out exchange transactions. The FRW was initially pegged to the Belgian franc, then to the American dollar and finally to the special drawing rights (SDR). Its value did not reflect economic reality due to lack of exchange rate flexibility (Himili, 2000). During this period, the exchange rate seemed to be overestimated; causing the rising of effective prices of Rwandan exports and loss of competitiveness on the international market. However, many reforms of exchange rate system were undertaken since 1990 to correct the overvaluation of FRW and improve external competitiveness.

The statutory order n° SP 1 of 3rd March 1995 organizing the foreign exchange market instituted a flexible system of FRW exchange. In this new system, the exchange rate is market driven, BNR intervening on foreign market to smoothen the volatility of exchange rate.

Figure 1: Nominal exchange rate and Inflation



Source: BNR, statistics Department

Figure 1 above, shows that over the sample period, movements in consumer price index has moved in tandem with exchange rate. The table below presents descriptive statistics in inflation and nominal exchange rate. The variation in both inflation and nominal exchange rate have been minimal, averaging 4.16 and 4.73 in inflation and nominal exchange rate respectively while the standard deviation is 0.33 and 0.21 for inflation and nominal exchange rate respectively. This is because Rwanda has registered both stable exchange rate and inflation except for some periods like 2008 where we observe a surge in both variables as a reflection of global financial crisis.

Table 1: Variation in Inflation and Nominal Exchange rate

	LNCPI	NEER
Mean	4.168506	4.737448
Median	4.178991	4.665700
Maximum	4.616110	5.259212
Minimum	3.641380	4.512506
Std. Dev.	0.339898	0.209181
Skewness	-0.166727	1.261046
Kurtosis	1.534311	3.284091
Jarque-Bera	5.648589	16.10413
Probability	0.059351	0.000318
Sum	250.1104	284.2469
Sum Sq. Dev.	6.816325	2.581637
Observations	60	60

Source: Author's estimation

3. Literature review

3.1. Theoretical Literature

The exchange rate pass -through to inflation (ERPT) is defined as the percentage change in consumer prices following a one percentage change in exchange rate. A one to one response of consumer prices to exchange rate is known as complete ERPT while a less than one to one is known as partial/incomplete ERPT. The exchange pass-through to domestic prices has gained considerable significance in both theoretical and empirical literature given that most countries are interlinked to the rest of the world with the increased incidence of large fluctuations in nominal exchange rate that has evoked interest in the exchange rate pass through.

As in Sanusi (2010), the general literature distinguishes between direct and indirect channels[6] through which changes in the exchange rate may be transmitted to consumer prices. The direct channel of movements in the exchange rates on domestic prices is through prices of imported consumer goods or through domestically produced goods priced in foreign currency. While the indirect channel is via changes in prices of imported intermediate goods due to movements in the exchange rate, which may influence costs of production.

Choudhri and Hakura (2006), in their policy debate for the contemporaneous monetary and exchange rate policy implementation reveal the degree to which changes in exchange rates or import prices impact or pass-through into domestic consumer prices.

They conclude that a low exchange rate pass-through provides policy makers freedom to pursue an independent monetary policy.

Campa and Goldberg (2002) show that low import price pass-through of nominal exchange rate fluctuations lead to lower expenditure-switching effects in the domestic economy, thereby leaving monetary policy free to deal with real shocks. Otherwise, shocks due to the pass-through effects of import prices and exchange rates make the domestic economy fragile and susceptible to trade linkages. Using data from the OECD

[6] See a flow chart on direct and indirect channels of exchange rate pass through by la fleche(1996)

countries, they find that macro variables do not have high explanatory power in describing the pass through process. Instead, the composition of industries in a country's import basket plays a much more important role in determining the pass-through. In this sense, the import price pass-through would mainly reflect the pricing behavior of foreign firms.

Frankel et al (2005) give a brief summary of the factors affecting exchange rate pass-through for the developed and developing countries. They conclude that exchange rate pass-through effects have historically been much higher in poor countries than in rich ones and are significantly higher in an environment of high inflation. They observe that pass-through effects have declined significantly in the 1990s due to price discrimination by firms in different countries where foreign producers adjust their markups to maintain a stable market share in the domestic economy thereby reducing the rate of pass-through (Korhonen and Wachtel, 2006).

Garcia and Restrepo (2001) observe that the exchange rate pass-through has been low for Chile and conclude that exchange rate pass-through depends on economic activity. Declines in economic activity reduce the output gap and compensate for the inflationary impact of exchange rate depreciations. Goldfajn and Werlang (2000) find that the cyclical component of output is the main determinant of the inflationary pass-through of exchange rate depreciation.

Taylor (2000) contend that lower and more stable inflation is a factor behind the reduction in the degree of pass-through into the firms' own prices.. Using a model of firm behavior based on staggered price setting and monopolistic competition, he explains that since firms set prices for several periods in advance, their prices respond more rapidly to cost increases in the resources they purchase due to exchange rate depreciations if such changes are perceived to be persistent. Regimes with higher inflation tend to have more persistent cost changes. A high inflation environment would thus tend to increase the exchange rate pass-through. Evidence from the U.S. supports such an explanation where relatively low persistence of inflation and the monetary policy that has delivered it have led to lower pass-through through a reduction in the expected persistence of cost and price changes.

3.2. Empirical Literature

Empirical studies on the exchange rate pass-through to domestic prices are based on different theoretical frameworks, empirical models and sample spans which often produce divergent results.

Kim (1998) investigates exchange rate pass-through in the United States using multivariate cointegration framework. He relates changes in producer prices to changes in the trade weighted nominal effective exchange rate, money supply, aggregate income and interest rates. The exchange rate is found to contribute significantly to producer prices.

Goldfajn and Werlang (2000) conducted a study of 71 countries, where exchange rate pass-through into consumer prices is investigated using panel estimation methods on data from 1980 up until 1998. Both developed and emerging market economies are included in their study. They report that the pass-through effects on consumer prices increase over time and reach a maximum after 12 months. The degree of pass-through is, furthermore, found to be substantially higher in emerging market economies than in developed economies.

Mwase (2006) using quarterly data for the period 1990-2006 and an SVAR model, quantifies the exchange rate pass-through for Tanzania: first for the full sample; and second for two sub-periods, i.e. periods prior to and after 1995. He finds pass-through elasticity of 0.028 in the full-sample, and 0.087 in the period before 1995, which however declines to 0.023 after 1995. Overall, he finds that the exchange rate pass-through has declined despite depreciation of the currency and this because the period after 1995 was characterized by exchange rate flexibility but with occasional central bank intervention to stabilize exchange rate.

Nkunde (2006) employs the SVAR framework for the period 1990-2005 and finds an incomplete exchange rate pass-through to inflation for Tanzania, where 10% depreciation was associated with a 0.05% increase in inflation after a two quarter lag.

Sanusi (2010) using an SVAR model applied on quarterly data spanning the period 1983Q3 - 2006Q3 to estimate the pass-through effects of exchange rate changes to consumer prices for the Ghanaian economy and finds that in Ghana the pass-through, although incomplete, is substantially large, with a dynamic pass-through elasticity of 0.79.

Frimpong and Adam (2010) also estimate exchange rate pass through for Ghana using vector auto-regression (VAR) models applied on monthly data for the period 1990-2009. They find incomplete, decreasing and low exchange rate pass-through with 1% depreciation is associated with a 0.025% increase in inflation after a quarter after initial impact and to 0.09% after eight quarters before decreasing sluggishly to 0.07% after twelve quarters of its initial impact.

Rincón (2000) follows the Johansen framework to estimate the pass-through effect for Colombia using monthly data for the period 1980 to 1998 and finds exchange rate pass-through to be incomplete. The estimated long-term elasticities of import and export prices to a change in the exchange rate are 0.84 and 0.61 respectively. The direct long-term effect of the exchange rate on the consumer prices is found to be 0.48.

Anguyo (2008) employs vector error correction model (VECM) to investigate the effect of exchange rate changes on consumer prices in Uganda, Using monthly data for the period 1996M7 – 2007M5. He finds low, significant and persistent exchange rate pass-through to inflation. Specifically, he found that a 1% exchange rate depreciation results in a 0.056% increase in inflation, in the second month.

McCarthy (1999) investigates the effect of exchange rate changes and import prices on producer and consumer prices in a recursive vector autoregressive (VAR) model. Relying on data from 6 industrialized OECD nations, he discovered that exchange rate movements have modest impact on domestic consumer prices.

Leigh and Rossi (2002) employ a recursive vector autoregressive model to investigate the impact of exchange rate movements on prices in Turkey. They find that the impact of the exchange rate on prices is over after about a year, but is mostly felt in the first

four months, the pass-through to wholesale prices is more pronounced compared to the shorter time and is larger than that estimated for other key emerging countries.

Generally, the review of literature on the exchange rate pass through has shed some light on the subject matter. The review has further helped in suggesting a suitable model for estimating the pass through effects, though, empirical literature is not unanimous as to which empirical model is appropriate for estimating ERPT, recent wave of literature seem to be increasingly adopting the SVAR models because it has economic foundations since structural shocks are identified through economic intuition as opposed to other models like basic VAR which is just a statistical model.

4. Methodology

To estimate the exchange rate pass-through to domestic prices in Rwanda, we use structural vector autoregressive model (SVAR) a kin to Bernanke (1986) and Sims (1986) given that offers the link between data and theory by imposing contemporeous structural restrictions based on the assumption about the underlying structure of the economy. The form of the structural vector auto regression (SVAR) that we utilize in this paper reflects the fact that Rwanda is a small, open economy for which exchange rate shocks can be an important driver of inflation.

In a vector autoregressive framework all variables are endogenous and as a reduced form of representation of a large class of structural models (Hamilton, 1994), SVAR model offers both empirical trackability and a link between data and theory using the assumptions underlying the structure of the economy. This approach identifies impulse responses by imposing a priori restrictions on the variance-covariance matrix of the structural innovations.

To capture the exchange rate pass through to inflation, we estimate a five variable SVAR model with nominal exchange rate (lnexch), output gap (lngdpgap[7]), international oil prices (lnoip), CPI inflation (lncpi) and broad money (lnm3) all variables are transformed into natural logarithm and on the basis of the estimated

[7] Lngdpgap is defined as the percentage deviation of actual output from the trend or equilibrium level of output, where trend output is generated from quarterly GDP using the Hodrick-Prescott (HP) filter.

SVAR model we identify the dynamic impulse response function[8]. The model is thus specified as-

Zt= (lnexch, lngdpgap, lnoip, lncpi, lnm3).....(1)

The choice of structural ordering of variables should not be interpreted as an attempt to provide strict identification of structural shocks but to assess the exchange rate pass through to inflation. In a matrix form a kin to Hamilton (1994), the basic SVAR model is written as –

$$\alpha_{0x_t}=n_t+\alpha_{1xt-1}+\alpha_{2xt-2}+.....\alpha^{x}_{pt-p}+u_t..... \quad (2)$$

Where X_ta vector of endogenous variables is u_t is an (nx1) vector of uncorrelated structural innovations or shocks corresponding to each element of X_t and p is the number of lags. The white noise error imply that the structural disturbances are serially uncorrelated such that $E|u_t u_t'|= \Delta$ is the diagonal matrix. If we multiply equation 2 by α_0^{-1}, the structural model represented by the above system must be identified for the purpose of policy analysis and must be given economic interpretation (Leeper et al, 1996). The obtained reduced form VAR of the dynamic structural model is obtained by multiplying both sides by α_0^{-1} as specified below-

$$X_t= \alpha_0^{-1}(n_t+\alpha_{1xt-1}+\alpha_{2xt-1}+.....\alpha_p\text{xt-p}+u_t..... \quad (3)$$

$$X_t=c_t+\varphi_{1xt-1}+\varphi_{2xt-2}+.....\varphi_{pxt-p}+\varepsilon_t$$

Where $\varphi_s=\alpha_0^{-1}\alpha_s$(s=1.....p), $C=\alpha_0^{-1}n$ and $\varepsilon_t=\alpha_0^{-1}u_t$

The variance- covariance matrix of the structural innovations is thus given by

$$E|\varepsilon_t\varepsilon_t|'=\alpha_0^{-1}E|u_t u_t'|\ (\alpha_0^{-1})\ '= \alpha_0^{-1}\Delta(\alpha_0^{-1})\ '=\omega$$

[8] Impulse response functions are calculated from the estimates of the VAR. they show how the current and future values of each variable in the VAR react to a one-off change in the current value of one of the structural shocks in the VAR holding other shocks constant.

To generate the structural shocks, we use structural factorization of the variance-covariance matrix of the reduced form VAR residuals ω. Since the estimation of the SVAR model has n^2 more parameters than the VAR, in order to find a unique solution we require both the order condition and the rank condition to be satisfied.

The order condition requires that the number of parameters in the matrices α_0 and D should be less than the number of free parameters in the matrix ω . Since ω is a symmetric matrix, then the number of free parameters of the matrix ω is defined by $n(n+1)/2$. Where n is the number of endogenous variables included in the system.

Assuming that D is a diagonal matrix then α_0 can have no more free parameters than $n(n-1)/2$. We can impose two different restrictions on matrix α_0. The first is the normalization restriction that aims to assign the value of 1 to variables X_t, i in each of the i^{th} equation. And the second is the exclusion restriction that aims to assign zero to some variables in the equation (especially contemporaneous relations). These restrictions are defined by the theoretical model. After obtaining the sufficient condition for the local identification, we impose the restrictions suggested by the theoretical model[9] and construct the matrix α_0 to ascertain the relationship between the error terms of the reduced form model and the structural disturbances $\varepsilon_t = \alpha_0^{-1} u_t$

$$\begin{bmatrix} \varepsilon tlnoip \\ \varepsilon tlngdpgap \\ \varepsilon tlnm3 \\ \varepsilon tlnexchrate \\ \varepsilon tlncpi \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ b21 & 1 & 0 & 0 & 0 \\ b31 & b32 & 1 & 0 & 0 \\ b41 & b42 & b43 & 1 & 0 \\ b51 & b52 & b53 & b54 & 1 \end{bmatrix} \begin{bmatrix} u_t lnoip \\ u_t lngdpgap \\ u_t lnm3 \\ u_t lnexchrate \\ u_t lncpi \end{bmatrix} \quad \text{..... (4)}$$

Where $u_t$lnoip is the oil price shock (supply shock), $u_t$lngdpgap is the output gap shock (demand shock), $u_t$lnm3 is money supply shock (monetary policy shock), $u_t$lnexchrate denotes nominal exchange rate shock and $u_t$lncpi denotes inflation shock. This recursive identification scheme is a kin to Ito and Sato (2007), Hahn (2003) and McCarthy (2000), and implies that the identified shocks contemporaneously affect

[9] See Hamilton(1994)

their corresponding variables and those variables that are ordered at a later stage, but have no impact on those that are ordered before.

4.1. Identification procedure

As shown in the identification scheme above, at least 10 restrictions need to be imposed on the variance-covariance matrix to extract errors from structural innovations. To this end, the theory –consistent restrictions attaches economic meaning to the derived shocks.

The first restrictions assumes that oil price as external variable is exogenous and is therefore modeled as independent of all other shocks to the variable in the system.

The second set of restrictions is premised on the assumption that the demand shock contemporaneously responds to shocks to oil prices but independent of shocks to all other variables in the system.

The third set of restrictions is based on the assumption that monetary shock is contemporaneously influenced by shocks to oil prices and output gap but is independent of all shocks to other variables in the system.

We also assume that shocks to the exchange rate are influenced by shocks to the oil prices, shocks to the output gap and shocks to the money supply. In this respect, inflation is assumed to have no contemporaneous effect on exchange rate. Finally, Shocks to domestic inflation are ordered last because they are assumed to be influenced by shocks to all the variables in the system.

4.2. Data sources and Description

Quarterly data spanning the period 2000Q1 to 2014Q3 are used to estimate the exchange rate pass through to inflation in Rwanda. All the data are obtained from BNR data base and National institute of statistics. Oil price is the average crude oil price (including Brent oil, WTI and Dubai), output gap is defined as the difference between trend and actual real GDP, M3 is money supply and is included to capture monetary policy effects on the price level, NEER is nominal effective exchange rate and CPI is the price level measured by the consumer price index (CPI).

5. Empirical Results

6.1. Unit root test

The empirical analysis begins with analyzing the order of integration of the variables using the Augmented Dickey Fuller unit root tests. As indicated in the below all variables are integrated of order one I (1) except output gap. We therefore estimate the equation specified in our model with differenced variables but output gap

Table 2: Unit Root Test Results

Variables	ADF statistic	Critical values			Order of integration
		1%	5%	10%	
Lnoil	-6.25	-4.12	-3.49	-3.17	I(1)
Lnngdpgap	-6.23	-4.12	-3.48	-3.17	I(0)
Lnm3	-3.58	-4.14	-3.49	-3.17	I(1)
Lnneer	-3.38	-3.56	-2.92	-2.59	I(1)
Lncpi	-7.28	-3.54	2.91	2.59	I(1)

Source: Author's estimation

5.2. Estimation of Exchange rate pass- through to Inflation

To obtain the impact of exchange rate to domestic prices, we utilized SVAR model using structural factorization to recover the structural errors identified in our recursive matrix. On the basis of the estimated model, we obtain the dynamic impulse response functions (IRFs) using structural decomposition as the impulse definition and variance decomposition.

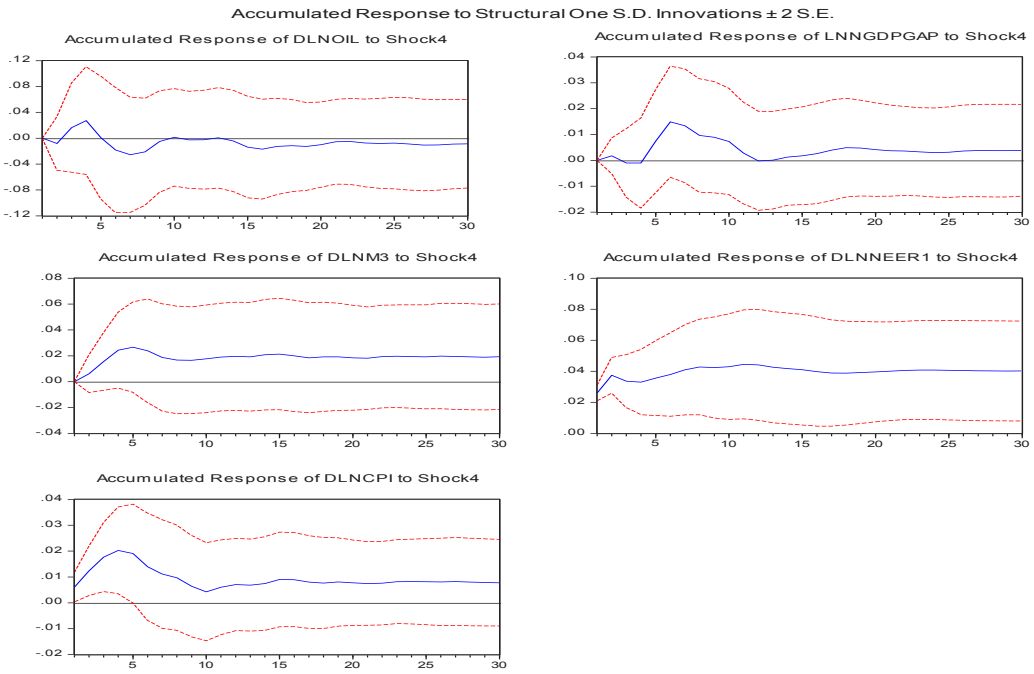
Impulse responses trace out the effects of an endogenous variable to other variable through the dynamic structure of VAR while variance decomposition measures the proportion of the forecast variance in domestic prices that is attributed to various shocks.

5.2.1. Impulse responses

The results of the exchange rate shock under the identification scheme specified in equation 4 above are depicted in panel 1 below. Panel 1 particularly shows the effect of a one standard deviation shock, defined as an exogenous, unexpected, temporary

depreciation in the exchange rate with a 95 percent confidence level on inflation, output gap, oil price and broad money in the initial period. The solid line in each figure is the estimated response while the dashed lines depict a two standard error confidence band around the estimate. Since the data are in first differences of logarithms, the impulse response functions(IRFs) need to be regarded as measuring a proportional change in the rest of the variables specified in the model due to one standard innovation (at the initial period) in the exchange rate.

Figure 2: Impulse response Function



The impulse responses obtained from the SVAR model indicate that save for inflation and exchange rate own innovations, most of the variables emerge insignificant and this could be due to the fact that Rwanda's exchange rate has generally been stable over the sample period. The result for output and broad money is not surprising; a plausible explanation is that Rwanda's financial system is still plagued with structural weakness which has hampered the transmission mechanism. The effect of exchange

rate shock on inflation is fairly gradual and persistent taking about 4 quarters to have full impact.

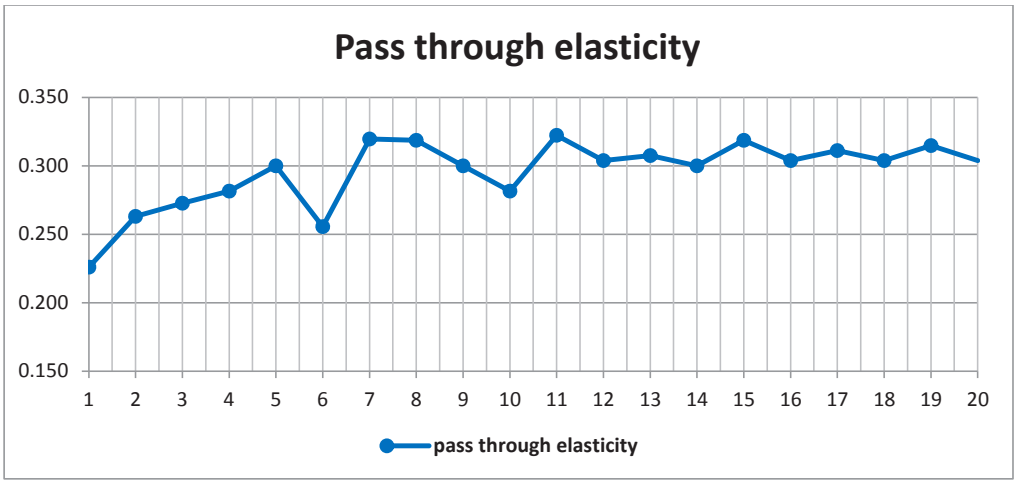
Numbers in the table 2 below indicate the immediate effect of a structural one standard deviation shock to the exchange rate depreciation is about 0.006 (or 0.6%) increase in the domestic price level. This suggests an impact exchange rate pass-through elasticity of 0.22. The full effect of this shock, which is realized after about 4 quarters, is about 0.0075 (0.76%) increase in the price level, implying a dynamic exchange rate pass-through elasticity of 0.28[10]. A peer comparison of Rwanda's ERPT Coefficient with other developing countries indicate that 0.28 dynamic exchange rate elasticity is consistent with those in Chaoudhri and Hakura (2001), who found the pass-through elasticity of 0.39 for Kenya and Cameroon, and 0.46 for Zambia.

Table 3: Effect of Cholesky to One S.D. Exchange rate Innovation

Period	DLNOIL	LNNGDPGAP	DLNM3	DLNNEER1	DLNCPI
T= 1	0	0	0	0.026853	0.006121
T= 2	-0.026635	0.005081	0.006050	0.038644	0.007117
T= 3	-0.024422	0.003081	0.007226	0.036227	0.007970
T= 4	-0.015974	-0.000944	0.011833	0.035102	0.007550

[10] Pass-through elasticity = $\frac{\%Dcpi(t)}{\%Dneer(0)}$, Where the denominator is the initial shock of exchange rate (assuming only one shock in the system)

Figure 3: Dynamic Elasticity of Exchange rate pass-through



Source: Author's estimation

The above figure shows the coefficients of dynamic elasticity of exchange rate pass-through to inflation considering 20 quarters. The pass through effect is contemporaneous but takes full impact in the fourth quarter and dies out in the fifth quarter.

5.2.2 Variance Decomposition

Variance decomposition gives insights into the relative contribution of the structural shocks in explaining fluctuations in inflation. As argued by Taylor (2000), the results of variance decomposition help confirm conclusions about ERPT. Specifically, a higher level of ERPT insinuates high transmission of exchange rate shock to consumer prices.

Congruent with the IRFs discussed above, variance decomposition indicate that exchange rate shocks have a modest contribution to inflation variance, but inflation is mainly driven by own shocks especially at shorter horizons. Specifically, exchange rate shocks account for 7.6 to 15.6 percent (at 1 to 10 quarters horizon respectively), while own shocks account for about 85.5 to 45.2 percent over the same horizon, suggesting as in (Choudhri and Hakura, 2001) that the inflation is to a larger extent influenced by its own innovations.

Table 4: Variance Decomposition

Period	S.E.	dlnoil	lnngdgap	dlnm3	dlnneer	dlncpi
T= 1	0.13	1.84	0.24	4.81	7.63	85.47
T= 2	0.14	4.64	2.51	6.21	13.46	73.16
T= 3	0.16	17.86	2.29	5.07	15.05	59.71
T= 4	0.17	20.61	5.96	5.39	13.99	54.04
T= 5	0.18	19.62	6.63	8.15	13.50	52.09
T= 6	0.18	18.79	6.51	7.83	15.69	51.17
T= 7	0.19	18.13	6.88	9.52	15.92	49.54
T= 8	0.19	21.79	6.39	10.06	14.97	46.77
T= 9	0.19	20.90	6.12	12.03	15.35	45.59
T=10	0.19	20.83	6.24	12.16	15.58	45.19

Source: Author's estimation

6. Conclusion and Policy recommendations

The objective of this study is to investigate the degree of exchange rate pass-through to inflation in Rwanda spanning the period 2000Q1 and 2014Q3 using structural vector autoregressive model (SVAR).

The empirical analysis begins with checking the time series properties of the variables to avoid incidence of spurious regression. On the basis of ADF, the null hypothesis of unit root was rejected for all the variables at first difference save for output gap.

Using the SVAR model and the resultant impulse response functions and variance decomposition, we establish the degree of exchange rate pass-through to inflation in Rwanda to be small, persistent and significant. Exchange rate pass through effect dies after 5 quarters.

The impulse response functions indicate a small, persistent and incomplete exchange rate pass through in Rwanda with a dynamic exchange rate elasticity of 0.28. In addition, variance decomposition indicates that exchange rate has modest contribution to inflation variance, inflation being mainly driven by its own innovations especially at shorter horizons but persistent over the long run

The finding is relevant from the Central Bank's perspective given its task of achieving a stable exchange rate system through appropriate intervention in the market and efficient management of foreign reserves and the policy implication arising from these findings is that monetary authority should be vigilant at exchange rate movements so as to take prompt and appropriate monetary policy action and focus on exchange rate interventions to curb inflationary pressures from external sector.

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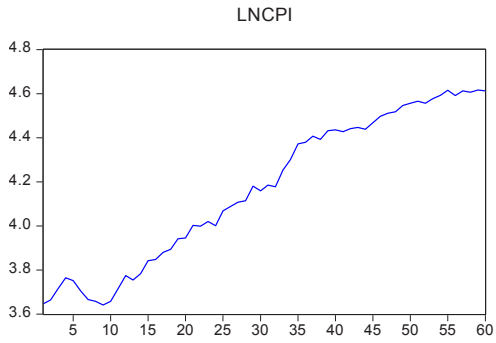
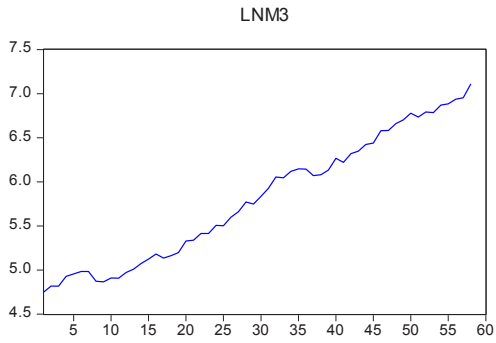
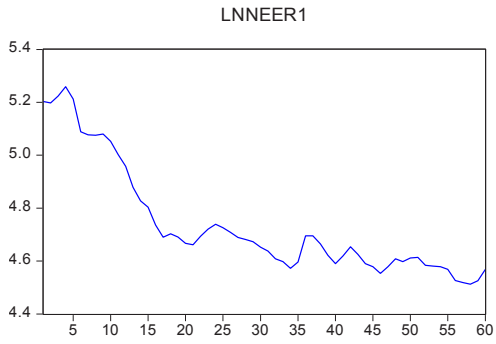
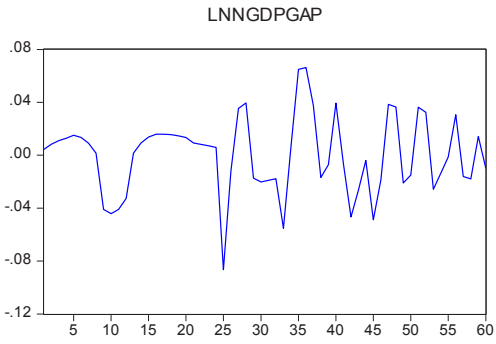
Appendices

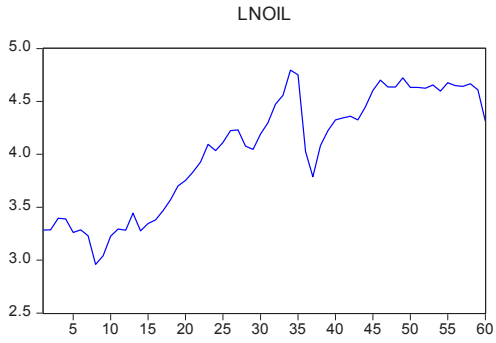
Appendix 1: Graphical presentation of variables











Appendix 2: Descriptive statistics

	LNOIL1	LNNGDPGAP	LNM3	LNNEER	LNCPI
Mean	4.022763	0.000534	5.763903	4.667265	4.136854
Median	4.104811	0.005987	5.759061	4.693867	4.136515
Maximum	4.807220	0.066258	6.935551	4.881659	4.615120
Minimum	2.962266	-0.086653	4.749607	4.447978	3.641380
Std. Dev.	0.573318	0.029847	0.695925	0.113962	0.329592
Skewness	-0.223458	-0.298101	0.133635	-0.341075	-0.083048
Kurtosis	1.640982	3.334379	1.630111	2.284586	1.533200
Jarque-Bera	4.775552	1.090286	4.545399	2.280006	5.084543
Probability	0.091834	0.579759	0.103034	0.319818	0.078687
Sum	225.2747	0.029879	322.7786	261.3669	231.6638
Sum Sq. Dev.	18.07816	0.048998	26.63714	0.714304	5.974688
Observations	56	56	56	56	56

Appendix 3: Structural VAR estimation

Structural VAR Estimates
Date: 04/23/15 Time: 08:44
Sample (adjusted): 5 58
Included observations: 54 after adjustments
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 7 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I
Restriction Type: short-run text form
@e1=c(1)*@u1
@e2=-c(2)*@e1+c(3)*@u2
@e3=-c(4)*@e1-c(5)*@e2+c(6)*@u3
@e4=-c(7)*@e1-c(8)*@e2-c(9)*@e3+c(10)*@u4
@e5=-c(11)*@e1-c(12)*@e2-c(13)*@e3+c(14)*@e4+c(15)*@u5
where
@e1 represents DLNOIL residuals
@e2 represents LNNGDPGAP residuals
@e3 represents DLNM3 residuals
@e4 represents DLNNEER1 residuals
@e5 represents DLNCPI residuals

	Coefficient	Std. Error	z-Statistic	Prob.
C(2)	0.048736	0.019771	2.464993	0.0137
C(4)	-0.091998	0.043697	-2.105340	0.0353
C(5)	-0.198049	0.285148	-0.694547	0.4873
C(7)	0.068789	0.028684	2.398182	0.0165
C(8)	0.065653	0.180738	0.363248	0.7164
C(9)	0.038275	0.085872	0.445719	0.6558
C(11)	-0.045578	0.027980	-1.628954	0.1033
C(12)	0.279112	0.167808	1.663283	0.0963
C(13)	0.102846	0.079778	1.289152	0.1973
C(14)	0.227953	0.126193	1.806381	0.0709
C(1)	0.139780	0.013450	10.39230	0.0000
C(3)	0.020308	0.001954	10.39230	0.0000
C(6)	0.042554	0.004095	10.39230	0.0000
C(10)	0.026853	0.002584	10.39230	0.0000
C(15)	0.024901	0.002396	10.39230	0.0000

Log likelihood 498.7922

Estimated A matrix:

1.000000	0.000000	0.000000	0.000000	0.000000
0.048736	1.000000	0.000000	0.000000	0.000000
-0.091998	-0.198049	1.000000	0.000000	0.000000
0.068789	0.065653	0.038275	1.000000	0.000000
-0.045578	0.279112	0.102846	-0.227953	1.000000

Estimated B matrix:

0.139780	0.000000	0.000000	0.000000	0.000000
0.000000	0.020308	0.000000	0.000000	0.000000
0.000000	0.000000	0.042554	0.000000	0.000000
0.000000	0.000000	0.000000	0.026853	0.000000
0.000000	0.000000	0.000000	0.000000	0.024901

Appendix 4: VAR Lag Order Selection Criteria

VAR Lag Order Selection
Criteria
Endogenous variables: DLNOIL LNNGDPGAP DLNM3
DLNNEER1 DLNCPI
Exogenous variables: C
Date: 05/04/15 Time: 17:02
Sample: 1 60
Included observations: 53

Lag	LogL	LR	FPE	AIC	SC	HQ
0	449.6769	NA	3.55e-14	-16.78026	-16.59438*	-16.70878
1	490.8133	72.95890	1.94e-14*	-17.38918	-16.27392	-16.96031*
2	513.5308	36.00502	2.17e-14	-17.30305	-15.25841	-16.51678
3	539.4554	36.19660	2.24e-14	-17.33794	-14.36391	-16.19427
4	571.4561	38.64238*	1.96e-14	-17.60212*	-13.69871	-16.10105

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Financial development, monetary policy and economic growth in Rwanda

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Abstract

This study has two objectives: analyze the link between financial sector development and economic growth in Rwanda and assess how BNR, through the implementation of its monetary policy has been influencing commercial banks' decisions in terms of financing the private sector. To investigate the relationship between economic growth and financial sector development in Rwanda we have estimated a growth model using credit to the private sector as percentage of GDP as a measure of financial sector development.

The results indicate positive and significant impact of credit to the private sector on the economic growth in Rwanda (in addition to classical drivers of the economic growth such as capital, labor and term of trade). They also indicate a negative link (even if it still very low) between interest rate spread and economic growth showing how high lending rate may discourage investment with its impact on economic growth. After establishing that high growth in credit to private sector recorded in Rwanda since 2006 has contributed to high economic growth recorded in the same period, we have analyzed if the development in bank loans was influenced by BNR monetary policy.

The impulse functions of the impact of policy variables on output and prices indicate that a monetary policy shock has significant effects on output and not on inflation. An increase in the repo rate, which indicates monetary policy tightening, leads to a decline in the volume of bank loans to the private sector. The same results show that there is a positive and significant relationship between credit to the private sector and real GDP. Thus, tight (accommodative) monetary policy which reduces (increases) the volume of credit to the private sector will reduce (boost) the economic growth. This is in line with the negative relationship found in this study between repo rates and real GDP.

Compared to previous studies, the results of our research indicate good development in terms of improvement in BNR monetary policy framework. This study has indicated that changes in repo rates affect the volume of credit to the private sector even if the magnitude of the effect remains low. This development is the result of reforms implemented by BNR since 2008 in terms of modernization of the monetary policy framework.

Key words: Financial Sector Development, Economic Growth, Cointegration test, VAR model.

JEL Classification: C32, G21, O43

1. Introduction

The relationship between financial sector development and economic growth has received much attention in the literature. However the existing theoretical and empirical studies did not lead to a consensus about the existence of the link and direction of the relationship.

While there is a near consensus that a well-functioning financial sector is a precondition for the efficient allocation of resources and the exploitation of an economy's growth potential, the economic literature is less consensual on how and to what extent finance affects economic growth. This, invariably, culminated in the emergence of demand-led theory of finance-growth nexus. Some researchers believe that the operation of the financial sector merely responds to economic development, adjusting to changing demand from the real sector (Robinson, 1952; Lucas, 1988; Anand Chandavarkar, 1992).

The simple explanation to this theory is that where enterprise leads, finance simply follows, suggesting that it is economic development which creates the demand for financial services and not vice versa. Giving further support to this line of argument, Gurley and Shaw (1955) contend that if income grows at a warranted pace, then the demand for financial assets also grows at a specifiable pace. Moreover, Lucas (1988) has argued that economists "badly overstress" the importance of the financial system on economic growth. It is simply a "sideshow" for economic activity. Recent developments in some economies around the world seem to provide further support for this school of thought. Specifically, the rapid growth of many Asian economies was accomplished despite a domestic financial sector that could not be regarded as developed (Shan, et al, 2001).

For example, it is not easy to link high growth of China with an average real GDP growth of 13.5 percent with the widespread view that its financial system is repressive, grossly distorts the optimal allocation of loanable funds and is, therefore, inefficient. In view of this puzzle, empirical researches are conducted at country level to examine

whether it is the development of the financial sector that leads to economic growth or vice versa.

Different studies have been conducted on nexus between financial sector development and economic growth in both developed and developing countries. However, very few studies have been carried out on Sub- Saharan African countries and to our best knowledge; no study was conducted on the case of Rwanda.

This study is filling that gap and contributes to the existing literature by examining the relationship between financial sector development and economic growth in Rwanda. As in other African countries, we focus on the impact of the banking sector on economic growth given its important role in financial intermediation.

The main hypothesis in this research is that high growth in banks' credit to the private sector recorded since 2000 has contributed to good economic performance in Rwanda. A subsequent research question is to assess if the National Bank of Rwanda, through the implementation of its monetary policy, has been influencing the volume and /or cost of banking loans to the economy. This is about assessing the monetary transmission mechanism in Rwanda. Understanding monetary policy transmission mechanism is crucial for central banks because it contributes to identify policy variables which have more predictive power for primary objective of monetary policy namely inflation. The analysis of channels of monetary transmission mechanism aims at describing their relative dominance, importance and spread of propagating effects (time-lag).

The remainder of this paper is structured as follows. Section two deals with the literature review on the relationship between financial sector development and economic growth as well as on monetary transmission mechanism. Section three describes the methodology used followed by a discussion of empirical results in section four before concluding the paper.

2. Literature Review

The relationship between finance and growth has been extensively debated and investigated over the last two centuries. Some argue that finance is a strong contributor to growth (Baghehot, 1873; Schumpeter, 1912; Hicks, 1969 and Miller, 1998) while others such as Robinson (1952) suggest that growth leads to financial development and Lucas (1988) shows that finance is over-stressed in explaining growth.

These conclusions have to be considered with caution because economic growth is determined by different factors and not only by financial sector development. These factors include the capital, labor, technology and trade openness. Thus, recent studies use both financial variables and other factors of growth as control variables (King, Levine, 1993; Levine, 1997; Kilimani, 2009; Sunde, T, 2012).

Levine (1997) identifies five basic functions of financial intermediaries which give rise to positive effects of financial sector on economic growth. They include: savings mobilization, risk management, acquiring information about investment opportunities, monitoring borrowers, exerting corporate control and facilitating the exchange of goods and services. To further strengthen financial intermediaries influence, Greenwood and Jovanovic (1990), Lavine (1991), Bensivenga and Smith (1991) as well as Saint Paul (1992) have constructed a theoretical model and established that an efficient market improves the quality of investment and thus accelerates economic growth.

Looking at modern growth theories, two specific channels through which the financial sector might affect long-run growth are identified: The impact of financial sector on capital accumulation (including human as well as physical capital) and its impact on the rate of technological progress. These effects arise from the intermediation role provided by financial institutions which enable the financial sector to mobilize savings for investment, facilitate and encourage inflows of foreign capital (including FDI, portfolio investment and bonds, and remittances) and to optimize the allocation of capital between competing uses, ensuring that capital goes to its most productive use. Different empirical studies have led to conflicting results on causality, with some indicating reverse causality and others resulting in insignificant parameters. Arestis

and Demetriades (1996) using data from twelve countries concluded that the direction of causality depends on used measures of financial sector development. In addition, their results did not exhibit a pattern for developed or developing countries which confirms the hypothesis that institutional considerations and policies of countries do play a role in the relationship between finance and growth.

Empirical studies suggest three types of causal direction between finance and growth namely; supply flowing phenomenon where financial development affects economic growth, demand flowing phenomenon where finance is said to simply follow economic growth and bi-directional causality, where finance leads to growth and growth as well leads to finance.

Goldsmith (1969) analyzed data from thirty-five countries for the period 1860-1963 and found that financial and economic developments are positively correlated over periods. Financial development was measured in his study by the ratio of financial intermediary assets divided by gross national product. The results from Goldsmith's study have not solved the puzzle because each variable has a feedback effect on the other. In an attempt to explain the puzzle, Goldsmith (1969) stresses that financial development largely occurs during the early stages of economic development when countries have low levels of income. This rationale seems to be debunked by the finding of Besci and Wang (1997) who point out that even though financial development occurs and may precede economic growth, it is unclear that it provides causality in an economic sense.

The finding of Goldsmith (1969) was later confirmed by De Gregor and Guidotti (1995) in their study on OECD countries. They noted that over time, the correlations between financial development and economic growth are strong in the early stages of development and are diminished or even eliminated over time. This finding was further reinforced in the work of Wachtel and Rousseau (1998) using data from five industrialized economies at their early stages of development.

Furthermore, some studies have examined the direction of causality through the use of instrumental variables that are correlated with financial development but not with growth. La Porta, et al (1998) show that economies could be classified into four types, depending on whether their commercial/company laws were derived from English,

French, German, or Scandinavian law. Using this measure of legal origin as instrumental variables, both Levine (1998), and Levine, et al (2000) find a strong positive connection between instrumental variables and growth.

Some researchers have also explored causality with time series analysis such as Granger-type causality tests and vector autoregressive equations. Though some of these studies have mixed results over causality, majority of the works indicate that financial development leads to stronger growth. Xu (2000), using a VAR analysis, rejects the hypothesis that finance simply follows growth. Similarly, Chritopoulous and Tsionas (2004), using a panel data, show that causality runs from finance to growth.

In support of the supply flowing hypotheses, King and Levine (1993a) concluded that there is a positive relationship between financial indicators and growth, and that financial development is robustly correlated with subsequent rates of growth, capital accumulation, and economic efficiency. They correctly emphasize that policies that alter the efficiency of financial intermediation exert a first-order influence on growth.

Most of the researches done on African countries have supported the supply flowing hypothesis (Ghali, 1999; Bolbol et al. 2005; Abu-Bader and Abu-Qarn, 2008; Kargbo and Adamu, 2009; Abdelhafidh, 2013, Odhiambo (2002 and 2009c)). Ghali (1999) investigated the question of whether finance contributes to economic growth in Tunisia, using two measures of financial development (the ratio of bank deposit liabilities to GDP and the ratio of bank claims on the private sector to nominal GDP). The results indicated the existence of a long-term stable relationship between financial development and per capita real output where the causality runs from finance to growth.

Odhiambo (2002) looked at the impact of financial reforms and savings on economic development in Kenya. He used a dynamic model and found that the more attractive the financial services, the more the investment and hence the higher the growth rate. He thus concluded that finance leads to growth. Finally, Odhiambo (2009c) set out to determine whether financial development which follows interest rate reforms causes

economic growth in Kenya. He found that financial development caused by interest rate reforms influences economic growth both in the short and long run.

Bolbol et al. (2005) analyse the relationship between Egypt's financial structure and total factor productivity (TFP) during the 1974-2002 period. They found that bank-based indicators have a negative effect on TFP unless they are interacted with per capital income, while the market-based indicators have a positive impact on TFP. On a multi-country analysis, Abu-Bader and Abu-Qarn (2008) explore the causal relationship between financial development and economic growth for six SEMCs (Algeria, Egypt, Israel, Morocco, Syria, and Tunisia) using a VAR model. They employ four different measures of financial development and support the hypothesis that finance leads growth in five countries (Algeria, Egypt, Morocco, Syria, and Tunisia).

Kargbo and Adamu (2009) examined the relationship between financial development and economic growth in Sierra-Leone for the period 1970–2008. Their results corroborate the finance-led growth hypothesis. More importantly they show that investment is an important conduit via which financial development feeds economic growth. Al-Awad and Harb (2005) investigate the relationship between finance and growth using the panel cointegration analysis on ten SEMCs over the period 1969-2000. The results indicate the existence of a long-run association between finance and growth.

Ndebbio (2004), using an ordinary least square regression framework, finds that financial sector development weakly affect per capita growth in Nigeria. He attributed the result to shallow finance and the absence of well functioning capital markets. The findings of Nnanna (2004) show that in Nigeria, financial sector development did not significantly affect per capita growth. Similarly, Nzotta and Okereke (2009) concluded that financial deepening did not support economic growth in Nigeria.

However, Afangideh (2009) found that a developed financial system alleviates growth financing constraints by increasing bank credit and investment activities with resultant rise in output. The finding of Agu and Chukwu (2008) is quite different from other authors on Nigeria. They employed the augmented Granger causality test to ascertain the direction of causality between financial deepening and economic growth

in Nigeria between 1970 and 2005. The findings reveal evidence to support both demand- and supply-leading hypotheses, depending on the financial deepening variable that is used.

Abdelhafidh (2013) investigates the direction of causality between finance and growth in North African countries over the period 1970-2008 by distinguishing between domestic saving and foreign inflows but also disaggregated the former into grants, FDI, portfolio investment and loans. They indicated that economic growth Granger-causes domestic saving.

About monetary transmission mechanism, there exist a vast literature both for developed and developing countries. The transmission mechanism of the monetary policy is about channels through which changes in monetary policy stance influence aggregate demand and inflation.

The literature on monetary policy transmission mechanism takes into account country differences in the financial, economic and institutional structure of advanced, emerging and low income economies. In the case of developing countries, commercial banks are the dominant of the formal financial intermediaries. However, formal financial system tends to be very small which limits transmission mechanism in those countries (Mishra et al., 2010, Mishra and Montiel, 2012).

Most empirical studies on monetary transmission mechanism use VAR models and the literature on methodology has mainly focused on identification of intermediate targets of monetary policy, exogenous monetary policy shocks, relevant identification techniques and identification of channels of transmission mechanisms(Ramey, 1993, Manuk Ghazan Chyan, 2014).

3. Methodology

3.1. Nexus between financial sector development and economic growth

To investigate the relationship between economic growth and financial sector development in Rwanda we estimate a growth model including a measure of financial sector development and other factors of growth used as control variables. Many

empirical studies build on the following equation (e.g Saunde T., 2012, Dimitris K. Christopaulos et al., 2004):

$$Y_i = \beta_0 + \beta_1 FD_i + \beta_2 X_i + \varepsilon_i \quad (1)$$

Where

Y_i: is the rate of growth; FD_i: is an indicator of financial depth; X_i: is a set of control variables (classical drivers of economic growth) and ε_i is the error term.

Several indicators of financial depth have been used. M3 as percentage of GDP which measures the liquid liabilities of the banking sector has been used in different empirical research. However, this measure may be a poor proxy for financial development, since it is more related to the ability of the financial system to provide transaction services than its ability to channel funds from savers to borrowers (financial intermediation).

As in many recent studies, we use credit to the private sector as percentage of GDP to measure financial intermediation. This indicator is very relevant in developing countries, including Rwanda where commercial banks dominate the financial sector. We use the following model:

$$Y_t = \beta_0 + \beta_1 FD_t + \beta_2 iY_t + \beta_3 dpop_t + \beta_4 TOT_t + \beta_5 \inf_t + \beta_6 IS_t + \varepsilon_t \quad (2)$$

Y: growth rate of real GDP; FD: credit to the private sector as percentage of GDP; iY: investment as share of GDP; dpop: growth rate of the population, TOT: Terms of trade, IS: interest rate spread (difference between lending rate and deposit rate), inf: inflation and ε_t is error term.

3.2. Monetary transmission mechanism

To analyze how BNR influences development in bank financing to the private sector. We estimate the following VAR model which describes the Rwandan economy

$$H(L)Y_t = K(L)X_t + \varepsilon_t \quad (3)$$

With $VAR(\varepsilon_t) = \Lambda$ (4)

The corresponding reduced form is

$$Y_t = A(L)Y_{t-1} + B(L)Z_t + \mu_t \quad (5)$$

Where Y_t is a vector of endogenous variables and Z_t a vector of exogenous variables. Y_t consists of constant GDP (y), price 2001, Consumer Price Index CPI, nominal effective exchange rate (e), credit to the private sector and repo rates.

A(L) corresponds to matrices of coefficients to be estimated, with lag lengths determined by standard information criteria. The vector Z_t consists of exogenous variables used to control for changes in global economy. In this study, we use international oil price. All data are expressed in natural logs, with exception of interest rate. The estimation is conducted on quarterly data from 2006 to 2014.
We adopt the following order of endogenous variables:

$$Y'_t = [y_t, p_t, m_t, i_t, e_t] \quad (6)$$

To characterize relationship between output, prices and policy related variables, Augmented Dickey-Fuller (ADF) tests are used to determine the level of integration of those variables. As in most VAR models of the monetary transmission mechanism, we do not perform an explicit analysis of the economy's long-run behavior, because monetary transmission mechanism is a short-run phenomenon. Using the estimated VAR model, we analyze short-term dynamics based on impulse response over the short to medium term. By estimating the VAR in levels, we implicitly allow cointegration relationships in the data.

Based on the estimated VAR model we examine the effect on both output and price, of a one standard deviation shock to the repo rates, credit to the private sector and exchange rate.

We estimate the reduced form by computing the Cholesky factorization of the reduced form VAR covariance matrix. In this framework, it is assumed that in ordering

variables in VAR model, given by (6), a variable have no immediate effects on the preceding one. The relation between the reduced form errors (μ) and the structural disturbance (ε) can be presented as follow:

$$\begin{bmatrix} \varepsilon_t^{\,y} \\ \varepsilon_t^{\,p} \\ \varepsilon_t^{\,m} \\ \varepsilon_t^{\,i} \\ \varepsilon_t^{\,e} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ e_{21} & 1 & 0 & 0 & 0 \\ e_{31} & e_{32} & 1 & 0 & 0 \\ e_{41} & e_{42} & e_{43} & 1 & 0 \\ e_{51} & e_{52} & e_{53} & e_{54} & 1 \end{bmatrix} \begin{bmatrix} \mu_t^{\,y} \\ \mu_t^{\,p} \\ \mu_t^{\,m} \\ \mu_t^{\,i} \\ \mu_t^{\,e} \end{bmatrix} \quad (7)$$

4. Empirical results

The main objective of this study was to establish the relationship between financial sector development and economic growth in Rwanda and to assess at what extent BNR affects banks' decision of financing the private sector.

4.1. Financial sector development and economic growth

Before testing the existence of possible long run relationship, it is important to analyze stochastic properties of time series used in the model, particularly their order of integration. Using Augmented Dickey-Fuller (ADF) tests of non-stationary we find that all variables are I(1). We have then tested the existence of long run relationship among variables using Johansen cointegration test. Both trace and rank test rejected the hypothesis of no cointegration and the hypothesis of one cointegrating vector is accepted (we present only the trace test).

Table 1: Short run results (trace and maximum Eigenvalue)

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.688297	134.7856	107.3466	0.0003
At most 1	0.378010	66.00905	79.34145	0.3283
At most 2	0.247091	37.99399	55.24578	0.6207
At most 3	0.186881	21.24915	35.01090	0.6252
At most 4	0.133911	9.043358	18.39771	0.5756
At most 5	0.009464	0.561053	3.841466	0.4538

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The following table gives the estimated long term co- integrating vector which indicates positive and significant impact of credit to the private sector on the economic growth in Rwanda (in addition to classical drivers of the economic growth such as capital, labor and term of trade). In other words, our study shows that the coefficient of financial proxy variable (credit to the private sector as percentage of GDP) is statistically significant; supporting the fact that in Rwanda financial sector development has contributed to economic growth. The results also indicate that there is a negative link (even if it still low) between interest rate spread and economic growth indicating how high lending rate may discourage investment with its impact on economic growth.

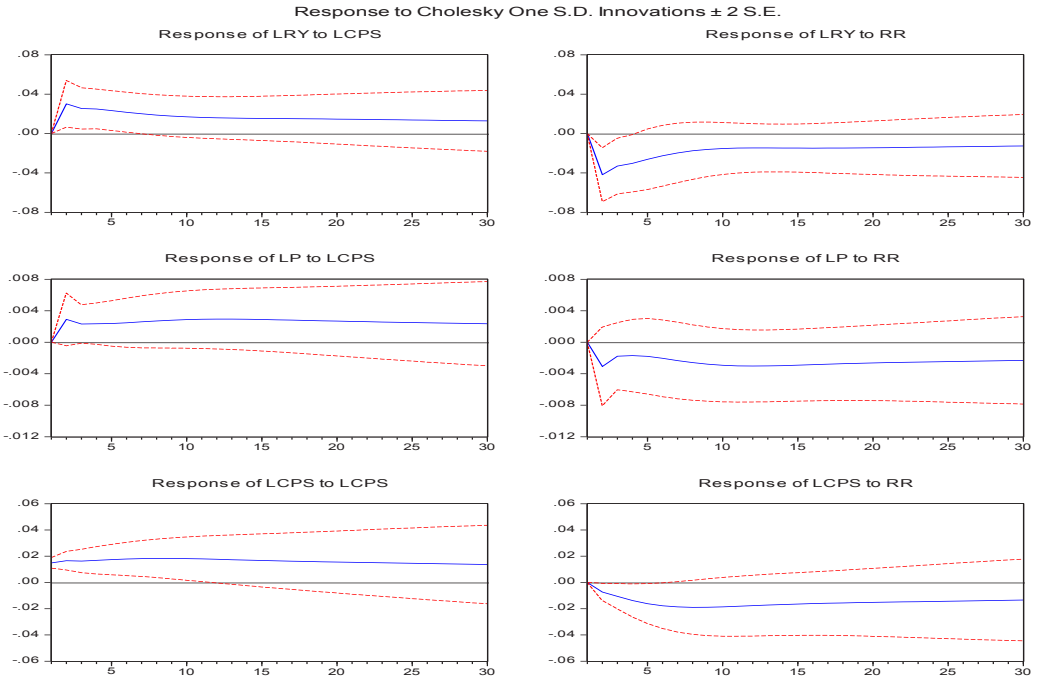
Table 2: Long-run Results:

Variables	Coefficients	Standard Errors	T-Statistics
LCPSY	0.31	0.11	2.8
iy	0.54	0.06	8.6
IS (-1)	-0.038	0.01	-3.6
Inflation	0.001	0.0009	1.1
HC	O.787	0.10	7.8
TOT	0.24	0.08	2.9

4.2. Monetary transmission mechanism

To analyze to what extent BNR influences banks' decision of financing the private sector, we have estimated the impulse functions of the impact of policy variables on output and prices from the VAR models. The results indicate that a monetary policy shock has significant effects on output and not on inflation. An increase in repo rates, which indicates monetary policy tightening, leads to a decline in the volume of bank loans to the private sector. Albeit statistically significant, the effect of monetary shock has small magnitude, appearing after 3 quarters and disappearing after 5 quarters. A study by Karangwa and Nyalihama(2014) show that market rates particularly lending rates are rigid to changes in money market rates due to high operating costs and provision for bad loans. In addition to their results, this behavior can be attributed to the limited information content regarding the stance of monetary policy because BNR implements a quantity based monetary framework. The same results show that there is a positive and significant relationship between credit to the private sector and real GDP. Thus, tight (accommodative) monetary policy which reduces (increase) the volume of credit to the private sector will reduce (boost) the economic growth. This is in line with the negative relationship found in this study between repo rates and real GDP.

Graph 1: Impulse response functions



Compared to previous studies conducted by Thomas Kigabo Rusuhuzwa, Munyankindi Pascal and Amahoro Adha (2008) and Thomas Kigabo Rusuhuzwa (2012), the results of our research indicate good development in terms of improvement in BNR monetary policy framework. The two previous studies which used data from 1995 to 2006 (first study) and 2011 (second study) have concluded to the absence of impact of interest rates on economic growth and inflation. This study has indicated that t changes in repo rates affect the credit to private sector even if the magnitude of the effect remains small. This development is the result of reforms implemented by BNR since 2008 in terms of improving the monetary policy framework. These reforms include the use of Key repo rate as signal of monetary policy stance since August 2008, the use of reserve money corridor since 2012 and the improvement in BNR monetary policy communication with the public.

As in the two previous studies, our results indicate that an increase in the volume of credit to the private sector leads to an increase in real activity but not in the price

level. This shows that bank credit to the private sector in Rwanda has been not inflationary as it financed more production rather than consumption.

5. Conclusion

This study has two objectives: analyze the link between financial sector development and economic growth in Rwanda and assess how BNR, through the implementation of its monetary policy has been influencing commercial banks' decisions in terms of financing the private sector. To investigate the relationship between economic growth and financial sector development in Rwanda we have estimated a growth model using credit to the private sector to GDP ratio to measure financial sector development and other factors of growth used as control variables. These factors are investment as share of GDP; growth rate of the population, Terms of trade, interest rate spread (difference between lending rate and deposit rate) and inflation.

The use of credit to the private sector as percentage of GDP is relevant since it is more related to the ability of the financial system to channel funds from savers to borrowers (financial intermediation). The results indicate positive and significant impact of credit to the private sector on economic growth in Rwanda. In other words, the study has established that coefficient of financial proxy variable (credit to private sector as a percentage of GDP) is statistically significant supporting supply led hypothesis (financial sector development leads to economic growth). They also indicate that there is a negative link (even if it still low) between interest rate spread and economic growth indicating how high lending rate may discourage investment with its impact on economic growth.

After establishing that high growth in credit to private sector recorded in Rwanda since 2006 has contributed to high economic growth achieved in the same period, we have analyzed if the development in bank loans to the private sector was influenced by BNR monetary policy.

The impulse functions of the impact of policy variables on output and prices indicate that a monetary policy shock has significant effects on output and not on inflation. An increase in the repo rates, which indicates monetary policy tightening, leads to a

decline in the volume of bank loans to the private sector. Albeit statistically significant, the effect of monetary shock has small magnitude, appears after 3 quarters and dies after 5 quarters. The same results show that there is a positive and significant relationship between credit to the private sector and real GDP. Thus, tight (accommodative) monetary policy which reduces (increase) the volume of credit to the private sector will reduce (boost) the economic growth. This is in line with the negative relationship found between the repo rates and real GDP.

Compared to previous studies, our research indicates good development in terms of improvement in BNR monetary policy framework. The two previous studies which used data from 1995 to 2006 (first study) and 2011 (second study) have concluded to the absence of impact of interest rates on economic growth and inflation. This study has indicated that bank loans to private sector are affected by changes in repo rates, even if the magnitude of the effect is small. This development is the result of reforms implemented by BNR since 2008. These reforms include the use of Key repo rate as signal of monetary policy stance since August 2008, the use of reserve money corridor since 2012 and the improvement in BNR monetary policy communication with the public.

The most important implication of our findings is that in their efforts of promoting and sustaining high economic growth in Rwanda, policy makers should focus on long run policies aiming at modernization of financial institutions and markets such as the banking sector and capital markets. In addition, BNR should continue to modernize its monetary policy framework, develop money market and work with commercial banks to eliminate factors which reduce the reaction of market interest rates to changes in repo rates. This will contribute to further increase the magnitude of repo rates effects on bank credit to the private sector and thus, improve the effectiveness of BNR monetary policy.

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The forecasting and policy analysis systems (FPAS) macro-model for Rwanda

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Abstract

In view of the challenges hampering the effectiveness of monetary policy embedded in the monetary targeting regime, the BNR is in the process of switching to the inflation targeting framework where the role of modeling and forecasting is paramount. Towards this end, the BNR has taken significant steps to put in place a Forecasting and Policy Analysis Systems (FPAS). This paper has developed and applied an FPAS macro-model for Rwanda focusing on explaining the key episodes in Rwanda's macroeconomic developments. The FPAS macro-model is structured in such a way that it captures the key transmission channels. Understanding these key transmission channels is crucial for it sheds light on how the Rwandan economy works, which itself is a useful input in the production of forecasts for key macro-economic variables. The model results adequately explain the historical developments in GDP growth, inflation dynamics and exchange rate movements between 2008 and 2014-15. However, the model needs to be extended to better capture the intrinsic realities of the Rwandan economy by for example including the fiscal sector, incorporating the policy actions, especially exchange rate smoothing, and the role of money. The good performance of the current model and the expected future improvements will strengthen the operationalization of the model to produce forecasts for key macroeconomic variables aimed at guiding monetary policy discussions. Currently, some of the model results, such as the projections on the output gap and inflation, are used to inform the Monetary Policy Committee.

Key Words: Forecasting & Policy Analysis systems, macro-model, Rwanda
JEL Classification: E52, E58, F47, O23

1. Introduction

During various policy discussions, the Central Banks across the East African Community (EAC) have acknowledged the numerous challenges limiting the effectiveness of monetary policy in the region. In the International Research conference held in Kigali on 19th-20th July 2012, Central Bank Governors in the region acknowledged the weak monetary policy transmission mechanism ingrained in the monetary targeting regime. The monetary targeting framework, which is generally based on the quantity theory of money, is based on simple and unrealistic assumptions. First, it assumes a stable and predictable relationship between money supply and inflation, holding money velocity constant. Indeed, for a stable relationship between money supply and inflation to exist, the money multiplier must be stable. Recent empirical evidence shows that there is growing breakdown of the link between money supply and inflation in the EAC region, largely due to the instability of the money multiplier (Adam and Kessy, 2011; Kigabo and Irankunda, 2012). In this respect, the Central Bank Governors committed themselves to modernize monetary policy regimes and this has repeatedly featured in the East African community's Monetary Affairs Committee (MAC) meetings.

At present, the EAC central banks have embarked on the modernization of their monetary policy frameworks with the objective of transiting to a more price-based forward looking monetary policy framework by 2018. Some of the changes introduced so far include, allowing greater exchange rate flexibility, enhancing the role of policy rates in the signaling of the monetary policy stance, announcing inflation targets and introducing the forward-looking elements in policy formulation and communication strategies (Luisa Charry et al., 2014).

The EAC Central Bank Governors in the region agreed to develop and operationalize the Forecasting and Policy Analysis Systems (FPAS), which has various forward-looking elements entrenched in the Central Bank structure and policy processes. These forward-looking elements include: putting in place a team fully dedicated to forecasting with clearly defined responsibilities, developing a database infrastructure with a system that collects and organizes the relevant information for this exercise, introducing a set of near-term forecasting and nowcasting tools, building a quarterly

projection model, conducting a cycle of meetings on a regular basis to update the forecast and interact with senior management, and adopting a reporting process that presents the analysis in a coherent, clear and straightforward manner so as to facilitate policy discussions.

In the FPAS context, the National Bank of Rwanda has already taken significant steps that will provide a firm foundation for the envisaged shift to a forward-looking monetary policy. The reforms undertaken include the on-going modernization of electronic systems (including the putting in place of a data ware house), revision of the monetary policy framework whereby a reserve money band is targeted, using of the policy rate to signal the monetary policy stance, improving communication of monetary policy decisions to the public (including publication of inflation reports and MPC press releases), setting up of the division in charge of modeling and forecasting, the continued use of near-term forecasting tools (such as ARMA and VARs) and most recently the ongoing efforts to build and fully operationalize the small quarterly projections model (QPM). Other reforms include the introduction of measures to absorb excess liquidity and improve the inter-bank market as well as the BNR commitment to maintain low and stable inflation, not exceeding 5%.

The QPM under the FPAS is simply a small Keynesian macro-economic model, with four core equations describing developments in inflation (Phillips curve), aggregate demand (IS curve), exchange rates (UIP) and the behavior of monetary authorities (Taylor rule) as explained in Luisa Charry et al. (2014).

This paper explains the structure and application of the QPM to the Rwandan economy. The main advantages of the QPM are: the ability to model the macro-economic linkages between sectors, the latitude to incorporate expert judgment (calibrations), and the provision of the room for having forecasts over a longer time horizon as well as serving as a consistent framework for streamlining monetary policy discussions, among others.

The successfulness of the model to explain key historical developments of the Rwandan economy is a stepping stone towards production of reliable forecasts for key macro-economic variables, such as for inflation and output gap, that the MPC needs

for policy discussions. Therefore, the main focus of this paper is to use the QPM to explain the key episodes in Rwanda's macroeconomic developments. Periods such as 2008, 2011, 2014-15 were adequately explained by the QPM to especially understand the dynamics behind inflation developments. Some of these explanations were provided in previous studies such as Luisa Charry et al. (2014) and Andrew Berg et al. (2013).

The rest of the paper is organized as follows: section one gives the introduction with particular emphasis on the background, structure of and rationale for the FPAS model; section two, which is the gist of this paper, dwells much on the application of the FPAS model to the Rwandan economy and gives a model consistent interpretation of the Rwandan economy over the recent past by especially explaining the inflation dynamics in 2008, 2011 and 2014-15. The third section dwells on the main conclusions of the study. The interpretations are based on the filtration results for the last eleven years, since 2004. The aforementioned QPM is cast in state-space format and filtered using the Kalman filter.

2. The FPAS macro-model for Rwanda

2.1 The model structure

The FPAS macro model upon which this paper is based is simply a rational expectations New-Keynesian model, similar to models used in central banks around the world, with both nominal and real rigidities. It is specified in gaps and the main mechanism driving inflation over the business cycle is fluctuations in real variables, such as output, around their long-term trends. The model is basically suitable for a fully-fledged inflation targeting country with a flexible exchange rate. Therefore, the main policy instrument is the interest rate whereas the long-term neutrality of money is implied.

The model consists of four basic behavioral equations: the IS curve (aggregate demand), which relates monetary policy and the real economic activity; a set of Phillips curves (aggregate supply) that link economic activity and inflation; a monetary policy

rule that describes the response of the central bank to deviations of inflation from target and the cyclical behavior of the economy.

2.1.1 The aggregate demand (IS curve) equation

As explained by Ferrara (2008), Giannone (2005) and Billi (2012), the most important measure of economic performance is real GDP. Under the FPAS framework, the output gap is used as a proxy for aggregate demand and is measured as percentage deviation of actual output from its potential level[11]. The rationale is that a positive output gap implies overheating of the economy and upward pressures on inflation. Conversely, a negative output gap implies economic slowdown and downward pressures on inflation. The influences of the output gap on inflation are well captured in the Phillips curve. The aggregate demand equation is specified as follows:

$$\hat{y}_t = a_1^{\hat{y}} * \hat{y}_{t-1} - a_2^{\hat{y}} * rmci_t + a_3^{\hat{y}} * \hat{y}_{t-1}^{US} + \varepsilon_t^{\hat{y}} \quad \text{.....(1)}$$

Whereby:

$\hat{y}_t$ is the output gap, $rmci_t$ is the real monetary condition index; $\hat{y}_{t-1}^{US}$ is the lagged global aggregate demand, approximated here using the lagged US output gap, and; $\varepsilon_t^{\hat{y}}$ is the demand shock.

The output gap is computed as the difference between actual (l_y_t) and potential output ($l\_\bar{y}_t$), measured in logs:

$$\hat{y}_t = l\_y_t - l\_\bar{y}_t \quad \text{.....(2)}$$

Where by $l\_y_t = 100 * \log(RGDP_t)$ and the gap and trend are derived using the Kalman filter; and $RGDP_t$ stands for real GDP for quarter "t".

[11] For details about the estimation of the output gap in Rwanda, see Kigabo and Irankunda (BNR, economic review, 2014, N°5 pp. 19-40).

foods imported to be used as final goods, can be sourced from the rest of the world and are thus not excluded when computing core inflation.

Conversely, both imported food and oil inflation are included in the non-core equation since Rwanda's non-core basket contains energy and fresh foods. Common to both equations however is the fact that imported oil and food inflation represent the direct effect, usually seen as a temporary but immediate spike in inflation emanating from an increase in either international food or oil prices. Since international oil and food prices are quoted in USD, they have to be converted to the FRW before being entered into core and non-core equations respectively. The real marginal costs, which capture the indirect effects to domestic inflation, are specified as:

$$rmc_t^{core} = b_1^{rmc\_core} * l\_y\_gap_t + b_2^{rmc\_core} * (l\_qfood\_gap_t + l\_z\_gap_t + w_1^{rmc} * \hat{rp}) + b_3^{rmc} * (l\_qoil\_gap_t + l\_z\_gap_t + w_1^{rmc\_core} * \hat{rp}) + (1 - b_1^{rmc\_core} - b_2^{rmc\_core} - b_3^{rmc\_core}) * \left(l\_z\_gap_t + (w_1^{rmc} - 1) * \hat{rp}\right) \quad .....(11a)$$

$$rmc_t^{xcore} = b_1^{rmc\_xcore} * l\_y\_gap_t + b_2^{rmc\_xcore} * (l\_qfood\_gap_{t-1} + l\_z\_gap_{t-1} + w_1^{rmc} * \hat{rp}_{t-1}) + b_3^{rmc\_xcore} * (l\_qoil\_gap_t + l\_z\_gap_t + w_1^{rmc\_xcore} * \hat{rp}) + (1 - b_1^{rmc\_xcore} - b_2^{rmc\_xcore} - b_3^{rmc\_xcore}) * \left(l\_z\_gap_t + (w_1^{rmc}) * \hat{rp}_{t-1}\right) \quad .....(11b)$$

Whereby, $l\_qfood\_gap_t$ is the real food price gap, $l\_qoil\_gap_t$ is the real oil price gap, $\hat{rp}$ is the relative prices gap whereas other variables are named as before. Therefore $\hat{rp}$ is the relative prices gap and w_1^{rmc} partitions the effect of relative prices between core and non-core inflation equations, respectively. The inflation expectations are modeled as follows:

$E\pi_t^{core}$ & $E\pi_t^{xcore}$, standing for core and non-core inflation forward-looking expectations, respectively. Since the core and non-core inflation equations contain $E\pi_{t-1}$ and $E\pi_{t+1}$, they capture both forward-looking and backward-looking inflation expectations and must also satisfy the linear homogeneity assumption.

Having two Phillips curves, for core and non-core inflation, brings forth the need to tie together these two measures of inflation, especially due to the fact they do not grow at the same rate. To establish this model-consistent relationship, the idea of relative prices between core and non-core inflation is used:

$$l\_rp_t = l\_P_t^{core} - l\_P_t^{xcore} \quad \text{.....(12)}$$

Where l_rp_t is the real relative price between core and non-core CPI; $l\_P_t^{core}$ is 100 times log of core CPI; and, $l\_P_t^{xcore}$ is 100 times the log of non-core CPI. The real relative price is then decomposed into trend and gap and the growth rate in the trend is, after making the necessary changes, modeled as a stationary process, in a similar way as in equations (28) and (34). With core and non-core inflation processes explicitly modeled, headline inflation is then derived as an identity using the respective weights of core and non-core inflation as follows:

$$\pi_t^{headline} = wt^{core} * \pi_t^{core} + \left(1 - wt^{core}\right) * \pi_t^{xcore} \quad \text{.....(13)}$$

2.1.3 The uncovered interest rate parity (UIP) equation

The uncovered interest rate parity equation explains how the nominal exchange rate (s_t) is determined. The nominal exchange rate is expressed in RWF/USD terms. According to equation 15 below, dynamics of the nominal exchange rate depend on expectations one quarter ahead (Es_{t+1}), nominal interest rate differentials, defined as the difference between the foreign nominal interest rate (i_t^*) and the domestic nominal interest rate (i_t), and the country's risk premium ($prem_t$). The interest rates are measured in annual terms. The premium is the compensation required by foreigners for holding domestic securities.

$$Es_{t+1} = d_1 * Es_{t+1} + (1 - d_1)\left[s_{t-1} + 2/4 * (dl\_\bar{z}_t + \pi_t^{4,tar} - \pi_{ss}^*)\right] \quad \text{.....(14)}$$

$$s_t = Es_{t+1} + (i_t^* - i_t + prem_t)/4 + \varepsilon_t^s \quad \text{.....(15)}$$

The expected one quarter ahead nominal exchange rate, taken as a weighted average between backward and forward-looking expectations, is approximated by a combination of the model consistent forecast for the nominal exchange rate and the backward looking expectation of the nominal exchange rate. The backward looking

term is then one quarter lagged nominal exchange rate level (s_{t-1}) plus the equilibrium nominal depreciation over the two periods ahead. The equilibrium nominal depreciation is given by equilibrium real exchange rate depreciation $dl\_\bar{z}$ and the difference between the domestic inflation target ($\pi_t^{4,tar}$) and foreign steady state inflation (π_{ss}^*) as shown in equation 14.

In addition, the real (long run) UIP assumes parity relationship between expected equilibrium real exchange rate appreciation ($e_1\_dl\_\bar{z}_t$), differential of equilibrium real interest rates $\bar{r}_t - \bar{r}_t^*$ and the country risk premium ($prem_t$). This equality implicitly pins down the country risk premium. This specification of the UIP does not however take into account the possibility of central bank intervention in the forex market mainly aimed at smoothing exchange rate volatility. The latter constitutes one of the areas to be considered for further improvements of the FPAS model in future.

$$\bar{r}_t = \bar{r}_t^* + e_1\_dl\_\bar{z}_t + prem_t \quad \text{.....(16)}$$

$$\bar{r}_t - \bar{r}_t^* = e_1\_dl\_\bar{z}_t + prem_t \quad \text{.....(17)}$$

$$e_1\_dl\_\bar{z}_t = dl\_\bar{z}_{t+1} \quad \text{.....(18)}$$

2.1.4 The monetary policy reaction function

The monetary policy reaction function does not necessarily imply a central bank rule but rather a model representation of how the central bank conducts monetary policy. The monetary policy rule explained here is typically for inflation targeting countries using the interest rate as an operational target. Though the National Bank of Rwanda uses reserve money as the operational target, the key repo rate is up to now used as a signal of the monetary policy stance until full transition to the inflation targeting regime is attained. The monetary policy rule is specified in a way to reflect the main objectives of the central bank. It is here assumed that the central bank sets the nominal interest rate in response to the deviations of the one year a head inflation forecast from the inflation objective and the output gap.

The long run objective of monetary policy is to bring inflation to the objective. Inflation deviation from the target is defined as one- quarter-ahead model consistent forecast of y-o-y inflation minus the inflation target. The first short run objective is to smooth the output gap and keep the economy close to its potential level. Another objective is to smooth nominal exchange rate volatility with respect to the trend implied by real exchange trend and difference in inflation targets. Therefore monetary policy is consistent and keeps the exchange rate in accordance with its primary target, which is the medium-term inflation objective. The resulting Taylor rule, taking into account all these objectives is specified as follows:

$$i_t = f_1 * i_{t-1} + (1 - f_1) * \left[i\_neutral + f_2 * \pi_t^{yoy,dev} + f_3 * \hat{y}_t + f_4 * dl\_s_t^{qoq,dev} \right] + \varepsilon_t^i \quad \text{.....(19)}$$

The monetary policy reaction function stated in equation (19) implies that the inter-bank rate, used here as a proxy for the policy rate (i_t) depends on the persistence term (i_{t-1}), the neutral interest rate ($i\_neutral$), deviation of YOY inflation from the target ($\pi_t^{yoy,dev}$), the output gap ($\hat{y}_t$) and QOQ annualized deviation of the nominal exchange rate depreciation from the trend ($dl\_s_t^{qoq,dev}$) as well as the monetary policy shocks (ε_t^i). The neutral nominal interest rate is defined in equation (20) as a sum of the real interest rate trend ($\overline{r}_t$) and the two periods ahead annual inflation target (equations 20 and 21):

$$i\_neutral_t = \overline{r}_t + E\pi_t^{yoy,tar} \quad \text{.....(20)}$$

$$E\pi_t^{yoy,tar} = \pi_{t+2}^{yoy,tar} \quad \text{.....(21)}$$

The YOY inflation deviation from the target is given by:

$$\pi_t^{yoy,dev} = E\pi_t^{yoy} - \pi_t^{yoy,tar} \quad \text{.....(22)}$$

The deviation of the nominal exchange rate depreciation from the target is defined as:

$$dl\_s_t^{qoq,dev} = dl\_s_t - (dl\_\overline{z}_t + \pi^{yoy,tar} - ss\_\pi^*) \quad \text{.....(23)}$$

Whereby dl_s_t is the QoQ annualized nominal exchange rate appreciation/depreciation, $dl\_\bar{z}_t$ is equilibrium real exchange rate depreciation, $\pi^{yoy,\,tar}$ is the annual inflation target and ss_π^* is the steady state level of foreign inflation. The term in brackets therefore gives the equilibrium nominal exchange rate depreciation. The neutral interest rate is defined as in equation (20) while the expected QOQ annualized inflation target is defined in equation (21). Note that the nominal interest rate is the closure rule for the model and ensures convergence to the steady state position.

2.1.5 Oil prices

Oil price quoted here is the international oil price measured in USD, converted into a real price in equation (25) using the US CPI index as the deflator. That is, the real price of oil is modeled as a relative price of oil to the foreign CPI. Then, equation (26) splits the real price of oil into a trend and gap. When real oil price is at trend (or equilibrium) level, then international oil prices have no pressure to other domestic prices. Equation (30) shows how the QoQ annualized % real oil price trend growth rate is computed while equation (29) explains the computation of the annualized Q-o-Q oil inflation. Equations (27) and (28) show the processes for the QoQ annualized % real oil price trend growth rate and the real oil price gap, respectively. \

$$\Delta l\_oil\_im_t = \Delta l\_oil_t + \Delta l\_s_t - \Delta l\_z\_tnd_t \quad (24)$$

$$l\_qoil_t = l\_oil_t - l\_P_t^* \quad (25)$$

$$l\_qoil_t = l\_qoil\_tnd_t + l\_qoil\_gap_t \quad (26)$$

$$\Delta l\_qoil\_tnd_t = c_1^{\Delta l\_qoil\_tnd} * \Delta l\_qoil\_tnd_{t-1} + \varepsilon_t^{\Delta l\_qoil\_tnd} \quad (27)$$

$$l\_qoil\_gap_t = c_1^{l\_qoil\_gap} * l\_qoil\_gap_{t-1} + \varepsilon_t^{\Delta l\_qoil\_gap} \quad (28)$$

$$\Delta l\_oil_t = 4*(l\_P_t^{oil} - l\_P_{t-1}^{oil}) \quad (29)$$

$$\Delta l\_qoil\_tnd_t = 4*(l\_qoil\_tnd_t - l\_qoil\_tnd_{t-1}) \quad (30)$$

Equation (27) implies that the equilibrium real oil price is modeled as a stationary process such that the innovation to this shock process moves the level of the real price

of oil only slowly to a new permanent level. The shock to this stationary process corresponds to the technology innovation process in the world economy. The gap of the real oil price represents all other movements in the real price of oil which imply inflation pressures. This gap is also modeled as a stationary AR (1) process in equation (28).

2.1.6 Food prices

The international food price is modeled in similar fashion as the international oil prices with the only exception that the steady state of the trend of the equilibrium of real price of food is equal to zero. This is premised on the fact that food takes a significant part of Rwanda's CPI basket, with a share of about 28%.

$$\Delta l\_food\_im_t = \Delta l\_food_t + \Delta l\_s_t - \Delta l\_z\_tnd_t \quad (31)$$

$$l\_qfood_t = l\_food_t - l\_P_t^* \quad (32)$$

$$l\_qfood_t = l\_qfood\_tnd_t + l\_qfood\_gap_t \quad (33)$$

$$\Delta l\_qfood\_tnd_t = c_1^{\Delta l\_qfood\_tnd} * \Delta l\_qfood\_tnd_{t-1} + \varepsilon_t^{\Delta l\_qfood\_tnd} \quad (34)$$

$$l\_qfood\_gap_t = c_1^{l\_qfood\_gap} * l\_qfood\_gap_{t-1} + \varepsilon_t^{\Delta l\_qfood\_gap} \quad (35)$$

$$\Delta l\_food_t = 4*(l\_P_t^{food} - l\_P_{t-1}^{food}) \quad (36)$$

$$\Delta l\_qfood\_tnd_t = 4*(l\_qfood\_tnd_t - l\_qfood\_tnd_{t-1}) \quad (37)$$

2.1.7 Long run trends

The FPAS macro-model aims at explaining the medium-term business cycle dynamics of the economy around its long-term trends. There are various ways of estimating long-term trends but the most commonly used one is the Kalman Filter technique, which estimates all the unobservable variables in the model structure and imposes restrictions on volatility. Below are the key trends estimated by the model:

$$\bar{r}_t = \phi_1 * \bar{r}_{t-1} + (1-\phi_1) * \bar{r}_{ss} + \varepsilon_t^{\bar{r}} \quad (38)$$

$$\bar{z}_t = \phi_2 * \bar{z}_{t-1} + (1-\phi_2) * \Delta\bar{z}_{ss} + \varepsilon_t^{\Delta\bar{z}} \quad (39)$$

$$\Delta\bar{y}_t = \phi_3 * \Delta\bar{y}_{t-1} + (1-\phi_3) * \Delta\bar{y}_{ss} + \varepsilon_t^{\Delta\bar{y}} \quad (40)$$

2.1.8 The foreign sector

The dynamics of the model are complete with the foreign block. Though exogenous to the domestic economy, the developments in the foreign sector tend to affect the domestic economy for example through the presence of the foreign output gap in the domestic IS equation, the effect of the foreign nominal interest rate on the domestic economy's UIP equation and the role of foreign inflation on the domestic economy's real exchange rate developments.

The US economy is used here as the foreign sector. Other options include using both the US and Eurozone since most of the trade is conducted using the dollar and euro as mediums of exchange. This option is more complicated since it requires the use of relative weights. The other option is consideration of the major EAC trading partners. This is equally more complicated since it not only requires weighting but also suffers from data problems since actual data and forecasts for developing countries are always not readily available on a timely basis. The foreign sector foreign block contains equations for the US: output gap (equation 39), real interest rate trend (equation 40), nominal interest rate (equation 41) and headline inflation (equation 42). These equations are modeled as stationary processes rather being dependent on macro-economic fundamentals since the model takes the foreign block as given.

$$\hat{y}_t^{us} = a_1^{\hat{y}^{us}} * \hat{y}_{t-1}^{us} + \varepsilon_t^{\hat{y}^{us}} \quad \text{.....(41)}$$

$$\bar{r}_t^{us} = a_2^{\bar{r}^{us}} * \bar{r}_{t-1}^{us} + \left(1 - a_2^{\bar{r}^{us}}\right) * \bar{r}_{ss}^{us} + \varepsilon_t^{\bar{r}_t^{us}} \quad \text{.....(42)}$$

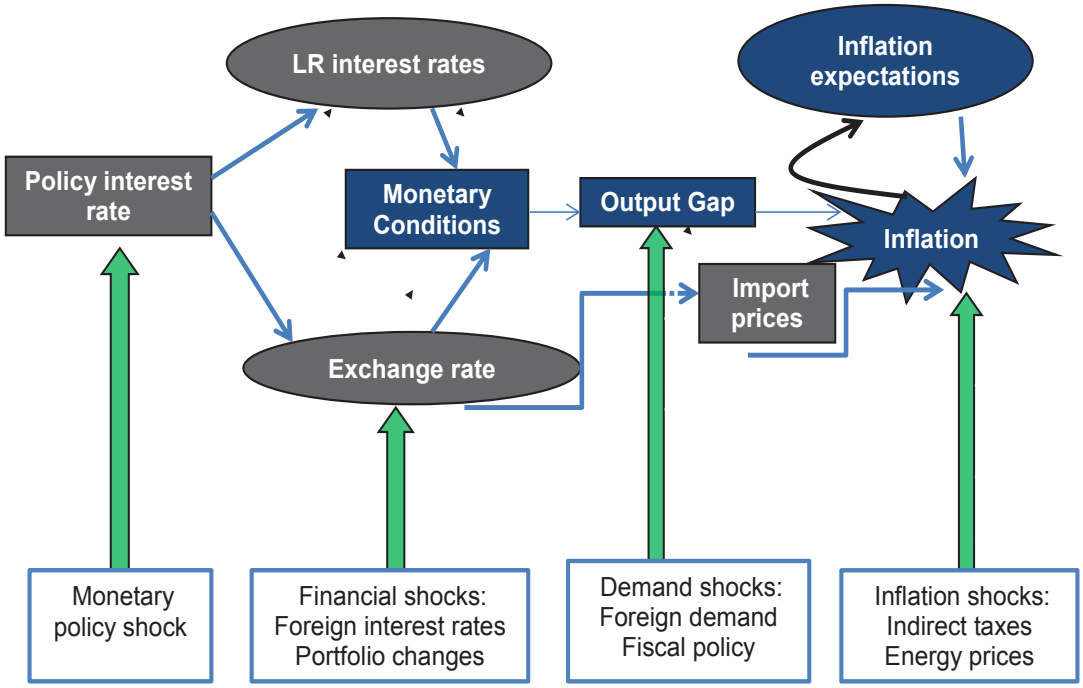
$$i_t^{us} = a_3^{i^{us}} * i_{t-1}^{us} + (1 - a_3^{i^{us}}) * (\bar{r}_{ss}^{us} + \pi_{ss}^{us}) + \varepsilon_t^{i^{us}} \quad \text{.....(43)}$$

$$\pi_t^{us} = a_4^{\pi^{us}} * \pi_{t-1}^{us} + (1 - a_4^{\pi^{us}}) * \pi_{ss}^{us} + \varepsilon_t^{\pi_t^{us}} \quad \text{.....(44)}$$

2.2 The transmission mechanisms implied by the model

The FPAS macro model for Rwanda assumes policy interest rate as the monetary policy instrument. The channels through which monetary policy affects the real economy are summarized in figure 1 and they include: the interest channel, the asset prices channel, the expectations channel and the exchange rate channel.

Figure 1: Transmission mechanisms



However, for the Rwandan economy, the main interest rate channel, exchange rate channel and expectations channel are more relevant though not fully effective. The interest channel begins with the pass-through from the policy rate to the market rates thereby by affecting the lending behavior of banks which has an impact on aggregate demand (through real monetary conditions index) and inflation. The exchange rate effects feed into inflation either directly or indirectly. The indirect channel works in a way that the change in the policy rate affects capital flows which in turn affects the

exchange rate. The change in exchange rates then affects the cost of imported intermediate goods and then domestic production and inflation. The direct effect occurs when exchange rate movements affect the prices of imported finished goods, directly feeding into inflation. The transmission mechanism in figure (1) takes care of the different shocks that may hit the economy, for example supply shocks in form of increasing/decreasing international commodity prices and domestic food supply shocks.

2.3. Data and calibration

The data on the interbank rate, exchange rate CPI, and GDP used were sourced from the National Bank of Rwanda and the National Institute of statistics of Rwanda, respectively. The CPI data includes the urban consumer price index as well as the core and non-core components. The non-core index represents about 75% of the overall CPI. The non-core index therefore represents 25% of the overall urban index, comprising of 7.8% for the energy index and 17.3% for the fresh products index. The other data used are the bilateral nominal exchange rates (RWF/USD), the interbank rate and real GDP growth rate. The international commodity prices (food & oil) as well as other foreign sector variables were obtained from OGRESEARCH. All the domestic variables are seasonally adjusted, log transformed and converted into quarterly frequency prior to being used. Some of the checks used to guide calibrations include examination of the impulse response functions, in sample simulations and historical decompositions to ensure they make economic sense and correctly portray the Rwandan economic realities, the starting point of course being the experience from other countries. The calibrations of the parameters used in the model are given in the appendix.

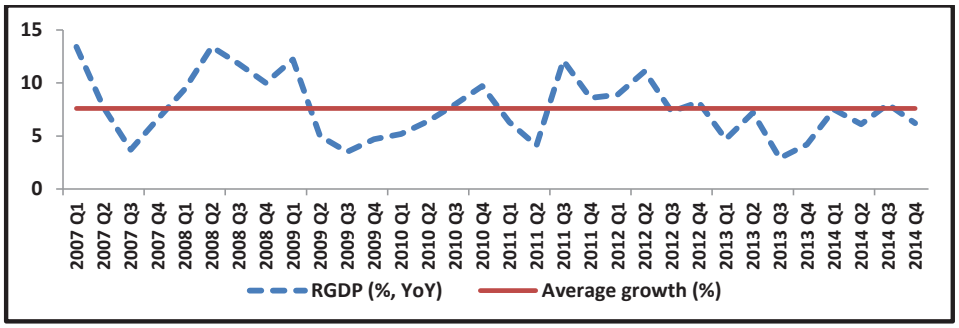
3. A model-based historical interpretation of the Rwandan economy

This section applies the model to Rwandan data with the objective of using the model results (Kalman Filtered results) to explain the key developments in the Rwandan economy over the recent past with respect to the drivers of inflation and real GDP growth dynamics as well as exchange rate movements.

3.1 Growth dynamics

Since 2007, the Rwandan economy has been steadily growing at an average rate of about 7.6% on annual basis on the back of sound macroeconomic policies and higher public investments.

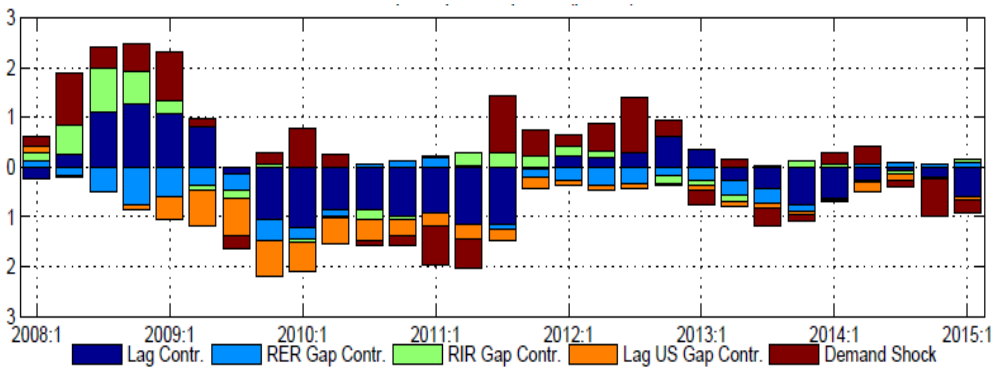
Figure 2: real GDP growth (%, Y-o-Y)



Source: BNR Monetary Policy Department

The model successfully explain the drivers behind the economic performance for key periods such as: the strong growth in 2008, the subsequent but delayed slowdown in 2009 due to the global financial crisis, the economic recovery of 2012 followed by the deceleration in economic performance especially in 2013 on the back of the aid shock and then the economic recovery after the shock. The 2008 increasing real economic activities mainly resulted from the demand shock and easy monetary policy as denoted by the positive contribution of these elements to the positive output gap. This period of double digit growth was in 2008Q2-2009Q1. The demand shock here may refer to expansionary fiscal policy that is not explicitly modeled.

Figure 3: Decomposition of the output gap

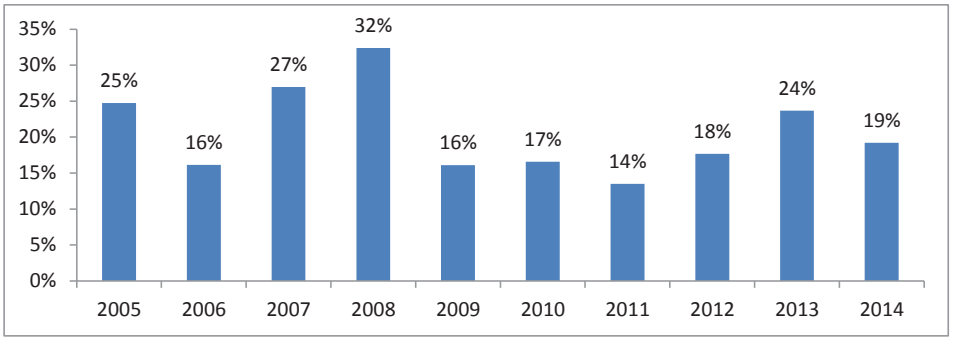


Source: BNR Monetary Policy Department

High demand in 2008 was supported by higher fiscal spending as evidenced by the increase in total nominal fiscal expenditure by 32%, the highest since 2005. However, though fiscal spending increased, its nominal value was amplified by the high level of inflation (i.e. 15.4% on annual average) that prevailed at the time.

The period of double digit growth was followed by economic contraction (single-digit growth) in 2009Q2-2011Q2 that was a result of the global financial crisis. The latter led to the decline in the global economy with negative implications on domestic demand, as captured by the negative contribution of the foreign output gap. Towards the end of this episode, the demand shock also dragged down the economy. The economy however recovered in 2012, thanks to the expansionary fiscal policy, leading to the positive contribution of the demand shock to the domestic output gap. In addition, monetary policy was also supportive to growth given the increasing credit to private sector that came as a result of a looser monetary policy that prevailed since 2011. This recovery was however short lived following the negative effects of the aid shock in the second half of 2012 that mainly materialized in 2013 as evidenced by the contraction in the demand shock contribution to the domestic output gap due to the shortfall in both household and government spending.

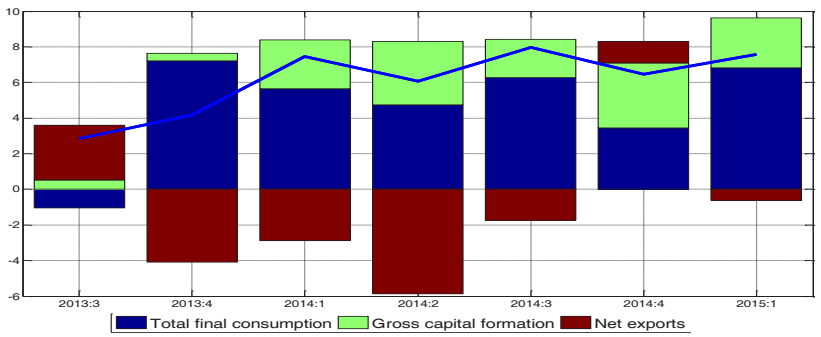
Figure 4: Nominal total fiscal expenditure and net lending (%, y-o-y)



Source: MINECOFIN

In 2014Q4 (figure 5), the economy started to slowdown following a decline in total final consumption in particular and aggregate demand in general. In the first quarter of 2015, the economy recovered, with real GDP growing by 7.6% following a rebound in total final consumption.

Figure 5: Real GDP growth in Rwanda

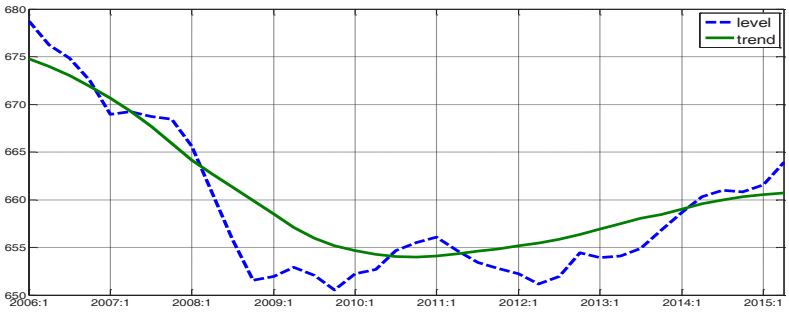


Source: BNR Monetary Policy Department

3.2 Exchange rate developments

The exchange rate dynamics since 2008 can be split into three episodes: the first episode is in 2008-2010 where the real exchange (RER) was appreciating, followed by the relative RER stability episode in mid-2010-mid 2011 and then the gradual RER depreciation thereafter, as shown in figure (6).

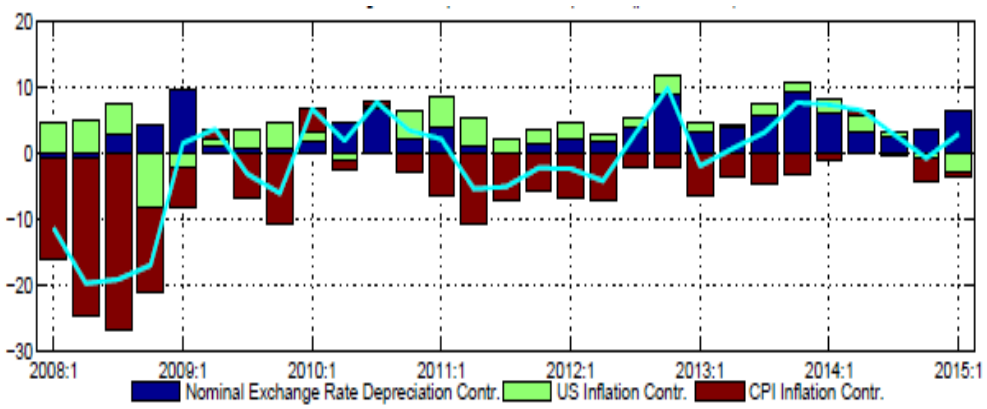
Figure 6: Real Exchange rate depreciation: FRW/USD



Source: BNR Monetary Policy Department

During the first episode, the RER appreciation was mainly driven by the fast increasing domestic inflation relative to foreign inflation, consistent with the fact that in 2008 inflation was rising on the account of rising international commodity prices, especially oil. The exception was in 2008Q4-2009Q1 where foreign inflation also contributed to RER appreciation and in 2008Q3-2009Q1 when the nominal exchange rate contributed to the slowdown in the RER appreciation.

Figure 7: Decomposition of Real Exchange Rate depreciation

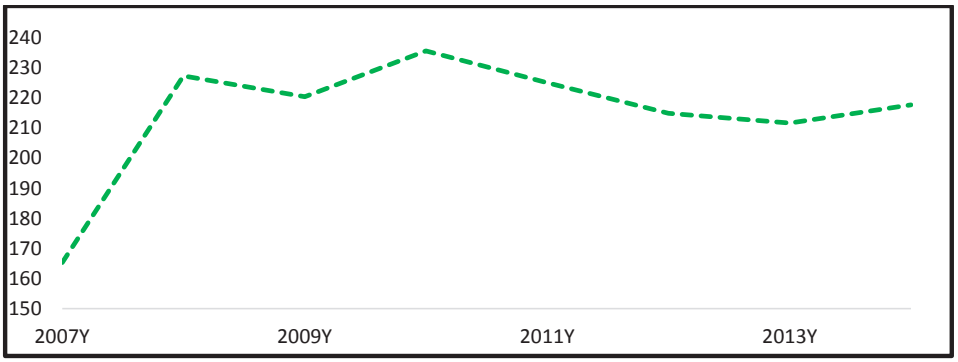


Source: BNR Monetary Policy Department

The second episode was characterized by the relative stability in the RER owing to the slowdown in domestic inflation, the relative stability of foreign inflation at around 2%

and stability of the FRW against the USD. The third and most recent episode was generally driven by the nominal depreciation of the FRW against the USD following the shortfall in aid inflows in the second half of 2012 and most recently, by the strengthening of the USD following the good performance of the US economy. This period coincided with moderate domestic and global inflation. Given the persistent nature of the US dollar and the expected monetary policy tightening towards the end of 2015, the ongoing depreciation of the FRW against the USD is also likely to continue in the medium term (Druck et al., 2015). The exchange dynamics during the three episodes are tracked quite well by the trend of the terms of trade index as shown in figure 8.

Figure 8: Terms of Trade (2000Y=100)

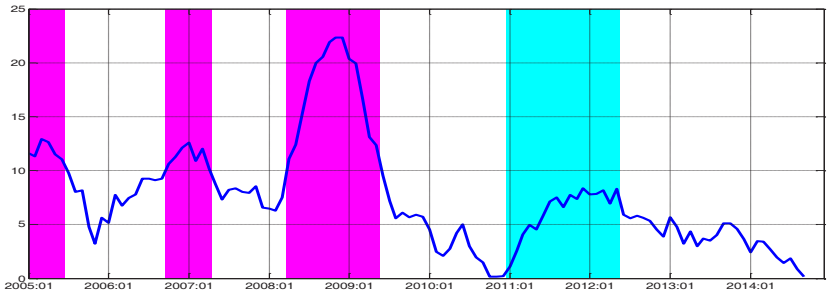


Source: World Bank & Bloomberg

3.3 Inflation developments

The key inflation episodes in Rwanda typically fall in three episodes, consistent with real economic growth and exchange rate developments discussed before. The first episode covers the 2008H2-2009H1 when inflation was in double digit, followed by the second episode of 2011 when inflation was rising but still in single digit and the third episode of 2014-15 characterized by falling inflation. These periods are chosen because of well-known developments in international commodity prices.

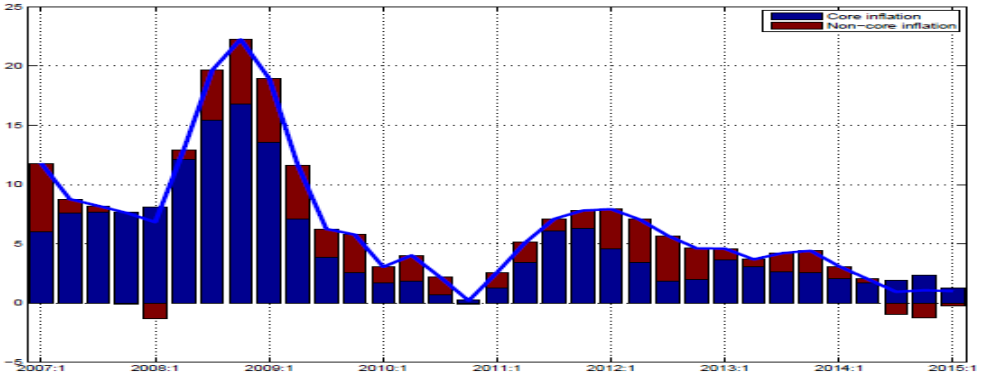
Figure 9: Key episodes for headline inflation



Source: BNR Monetary Policy Department

The role of international commodity prices can be viewed by looking at the contribution of non-core inflation to overall inflation. In the first and second episode, the contribution of non-core inflation was quite high, explaining why monetary authorities were reluctant to tighten the policy stance as the model suggests. In the last episode, the international commodity prices are declining, explaining why the contribution of non-core inflation is negative.

Figure 10: Decomposition of headline inflation



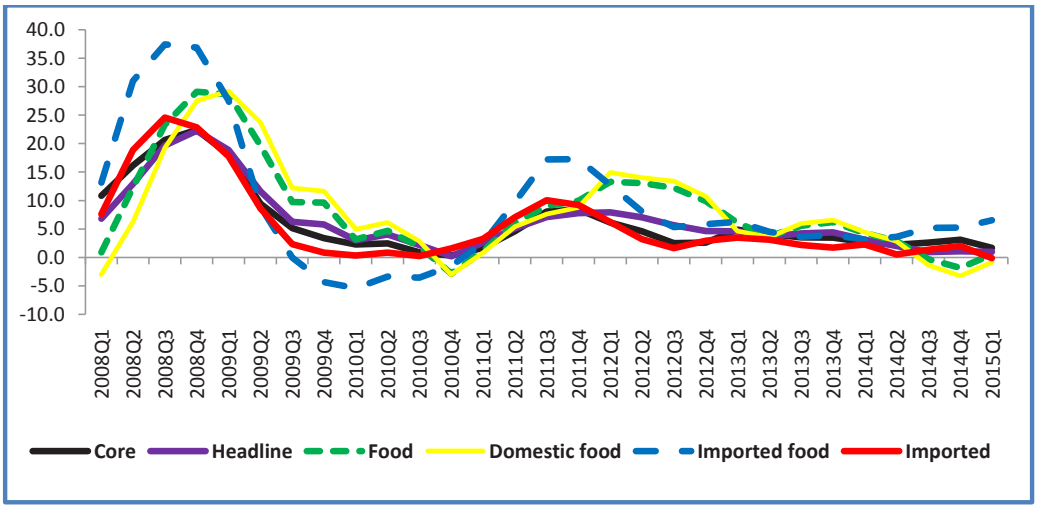
Source: BNR Monetary Policy Department

In the explanation of inflation dynamics, the model was designed to separate core from non-core inflation dynamics so as to be able to dissect the role of international

commodity prices, especially oil. The model detects the effect of imported food inflation on core inflation via the direct channel while the effect of imported oil inflation is captured through the indirect channel. Conversely the effect of both imported oil and food inflation affect non-core inflation through the indirect channel.

During the early period of the first episode, core inflation was rising mainly on the account of accelerating domestic food inflation (the positive contribution of the supply shocks) and marginally due to the influence of rising imported food inflation as well as increasing oil inflation (positive RMC contribution). Despite good agricultural harvests (total food production rose by 19.2% in 2008 and 12.6% in 2009), food inflation remained high following higher imported food inflation.

Figure 11: The influence of domestic and imported food inflation



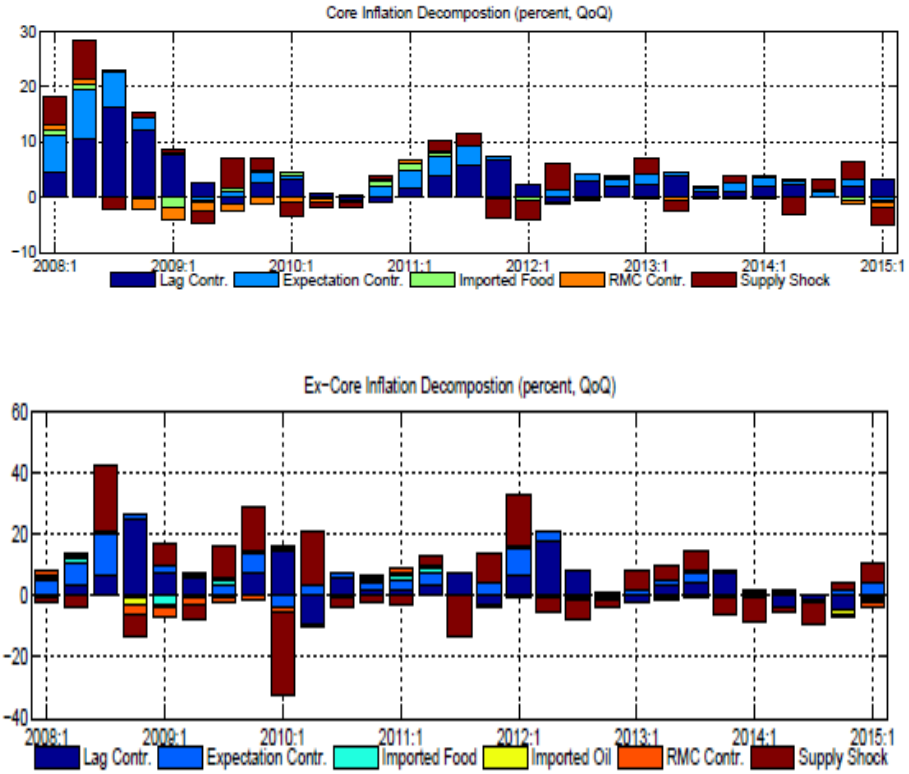
Source: BNR Monetary Policy Department

Owing to the rising trend of inflation globally, the role of expectations is also quite pronounced. Note that the contribution of monetary policy is missing due to the fact the model is designed in such a way that monetary policy reacts to headline inflation.

In the 2011 inflationary episode, the role of imported food inflation is slightly important at the beginning but fades later while the impact of supply shocks and

inflation expectations grow over time. This is consistent with the fact that the EAC region was experiencing droughts and rising food inflation in tandem with rising international commodity prices. The last episode starts in 2014 and is characterized by the decelerating international commodity prices, though their effect is rather small but likely to increase following the recent upward revision of local pump prices from 810 FRW/liter to 840 FRW/liter. Since core CPI account for about 78% of the overall CPI, the developments in core inflation tend to shape headline inflation in general.

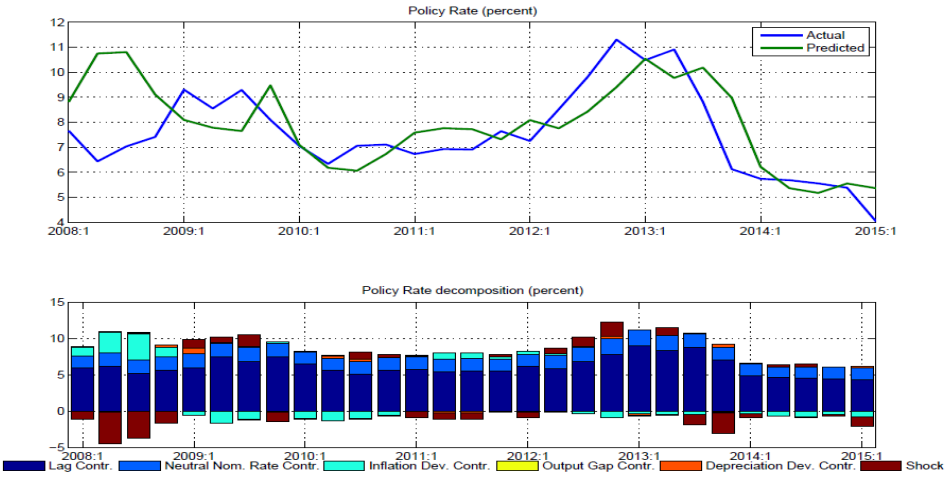
Figure 12: Decomposition of core and non-core inflation



Source: BNR Monetary Policy Department

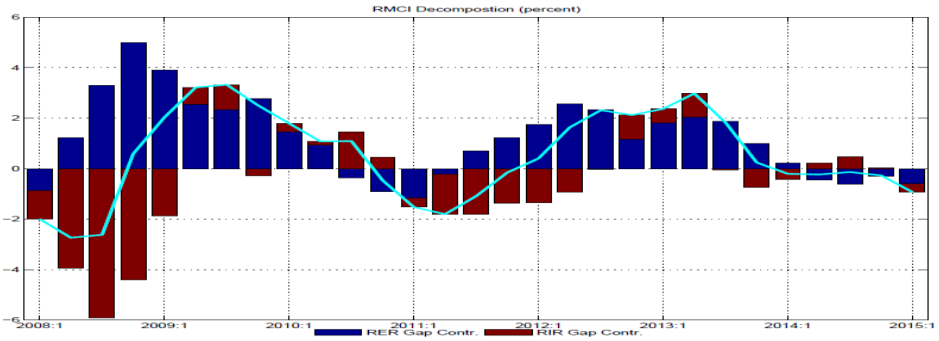
As mentioned earlier, the interbank rate is used here as the policy rate, especially because it reflects liquidity conditions and is also closely linked to other interest rates.

Figure 14: Monetary policy decomposition



Towards, the end of the last episode (2014-15), the National Bank of Rwanda adopted a loose monetary policy on the back of persistently declining inflation and the need to support economic recovery. This corresponds to the negative contribution of the real interest gap to the real monetary condition index as shown in figure 15.

Figure 15: Decomposition of the Real Monetary Conditions index (RMCI)



Source: BNR Monetary Policy Department

4. Conclusion

The FPAS macro-model discussed in this paper is designed to capture the key features of the Rwandan economy and will be a key building block for the transition to a forward-looking price based monetary policy framework. Despite its simplicity, the model tracks well the key developments in the Rwandan economy notably the inflationary periods of 2008-09 and 2011, the deflationary period of 2014-15 and the movements in the real exchange rates: appreciation in 2007-2010, stability thereafter followed by mild RER depreciation driven by the strengthening of the USD against the FRW. The model however has some drawbacks that need to be addressed in future by for example including the fiscal sector, incorporating the policy actions, especially exchange rate smoothing, and the role of money. Basing on the good performance of the model, the National Bank of Rwanda has started using some of its results, such as inflation and output gap projections, to inform monetary policy decision making. After making the mentioned improvements, the model will be fully operationalized to produce forecasts on key macro-economic variables and to provide a consistent framework for monetary policy discussions.

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APPENDIX

Appendix 1: Calibration of the model parameters

Parameter	Description	Value
	Output gap equation	
$a_1^{\tilde{y}}$	AR(1) parameter; output gap persistence	0.65
$a_2^{\tilde{y}}$	Coefficient of the real monetary conditions	0.15
$a_3^{\tilde{y}}$	Coefficient of the foreign output gap	0.15
a_1^{rmci}	Weight of the real exchange rate in the real monetary conditions	0.6
	Core inflation equation	
b_1^{core}	AR(1) parameter; core inflation persistence	0.58
b_2^{core}	Coefficient of the real marginal costs in core inflation	0.4
b_3^{core}	Coefficient of international food price pressures adjusted by relative prices	0.02
$b_1^{rmc\_core}$	Weight of output gap in real marginal costs	0.50
$b_2^{rmc\_core}$	Weight of imported food prices gap and exchange rate gap in real marginal costs adjusted by relative price gap	0.05
$b_3^{rmc\_core}$	Weight of imported oil prices gap and exchange rate gap in real marginal costs adjusted by relative price gap	0.07
	Non-core inflation equation	
b_1^{xcore}	AR(1) parameter; non-core inflation persistence	0.55
b_2^{xcore}	Coefficient of the real marginal costs non-core inflation	0.60
b_3^{xcore}	Coefficient of international food prices pressures adjusted by relative prices	0.03
b_4^{xcore}	Coefficient of international oil prices pressures adjusted by relative prices	0.01
$b_1^{rmc\_xcore}$	Weight of output gap in real marginal costs	0.55
$b_2^{rmc\_xcore}$	Weight of imported food prices gap and exchange rate gap in real marginal costs adjusted by relative price gap	0.03

$b_3^{rmc\_xcore}$	Weight of imported oil prices gap and exchange rate gap in real marginal costs adjusted by relative price gap	0.07
Headline inflation equation		
wt^{core}	Weight of core inflation in Headline	0.7485
Exchange rate equation (UIP)		
d_1	AR(1) parameter; coefficient of the expected exchange rate	0.6
Monetary policy rule		
f_1	AR(1) parameter; Policy rate persistence	0.8
f_2	Coefficient of the expected inflation deviations from the target	1.5
f_3	Coefficient of the output gap in monetary policy rule	0.2
f_4	Coefficient of the exchange rate deviations from the long run trend	0.4
Oil inflation equation		
$c_1^{\Delta l\_qoil\_tnd}$	AR(1) parameter; coefficient of the change in oil prices trend	0.9
$c_1^{l\_qoil\_gap}$	AR(1) parameter; coefficient of the oil prices gap persistence	0.75
Food inflation equation		
$c_1^{\Delta l\_qfood\_tnd}$	AR(1) parameter; coefficient of the change in food prices trend	0.9
$c_1^{l\_qfood\_gap}$	AR(1) parameter; coefficient of the food prices gap persistence	0.75
Trends		
ϕ_1	Persistence, long run real interest rate	0.8
ϕ_2	Persistence, long run output growth	0.7
ϕ_3	Persistence, long run real exchange rate	0.8
Foreign block		
$a_1^{\bar{y}^{us}}$	AR(1) parameter, persistence of US output gap	0.80
$a_2^{\bar{r}^{us}}$	AR(1) parameter, persistence of US real interest rate trend	0.90
$a_3^{i^{us}}$	AR(1) parameter, persistence of US nominal interest rate	0.94
$a_4^{\pi^{us}}$	AR(1) parameter, persistence of US CPI inflation	0.30

Steady states: long run values		
$\bar{r}_{ss}$	Long run value of the domestic real interest rate trend	4
$\Delta\bar{y}_{ss}$	Long run value of the real GDP growth trend	100*log(1+7.5/100)
$\Delta\bar{z}_{ss}$	Long run value of the real exchange rate trend	-1
$\pi_t^{yoy,tar}$	Domestic CPI inflation steady state/target	100*log(1+5/100)
$\bar{r}_{ss}^{us}$	Long run value of the US real interest rate trend	1
π_{ss}^{us}	Foreign inflation steady state/target	100*log(1+2/100)
Standard deviation of the shocks		
$\varepsilon_t^{\tilde{y}}$	Shock to domestic output gap	0.9
$\varepsilon^{\text{core}}$	Shock to CPI core inflation	1.7
$\varepsilon^{\text{xcore}}$	Shock to CPI non-core inflation	5.5
ε_t^{s}	Shock to nominal exchange rate	1.3
$\varepsilon_t^{\Delta\bar{y}}$	Shock to real GDP growth trend	0.8
$\varepsilon_t^{\Delta\bar{z}}$	Shock to real exchange rate trend	1.5
$\varepsilon_t^{\bar{r}}$	Shock to real interest rate trend	0.7
ε_t^{i}	Shock to monetary policy rate	0.9
$\varepsilon_t^{\Delta l\_qoil\_tnd}$	Real international oil price trend shock	1
$\varepsilon_t^{\Delta l\_qoil\_gap}$	Real international oil price gap shock	12
$\varepsilon_t^{\Delta l\_qfood\_tnd}$	Real international food price trend shock	1
$\varepsilon_t^{\Delta l\_qfood\_gap}$	Real international food price gap shock	4
$\varepsilon_t^{\tilde{y}^{us}}$	Shock to foreign (US) output gap	0.56
$\varepsilon_t^{\bar{r}_t^{us}}$	Shock to foreign(US) real interest rate trend	0.1
$\varepsilon_t^{i^{us}}$	Shock to foreign(US) nominal interest rate	0.44
$\varepsilon_t^{\pi_t^{us}}$	Shock to foreign(US) CPI inflation	2.03

Source: Monetary Policy & Research Department

Modeling GDP in Rwanda: the dynamic factors model (DFM) nowcasting methodology

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Abstract

The National Bank of Rwanda has started its journey towards a more price-based forward looking monetary policy premised on among others, the forecasts of inflation and economic activities. In this respect, the quarterly projections model under the Forecasting and Policy Analysis Systems (FPAS) is being developed and uses real GDP growth rate as one of the key inputs. The latter comes with at least a one quarter lag and thus complicates the forecasting exercise. This paper seeks to address this issue by developing a methodology that can be used to fill real GDP growth rate gap for one quarter ahead, analogously called now-casting. The paper uses the famous Dynamic Factors Model (DMF) developed by Stock and Watson (1991), cast in a state space framework and estimated using the maximum likelihood technique. The DFM uses high frequency data on some indicators used to compute the real Composite Index of Economic Activities (CIEA). Results of the paper show a very good fit to historical data given that the real growth rate for real GDP is estimated at 6.7% in 2014Q4 against the actual of 6.2%. Going forward, real GDP growth rate is expected to stand at around 6.6% in 2015Q1. These DFM results fare well against the results of the univariate AR model, which is often considered as a benchmark model, especially in the short-run.

Key words: Nowcasting, Real GDP, Dynamic factors, Rwanda

JEL Classification: C53, E37

1. Introduction

In most cases, monetary policy decisions in real time are based on assessments of current and future economic conditions using incomplete data. Since most data are released with a lag and are subsequently revised, the reconstruction of current-quarter data on key variables is an important task for central banks and one to which they devote a considerable amount of resources. The Quarterly Projections Model (QPM) being developed at BNR uses data on domestic variables for real GDP, nominal interest rate, inflation and exchange rates as well as a set of foreign variables.

Real GDP is a useful measure of economic performance but more specifically, it is used to derive the output gap which is also used as a proxy for aggregate demand and it is one of the aggregate indicators of inflationary or deflationary pressures in the economy (Ferrara, 2008, Giannone, 2005, Billi, 2012). A positive output gap implies an overheating economy and upward pressure on inflation. By contrast, a negative output gap implies a slack economy and downward pressure on inflation. Unfortunately, GDP in Rwanda is produced with more than one-quarter lag which limits its use in the formulation of monetary policy stance. This paper seeks to develop a methodology for estimating real GDP using high frequency data so as to be able to have real time data required for the development of the QPM.

The main objective of this article is to develop a GDP nowcasting tool for Rwanda. Given the necessity of the output gap in monetary policy decision making process, it is imperative to nowcast output (GDP) data. GDP estimations are accomplished by constructing models which tend to explain the quarter-on-quarter GDP changes, with the support of new economic information conveyed in high frequency indicators (Celiku, 2009).

There are many different approaches to GDP nowcasting and a large body of literature on this topic as summarized in Liu et al. (2011). The differences stem from the variety of data available that is considered useful, and the different ways of modeling the relationship between these data and GDP. The approaches range from the simple autoregressive processes to the more sophisticated dynamic factor models. This paper

uses the Dynamic Factors model to nowcast GDP but also goes ahead to compare the results of the DFM with those of the benchmark AR model.

2. Theoretical foundations of the DFM

The Dynamic Factor models are rooted in financial economics, more specifically in investment/portfolio management/asset pricing theory. The factor models were adopted in other fields and became popular in macroeconomic analysis and forecasting especially in central banks as they allow predicting values of some important macroeconomic variables such as GDP based on information contained in some latent variables.

A static factors model, as in Bai and Serena (2008), seeks to predict the value of a variable y_t whose variations are theoretically assumed to result from shocks to other latent variables and to some idiosyncratic shocks. This can be summarized as follows:

$y_t = \lambda' f_t + e_t$ .....(1)

y_t is a vector defined as $y_t = [y_{1t}, ..., y_{Nt}]$ and each element of f_t can be represented as:

$f_{it} = \lambda_{i1} f_{1t} + ... + \lambda_{ir} f_{rt} + u_{it}$ .....(2)

Whereby $t = 1, .T.$ and f_t are referred to as common factors. Depending on the domain of interest, the factors can be macroeconomic variables or returns on portfolios that explain the variable of interest y_t.

$\lambda_{it} = [\lambda_{i1}, \dots, \lambda_{ir}]'$, $f_t = [f_{1t}, \dots, f_{rt}]'$, $e_t = [e_{1t}, \dots, e_{Nt}]'$ ..... (3)

λ_{it} is referred to as factor exposures, or factor sensitivities or factor loadings. It is a vector of weights that unit i put on the corresponding r common factor f_t.

It is assumed that e_t is a vector of uncorrelated errors. Thus, $E(e_t) = 0$ and $E(e_t e_t') = \Sigma =$ diagonal$(\sigma_1^2, \dots, \sigma_N^2)$; $E(f_t) = 0$ and $E(f_t f_t') = \Omega$; $E(f_t u_t') = 0$.

The equations (1) and (2) make together a system of state space model with equation (1) and (2) representing the measurement equation and transition equation respectively. Thus, it becomes possible to estimate the model by maximum likelihood function via Kalman filtration especially in case of a small number of factors. Solving

the system (1) and (2) using the Kalman filter implies that the estimated factors (conditional on information available at time t-1) are maximized.

3. Application of the DFM to the Rwandan data

The application of the DFM to the Rwandan data involves three important phases. The first phase consists of data transformation which includes log-transformation, seasonal adjustment, computing the year-on-year change and demeaning the latter. The second phase involves specification and estimation of the DFM whereas the last and third phase involves transformation of the DFM results into interpretable findings, notably the computation of the nowcast for real GDP growth rate.

In this paper, we perform a GDP now-casting application for Rwanda using the dynamic factor model (DFM) following the methodology proposed by Stock and Watson (1991). The DFM to be estimated is cast in the state-space form that consists of measurement and state equations. The measurement equations define relationships between the observable variables, GDP growth (dl_RGDP_t) for this case, and an unobservable common real factor S_t. By analogy, the common factor in Stock and Watson (1991) can also be called an index of coincident indicators. We estimate a nine-variable DFM, all variables are in real terms and expressed as year-on-year differences of logs times 100. The data in growth rates are demeaned prior to DFM estimation to ensure Stationarity.

The variables chosen are those that are often used to construct the real composite index of economic activities (CIEA). The choice of high frequency variables to include in the model is based on their respective correlation with Real GDP[12], economic intuition and plausibility of the results. Given the availability of data, we constrain the sample to 2007Q1 until 2015Q1. To start with, in-sample nowcasting for 2014Q1-Q4 was carried out and then the out-of-sample nowcast for 2015Q1. Table 1 gives a summary of the selected variables and their corresponding correlations with RGDP.

[12] The paper was based on real GDP data for 2006Q1-2014Q4 period

Table 1: Indicators selected in the DFM

Variable	*Label*	*Correlation with Real GDP*
Breweries	Breweries	0.74
Cement	Cement	0.94
CPS	Credit to private sector	0.97
Electricity	Electricity	0.97
m_total	Total imports	0.96
Manufacturing	Manufacturing	0.56
Trade	Trade	0.92
x_total	Total exports	0.9

Source: Authors' calculations

Given the above selected variables, we specify the DFM as consisting of the following set of equations:

$$RGDP\_d_t = c(1)*s_t + \varepsilon_{RGDP_t} \ldots\ldots\ldots\ldots\ldots\ldots(4)$$
$$Ind\_d_{i,t} = c_i * s_t + \varepsilon_{Ind\_d_{i,t}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$
$$i = 1\ldots, k$$

$$S_t = \rho_S S_{t-1} + \varepsilon_{S,t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

The Ind_d_i stands for each of the selected coincident indicator in table 1 above. Both equations 12 and 13 are measurement equations. The state (transition) equation then describes the motion of the common real factor as an AR(1) process: $S_t = \rho_S S_{t-1} + \varepsilon_{S,t}$. The above equations are stated in state space format and estimated using the Kalman filter with the underlying objective of using information on the high-frequency indicators to now-cast GDP. The remaining disturbances are independently and identically distributed normal random variables:

$$[\varepsilon_{RGDP}, \varepsilon_{CPS}, \varepsilon_{electricity}, \varepsilon_{m\_total}, \varepsilon_{trade}, \varepsilon_{cement}, \varepsilon_{manufacturing}, \varepsilon_{breweries},, \varepsilon_{x\_total}]$$

The state-space model is linear Gaussian and thus we use the Kalman filter. All factor loadings are collected in;

$$\theta_\lambda = \left[\lambda_{RGDP}, \lambda_{CPS}, \lambda_{Electricity}, \lambda_{M\_total}, \lambda_{Trade}, \lambda_{Cement}, \lambda_{Manufacturing}, \lambda_{Breweries}, \lambda_{X\_total}\right]$$

All persistence parameters are in $\theta_\rho = (\rho_S)$; and all standard deviations of disturbances are collected in:

$$\theta_\delta = \left[\delta_{RGDP}, \delta_{CPS}, \delta_{Electricity}, \delta_{M\_total}, \delta_{Trade}, \delta_{Cement}, \delta_{Manufacturing}, \delta_{Breweries}, \delta_{X\_total}\right]$$

so that $\theta = (\theta_\lambda, \theta_\rho, \theta_\sigma)$. Calibration of the starting values for the model parameters θ is done iteratively. The DFM is estimated as a state-space model using the ML procedure and θ_0 as starting values.

Then, the real GDP growth prediction in percent is $RGDP\_d_{T+1|T} + m_{RGDP}$, t=T-2, T-1, T, where m_{RGDP} is the sample mean of real GDP growth, estimated as the annual difference of the log of the seasonally adjusted RGDP times 100.

As with the one-step ahead forecasted states above, we may use the smoothed values to form s*moothed estimates of the signal variables* and to compute *smoothed disturbance estimates*. The latter disturbance estimates should be used to evaluate in-sample fit of the model.

Note that to perform this exercise, an excel sheet is used to transform the results. The excel sheet is simply used to compute the following:

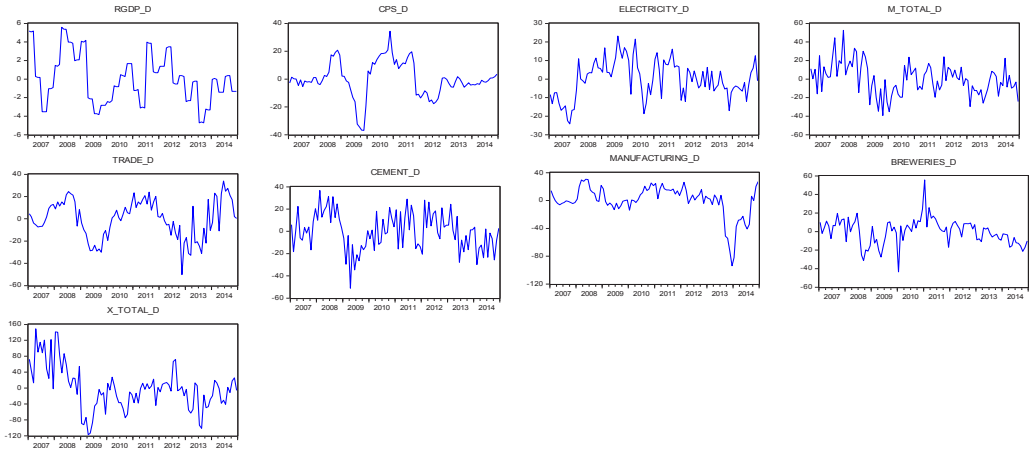
$RGDP\_d_{T+1|T} + m_{RGDP}$ for t=T-2, T-1, T

The common practice is to start with in-sample forecast and assess the goodness of the forecasts and then use the most parsimonious model to perform out-of-sample forecasts, which we do in this exercise. The most parsimonious model is one including the variables in table 1 above.

4. Results

The DFM model we chose is one that fits historical data quite well and whose residuals do not suffer much from auto-correlation. Figure 1 shows the development of all variables used to forecast RGDP.

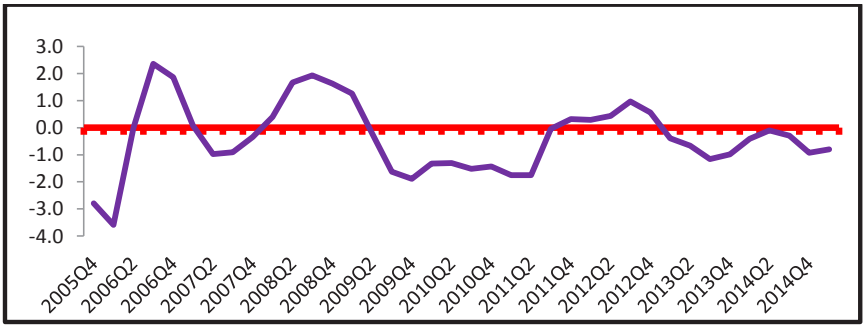
Figure 1: A plot of the demeaned series used in the DFM



Source: Authors' calculations

To be able to have in-sample real GDP growth forecasts, assumptions have to be made about the sample average to use to feed into the formula $RGDP\_d_{T+1|T} + m_{RGDP}$. This is done by observing the trend of the output gap to have an idea of the expected business cycle, which may change for a particular period of time. Once a slowdown or stagnation is expected, we assume a sample average of 6.5% (one standard deviation from potential GDP growth rate) whereas 7.5% (which is the potential GDP growth rate) is assumed for economic booms as indicated by the path of the output gap (figure 2).

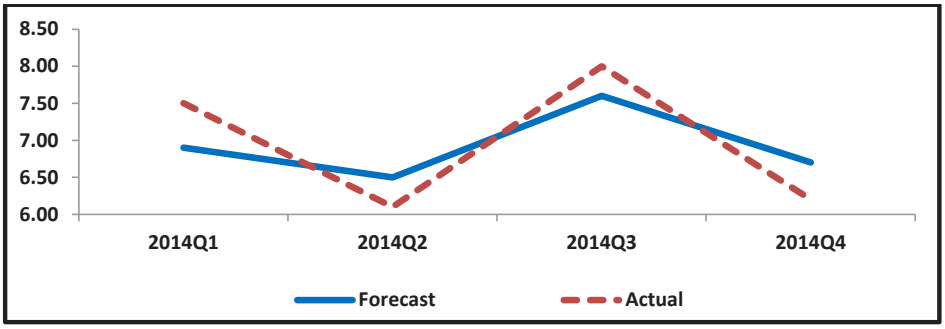
Figure 2: The output gap



Source: Authors' estimations

The forecast for a particular quarter is then derived as a moving average for the current and next quarters' forecasts. Basing on these assumptions, the forecasts for real GDP growth rate track well the trend of actual RGDP growth rate as shown by the figure 3. The in-sample forecasts for real GDP growth rate are 6.9%, 6.5%, 7.6%, and 6.7% for 2014Q1, 2014Q2, 2014Q3 and 2014Q4 respectively, compared to the actuals of 7.5%, 6.1%, 8% and 6.2% for the same period.

Figure 3: In-sample forecasts



Source: Authors' estimations

This close co-movement between the in-sample forecasts and actual real GDP growth rates suggests that the dynamic factors model can be used to provide reliable real GDP growth rate nowcast. The goodness of the nowcasts will however depend on the analysis of the trajectory of the business cycle. The nowcast for 2015Q1 is 6.6%, which indicates a small pickup in real economic growth.

Table 2: The results of the DFM for the 2015Q1 nowcast

Sspace: SS_9
Method: Maximum likelihood (Marquardt)
Date: 06/02/15 Time: 14:08
Sample: 2007M01 2015M03
Included observations: 99
Partial observations: 3
Estimation settings: tol= 1.0e-05, derivs=accurate numeric
Initial Values: C(1)=0.81913, C(2)=0.90260, C(3)=2.63500, C(4)=2.21359, C(5)=-0.21002, C(6)=2.08218, C(7)=4.36620, C(8)=2.25519, C(11)=4.29406, C(12)=2.30987, C(15)=9.88259, C(16)=2.72938, C(17)=4.06341, C(18)=2.29862, C(19)=4.77994, C(20)=2.49174, C(21)=1.07387, C(22)=2.29605, C(35)=0.91663
Convergence achieved after 59 iterations

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.713075	0.208148	3.425810	0.0006
C(2)	1.130993	0.080208	14.10078	0.0000
C(3)	2.637952	0.802560	3.286921	0.0010
C(4)	2.170549	0.049344	43.98822	0.0000
C(5)	-0.551364	0.530451	-1.039424	0.2986
C(6)	2.132374	0.042657	49.98918	0.0000
C(7)	4.019383	1.173761	3.424363	0.0006
C(8)	2.282144	0.040552	56.27743	0.0000
C(11)	4.199972	1.171642	3.584689	0.0003
C(12)	2.271617	0.030493	74.49689	0.0000
C(15)	9.958522	3.118122	3.193756	0.0014
C(16)	2.783296	0.024745	112.4785	0.0000
C(17)	3.707109	1.024641	3.617957	0.0003
C(18)	2.292296	0.039239	58.41861	0.0000
C(19)	4.263061	1.831486	2.327652	0.0199
C(20)	2.470565	0.024769	99.74495	0.0000
C(21)	1.326450	0.665409	1.993436	0.0462
C(22)	2.277279	0.026144	87.10497	0.0000
C(35)	0.919304	0.066565	13.81051	0.0000

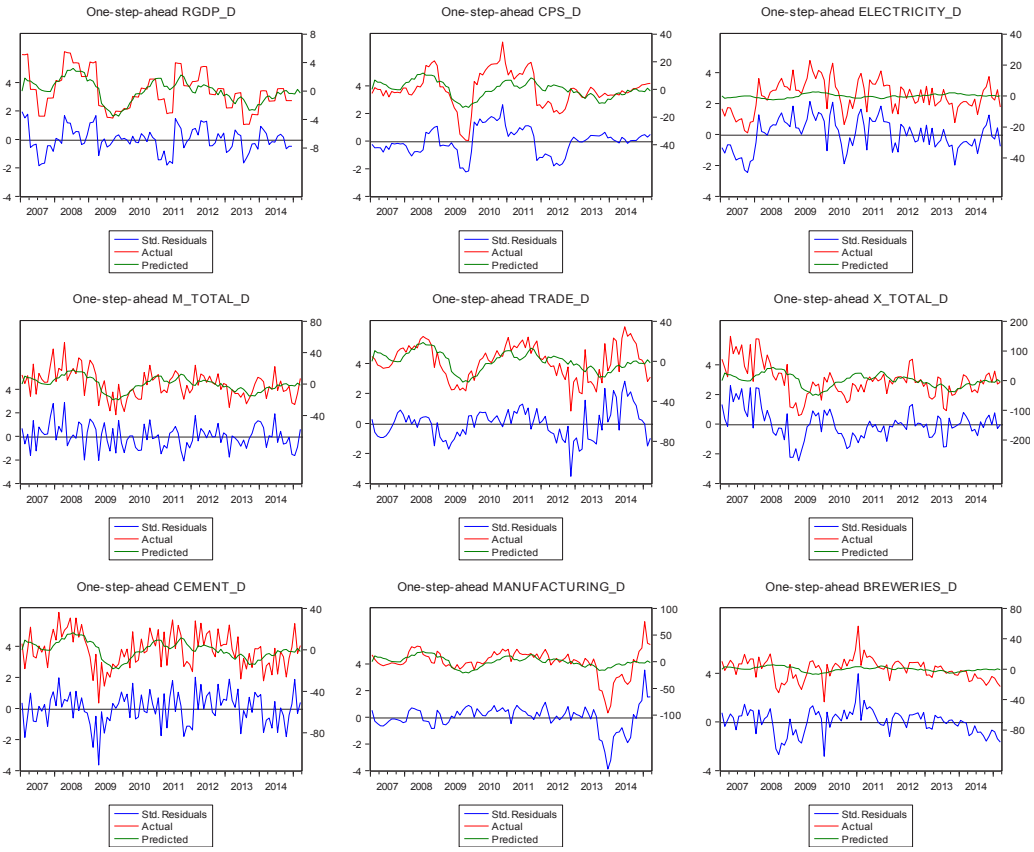
	Final State	Root MSE	z-Statistic	Prob.
S1	-0.084479	1.373734	-0.061496	0.9510

Log likelihood	-3529.497	Akaike info criterion	71.68681
Parameters	19	Schwarz criterion	72.18486
Diffuse priors	0	Hannan-Quinn criter.	71.88832

Source: Authors' estimations

Though the fit to the data of electricity and breweries is not quite good, the fit for the other variables seems plausible and on average given that the residuals are generally well-behaved for all the variables as shown in figure 4, the overall fit to the real GDP growth rate data is quite impressive.

Figure 4: Residuals and actual Vs predicted demeaned series plot



Source: Authors' estimations

We compare the results of the DFM with AR (1) forecasts. Using the Akaike, Swharz and Hannan-Quin information criteria, we find the ARMA (1, 0) as the best benchmark model as shown in the table 3.

Table 3: Lag length selection for the AR benchmark model

ARMA order	Akaike	Schwarz	Hannan-Quinn
0,0	4.818365	4.845077	4.829162
0,1	4.235507	4.288931	4.257102
1,0	* 3.795321	* 3.849087	* 3.817046
1,1	3.809789	3.890438	3.842377

* indicates best model

Source: Authors' estimations

The estimated benchmark model results are presented in table 4 below:

Table 4: Results of the Benchmark ARIMA (1, 0) model

Dependent Variable: RGDP
Method: Least Squares
Date: 06/02/15 Time: 15:02
Sample (adjusted): 2007M02 2014M12
Included observations: 95 after adjustments
Convergence achieved after 4 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.019091	0.763130	9.197769	0.0000
AR(1)	0.783775	0.061275	12.79107	0.0000

R-squared	0.637585	Mean dependent var	7.265579
Adjusted R-squared	0.633688	S.D. dependent var	2.639112
S.E. of regression	1.597289	Akaike info criterion	3.795321
Sum squared resid	237.2739	Schwarz criterion	3.849087
Log likelihood	-178.2777	Hannan-Quinn criter.	3.817046
F-statistic	163.6116	Durbin-Watson stat	1.845522
Prob(F-statistic)	0.000000		

Inverted AR Roots	.78

Source: Authors' estimations

Using the benchmark ARMA (1, 0) model, the real GDP growth rate forecasts for 2014Q1, 2014Q2, 2014Q3, 2014Q4 and 2015Q1 are respectively 5.0% ,7.1%, 6.1%, 7.6% and 6.2%. Clearly, the forecasts for 2015Q1 for the two models are quite close (6.2% for ARMA and 6.6% for DFM).

5. Conclusion

GDP forecasts, obtained using the aforementioned DFM, fare well compared to actual real GDP numbers. Comparison shows that the DFM out-performs the AR model even in the very short run though its performance is enhanced by the analysis of the path of the business cycle. The developed DFM shall continue to be tested in future to make it more realistic in terms of capturing the realities of the Rwandan economy particularly by using other GDP now-casting techniques that need to be experimented and compare their results with those of the DFM. Development of nowcasting tools are key inputs to improvement of modeling and forecasting and will pave way to successful transition to a forward-looking and evidence-based monetary policy framework.

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