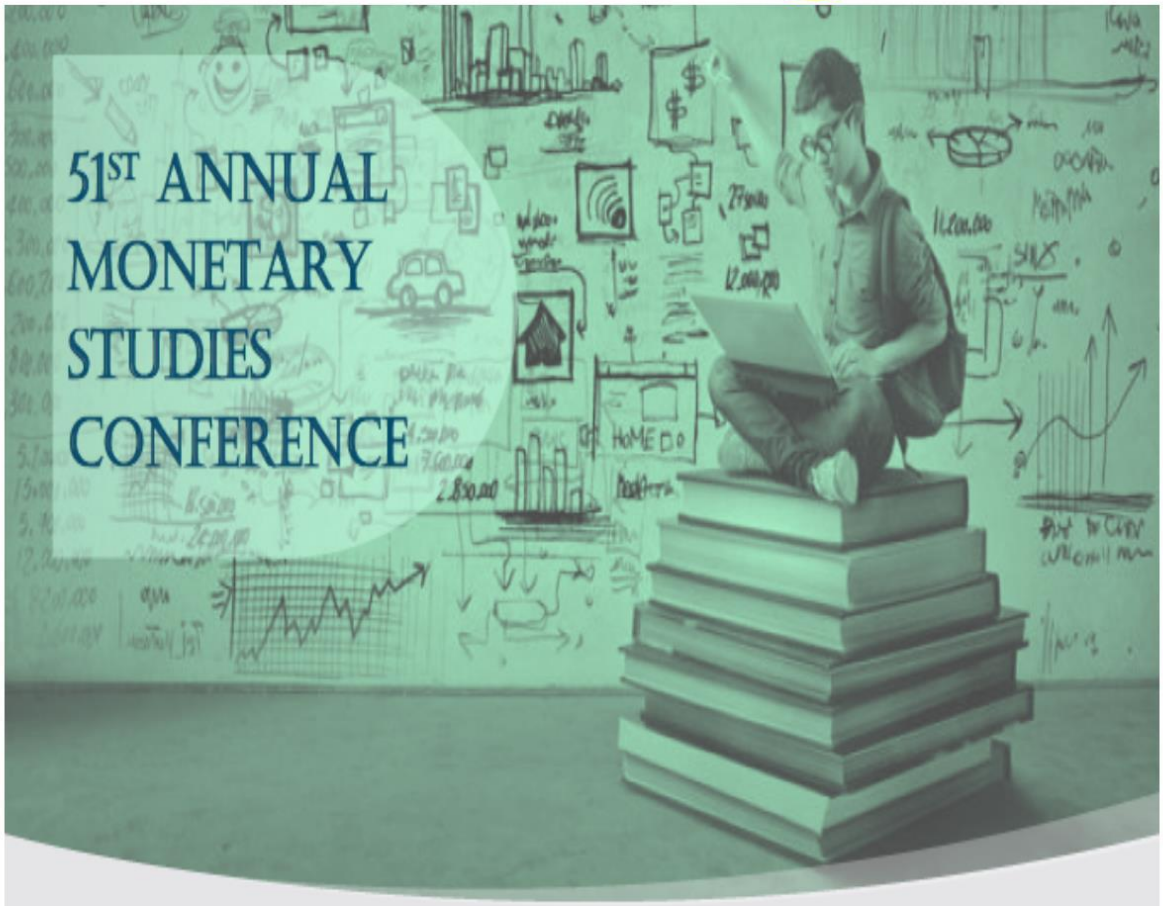
Caribbean Economic Research Team



51ST ANNUAL MONETARY STUDIES CONFERENCE

Hosted by the Eastern Caribbean Central Bank

Basseterre, St. Kitts and Nevis.

19th—21st November,2019.

CENTRAL BANK of BELIZE

Working Paper Series

CBB-WP-/004

The Monetary Policy Transmission Mechanism in Belize:

A Bayesian VAR Approach

Rumile Arana

Research Department
Economic Intelligence Unit

CBB Working Paper

Research Department

The Monetary Policy Transmission Mechanism in Belize: A Bayesian VAR Approach

Prepared by: Rumile Arana

Authorized for distribution by: Emory Ford

October 2019

Abstract

This paper investigates the effectiveness of the monetary policy transmission mechanism in Belize. Using a Bayesian Vector Autoregressive (BVAR) framework, the study examined the impact of monetary policy shocks on macroeconomic variables through the interest rate, bank lending, and exchange rate channels on quarterly data from 1995Q1 to 2019Q1. The results showed that shocks to cash reserve requirements were transmitted mainly through the bank lending channel to the real economy in the medium term. Signals through the interest channel were statistically insignificant, while those through the exchange rate channel went against a priori expectations. Shocks to the Treasury-bill rate were found to be statistically insignificant in an environment of high excess liquidity. Thus, the monetary policy transmission could be more effective by reducing excess reserves in the banking system.

JEL Classification Numbers: C23, C26, E12, E31, E52, E58

Keywords: Monetary Policy, Bayesian VAR, Minnesota Prior, Impulse Response function

Author's E-Mail Address: rumile.arana@centralbank.org.bz

Table of Contents

1. Introduction

Monetary policy transmission mechanism is the process through which monetary policy decisions affect key macroeconomic variables, particularly real output and inflation for stabilization purposes. Monetary policy decisions, usually made by a country's Central Bank, influences money supply and interest rates in an economy utilizing various tools such as reserve requirements and open market operations, ultimately to impact the overall performance of that economy. It is well known that the traditional monetary policy transmission process occurs through three main channels, namely, the credit, exchange rate, and asset price channels (Mishkin, 1996). Also, monetary policy generally works well in tandem with fiscal and structural growth policies to shape an environment conducive to sustainable economic growth.

Many studies have found that monetary policy indeed impacts real output (see for example Bernanke & Blinder, 1992; Bernanke & Gertler, 1995; Gertler & Hofmann, 2016; Rocabado, 2018). However, majority of these studies examined monetary policy transmission mechanisms in advanced economies with well-functioning financial systems (Mishra et. al., 2010), leaving gaps on how central banks influences the amount of money and cost of credit in developing economies. Previous empirical evaluations postulate that the credit channel may be the most significant transmission method in small states like Belize, however various institutional deficiencies may make the channel weak and unreliable (Mishra et al, 2010). Since the magnitude and the timing of the pass-through effects of monetary policy decisions to GDP and prices differ across economies based on idiosyncratic factors, it is important for central banks in developing countries to continuously examine how this process works across time as development takes place.

The limited number of studies that have investigated Belize's monetary policy transmission mechanism typically found evidence of a relatively benign transmission process. For instance, Khan (1998) and Caribbean Economic Research Team (CERT, 2019) indicated that the transmission mechanism is weak and short lived, while Kendall (2001) found that monetary policy shocks yield results contrary to *a-priori* expectations. Garcia et al. (2009), Vellos and Sosa (1996) and Alvarez (1986)

emphasized the importance of synchronizing monetary policy with fiscal policy for better monetary policy effectiveness.

Adding to the body of empirical work on small, developing economies, this study seeks to analyse the impact of the Central Bank of Belize's main monetary policy tools, the Treasury bill rate and reserve requirements, on the Belizean economy. It aims to identify the main monetary policy transmission channels and measure the magnitude and duration of their impact using a Bayesian vector autoregression (BVAR) framework. While BVARs were originally employed to improve forecasting accuracy by Litterman (1979) and Doan et al. (1984), Bayesian methods have become increasingly useful in solving the over-parameterization issue present in VAR modelling and in providing more precise parameter estimates as well. More accurate parameter estimates will improve the analysis from the model, the impulse response functions, and variance decompositions.

The results show that the most effective monetary policy channel in Belize is the credit channel, followed by the interest rate channel, both of which are being impaired by current excess liquidity conditions. The cash reserve requirement was the most effective monetary policy tool during the period under review (1995Q1 to 2019Q1), while shocks to the Treasury bill rate yielded statistically insignificant results. The latter outcome may be due to the fact that the instrument has only been actively utilized as a monetary policy tool during periods of elevated liquidity in the banking system. None of the policy instruments had any substantial impact on inflation. Thus, the effectiveness of Belize's monetary policy transmission could be strengthened by reducing the high level of liquidity in the banking system.

The rest of this paper is structured in the following way. Section 2 gives a background of the evolution of monetary policy in the economy and some of the main characteristics of the banking sector of Belize. Section 3 provides a review of the relevant empirical literature on monetary transmission mechanism. Section 4 examines the data used and the methodology employed in the research. Section 5 presents the results, while section 6 concludes with policy implications of the study.

2. Stylized Facts

2.1 Monetary Policy in Belize

Belize is characterized as a small open economy, and so the country bears most of the customary characteristics of one including, a dependence on external trade, a large public sector, and market imperfections, which may hinder policy implementation. Early monetary policy was enacted by the Monetary Authority of Belize (established 1976) under the mandate to "stimulate the economy, control inflation and maintain balance of payment stability" (See https://www.centralbank.org.bz/financial-system/monetary-policy). The Authority mostly used direct monetary policy instruments, particularly interest rate controls. However, they also used other tools, including, cash reserve and liquid assets ratios, and credit controls. In May 1976, the country pegged its currency (Belize dollar) to the United States dollar (BZ$2.00 to US$1.00) to maintain exchange rate stability and to keep inflation subdued. The Central Bank (CBB) was established shortly thereafter under the Central Bank of Belize Act in 1982. It's mandate was to foster "monetary stability, especially as regards stability of the exchange rate, and promoting credit and exchange conditions conducive to the growth of the economy of Belize" (Central Bank of Belize Act, revised 2011). The Central Bank 'inherited' all the tools of the Monetary Authority and continued to use direct monetary policy instruments to set key interest rates, including, various lending, deposit and discount rates.

Since the late 1980's and up until 2010, the Central Bank utilized reserve requirements as its main tool of monetary policy, incorporating interest rate controls and direct liquidity management activities[1] occasionally. The main goal of the Central Bank of Belize's monetary

[1] These actions included making Defense Bonds and Treasury notes available to domestic banks and the transfer of deposits of Statutory Bodies from their accounts at domestic banks to those at the Central Bank.

policy was to influence credit conditions and, through the effects of the transmission mechanism, manage pressure on the exchange rate by altering the demand for foreign currency reserves.

Table 1

Monetary Policy Changes & Impact[1] on Observed Variables (1990 -2010)

Date	Policy Variable Change:			Expected change in:					
	Statutory Liquidity	Cash Liquidity	Δ[2]	GDP[3]	Loans	For. Reserves	Import Cover	Stat Liq	Cash Liq[3]
1991Q3	**28 to 25**	**7 to 6**			**1**	**1**	**1**	**1**	
1992Q4	**25 to 27**	**6 to 7**			**1**	0	0	0	
1993Q4	**27 to 28**	**n.a.**			**1**	0	0	0	
1995Q1	**28 to 24**	**7 to 5**		0	0	0	0	**1**	
1995Q4	**24 to 26**	**5 to 7**		0	0	0	0	**1**	
1998Q4	**26 to 24**	**7 to 5**		**1**	**1**	**1**	**1**	**1**	
2000Q2	**n.a.**	**5 to 3**		0	0	**1**	**1**	0	
2001Q1	**n.a.**	**3 to 4**		0	0	0	0	0	
2002Q4	**n.a.**	**4 to 6**		0	0	0	0	**1**	**1**
2004Q2	**24 to 19**	**n.a.**		0	**1**	**1**	**1**	**1**	0
2004Q4	**19 to 20**	**6 to 7**		0	**1**	**1**	**1**	**1**	**1**
2005Q2	**20 to 21**	**7 to 8**		**1**	0	0	0	0	**1**
2006Q1	**21 to 22**	**8 to 9**		0	**1**	**1**	**1**	**1**	**1**
2006Q3	**22 to 23**	**9 to 10**		**1**	**1**	**1**	**1**	0	**1**
2010Q2	**n.a.**	**10 to 8.5**		0	**1**	0	0	**1**	**1**

[1] If variable shows expected movements after monetary policy change, table value is 1, if not 0

[2] Green represents expansionary monetary policy and red represents contractionary monetary policy

[3] Data was not available for missing time periods

To more readily ascertain the impact of changing reserve requirements, a scenario analysis was carried out in which the growth rate of several variables of interest were observed when there were policy changes. The ex-ante and ex-post growth rates were averaged for a period of six months to evaluate the immediate impact of monetary policy changes on excess cash reserves, excess statutory liquidity, loan growth, real GDP, and gross reserves. It's expected that when there is an expansionary monetary policy, the growth rate in real GDP and loans should increase while there will be a reduction in foreign reserves, import cover and both

measures of liquidity. Table 1 shows that following the fifteen monetary policy changes made between 1990 and 2010, loan growth (60%), statutory liquidity (60%), and cash liquidity (86%) responded majority of the time in line with a priori expectations. In contrast, the expected change in gross reserves and GDP growth occurred only 47% and 25%, respectively.

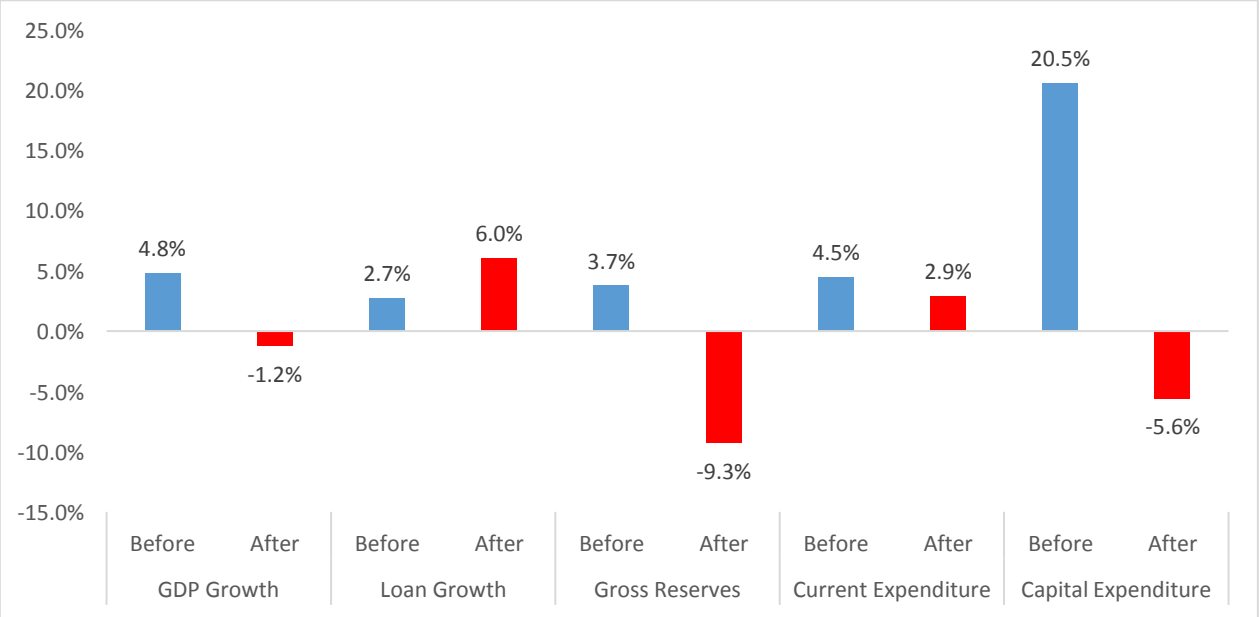


Figure 1: Growth in Macroeconomic Variables Before & After Expansionary Monetary Episodes (1990 to 2010).

When expansionary monetary policy is followed by contractionary fiscal activities, GDP growth tends to follow a contractionary path. As expected, domestic banks holdings of liquid assets and cash reserves, which grew by 0.8% and 8.0%, respectively before the change, then contracted by 4.0% and 4.3%, respectively after the reduction in reserve requirements. The drawdown in bank reserves funded a credit expansion, as loan growth expanded from 2.7% to 6.0% (see Figure 1). Unsurprisingly, accommodative monetary policies preceded a fall in international reserves. However, contrary to a priori expectations monetary policy expansions did not coincide with periods of higher economic growth. In fact, international reserves and real

GDP growth both declined on average by 9.3% and 1.2%, respectively. The latter can be partially attributed to episodes of fiscal consolidation by way of capital expenditure cuts, which swung from an average growth rate of 20.5% prior to episodes of monetary policy easing to an average decline of 5.6% thereafter.

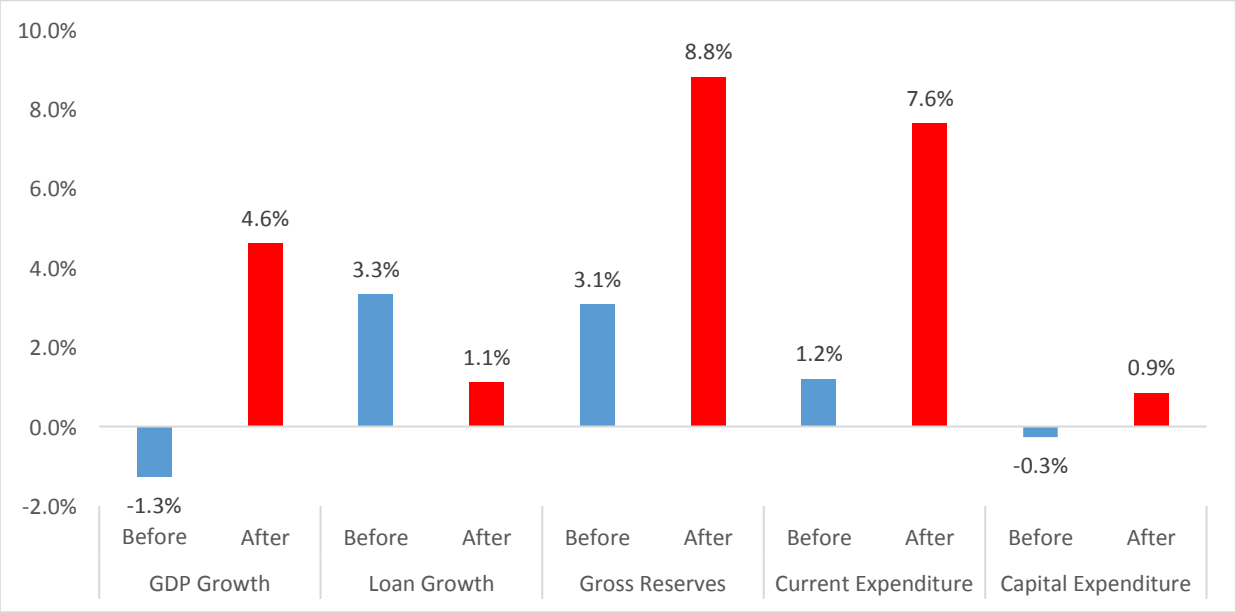


Figure 2: Growth in Macroeconomic Variables Before & After Contractionary Monetary Episodes (1990 to 2010).

In contrast, during the implementation of contractionary monetary policies, the opposite trend is observed with much of the variables of interest. The growth in domestic banks' holdings of liquid assets accelerated from an average of 2.3% to 6.2%, and cash reserve expansion increased from 3.7% to 18.3% with all banks maintaining their legal requirements. The expansion in reserves resulted in more subdued loan growth which fell from 3.3% to 1.1% and an improvement in international reserves by an average of 8.8% (see Figure 2). The growth in real GDP was again contrary to expectations after monetary contractions as the economy expanded by 4.6%. However, this trend did coincide with expansionary fiscal activities. Trends following changes in monetary policy indicate that they are used interchangeably with fiscal

policies over the years with the latter having a greater impact on economic growth. The scenario analysis coincides with the outcomes given by Vellos and Sosa (1996) and Alvarez (1986).

Policy Changes 1990 – Present Day

During the early 1990's, the liquid asset requirements were gradually reduced from 30% to 25% with the Central Bank of Belize seeking to stimulate loan growth and possibly influence higher GDP growth, showing some confidence in the transmission mechanism. However, between 1992 and 1994 when the country was experiencing high loan growth, increasing public expenditures and a deterioration in the official reserves, the Central Bank's response was to increase the cash reserves and required liquid assets ratio[2]. Official communication of the Central Bank was that the rate changes were made "to dampen the rate of credit expansion by absorbing some of the excess statutory liquidity in the system and ease the pressure on the official international reserve position" (Central Bank of Belize, 1992). Monetary policy at this time was used in an attempt to counter the impact of fiscal policies, a phenomena which would re-occur during the country's economic history. Other significant occurrences during the 1990's were the establishment of the interbank market, which was managed by the Central Bank, and the removal of most interest rate controls in 1996. The savings deposit rate was kept but lowered in the 2000's to provide a level of security to small savers.

[2] Additional policy actions were taken in 1994 to drain liquidity from the system including the floating of Treasury notes that banks were required to hold. Additionally $5.0mn in Government Defence bonds were also made available to the private sector.

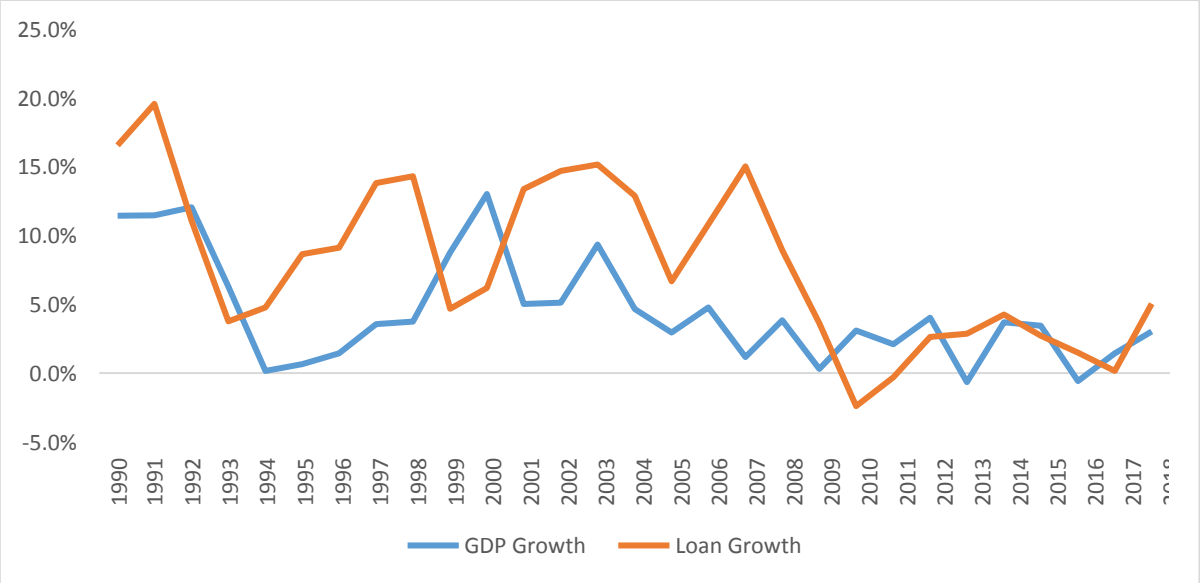


Figure 3: Annual growth in GDP versus Loan growth from 1990 to 2018.

In the early 2000's, "real GDP growth accelerated to 6.5% between 1999 and 2006, underpinned by expansionary fiscal and monetary policies implemented by the newly elected government" (Worrell et al., 2015). The cash reserve and liquid asset requirements were consistently lowered during the period, prompting rapid credit growth, and with the rise in public expenditure and explosion in external debt, the gross international reserves spiralled downwards once again. In 2004, the Central Bank tightened monetary policy by increasing the liquid asset and cash reserve ratios. The tightening continued in 2006 and 2009, aiming to curb credit growth and reduce the demand for foreign exchange. The subsequent slowdown in economic activities, which was exacerbated by the impact of the global economic crisis, led to a further dampening in lending activities and a sharp rise in excess statutory liquidity in the banking system. However, the domestic banks were still experiencing a shortage in foreign exchange, evidenced by the queuing issues at the time.

The Central Bank established a Monetary Policy Committee (MPC) in March 2009 to develop a market-oriented approach to monetary policy. To employ the Treasury bill rate as a monetary policy tool, the MPC liberalized the rate from a fixed position of 3.2% that year. In 2010, the MPC introduced a third tier of the liquid asset requirement, which required the banks to hold 6.5% of their average deposit liabilities in Treasury bills. The demand for Treasury bills soared, so the requirement was removed in October 2011 as the Central Bank sought to "set the stage for more aggressive loan marketing efforts by commercial banks accompanied by a downward trend in their lending rates[3]"(Central Bank of Belize Annual Report, 2011). To advance its work the MPC developed a liquidity monitoring framework and an accounting based-approach to forecast the Treasury bill rate, while implementing other legal and institutional improvements along the way. This study aims to strengthen the MPC's understanding of its monetary policy decisions on the economy.

2.2 The Belizean Banking Sector

The financial system is comprised of domestic and international banks, credit unions, insurance companies, and one development bank, the Development Finance Cooperation (DFC). The financial market had expanded consistently between 2008 and 2014 (from $3.7bn and peaking at $5.6bn at the end of 2014), however growth has been negative in the past four years. This was mostly attributed to the reduction in the international banks' assets due to the de-risking episode and the exit of an individual market participant. As a share of GDP, the financial sector expanded between 2008 and 2014 and has been declining thereafter. The growth in the credit unions accounted for the majority of the change with the rest of the market's assets, except for the international banks remaining relatively stable. The domestic banks lost 2.6% of their market

[3] The interest rates on savings deposits were also lowered from 3.5% to 2.5%

share between 2008 and 2018 but remain the largest sector, with assets as a percentage of GDP at 87.0% at the end of the period (see Table 1). Credit unions have grown consistently and have the second largest asset to GDP ratio at 27.1%, while the fall in the international banking assets have the sector at 15.7%. The share of banking assets to GDP in Belize is below the average for upper middle income countries (102.2%), but above average for its peers in the Latin America and Caribbean region (77.9%). The ratio implies that the commercial banks should have the largest impact on the Belizean economy, and bodes well for monetary policy and the transmission mechanism.

Table 2:

Structure of the Financial System of Belize

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017[R]	2018[P]
Number of Institutions											
Domestic Banks	*5*	*5*	*5*	*5*	*5*	*6*	*6*	*6*	*5*	*5*	*5*
International Banks	*7*	*7*	*7*	*6*	*6*	*5*	*5*	*5*	*5*	*5*	*4*
Credit Unions	*14*	*14*	*13*	*12*	*12*	*12*	*12*	*11*	*11*	*8*	*9*
Domestic Insurance Companies	*14*	*13*	*14*	*12*	*12*	*14*	*12*	*11*	*10*	*10*	*10*
Other Financial Institutions	*1*	*3*	*3*	*2*	*2*	*2*	*1*	*1*	*1*	*1*	*1*
Financial System Assets ($mn)	**3,772**	**4,136**	**4,382**	**4,651**	**5,035**	**5,166**	**5,647**	**5,597**	**5,575**	**5,621**	**5,401**
Domestic Banks	*2,435*	*2,529*	*2,517*	*2,565*	*2,760*	*2,788*	*2,967*	*3,210*	*3,230*	*3,187*	*3,350*
International Banks	*693*	*794*	*979*	*1,181*	*1,307*	*1,339*	*1,573*	*1,203*	*1,061*	*1,095*	*603*
Credit Unions	*441*	*483*	*535*	*589*	*653*	*720*	*768*	*827*	*907*	*943*	*1,045*
Domestic Insurance Companies	*169*	*179*	*193*	*211*	*215*	*226*	*248*	*253*	*272*	*287*	*294*
Other Financial Institutions	*34*	*151*	*159*	*104*	*99*	*94*	*90*	*104*	*105*	*109*	*109*
Assets as Percent of Total Financial System (%)											
Domestic Banks	*64.6*	*61.1*	*57.4*	*55.2*	*54.8*	*54.0*	*52.5*	*57.3*	*57.9*	*56.7*	*62.0*
International Banks	*18.4*	*19.2*	*22.3*	*25.4*	*26.0*	*25.9*	*27.9*	*21.5*	*19.0*	*19.5*	*11.2*
Credit Unions	*11.7*	*11.7*	*12.2*	*12.7*	*13.0*	*13.9*	*13.6*	*14.8*	*16.3*	*16.8*	*19.3*
Domestic Insurance Companies	*4.5*	*4.3*	*4.4*	*4.5*	*4.3*	*4.4*	*4.4*	*4.5*	*4.9*	*5.1*	*5.4*
Other Financial Institutions	*0.9*	*3.7*	*3.6*	*2.2*	*2.0*	*1.8*	*1.6*	*1.9*	*1.9*	*1.9*	*2.0*
Assets as Percent of GDP (%)	137.8	154.7	156.8	156.4	160.0	160.2	165.7	157.3	153.1	150.9	140.3
Domestic Banks	*89.0*	*94.6*	*90.1*	*86.3*	*87.7*	*86.4*	*87.0*	*90.2*	*88.7*	*85.6*	*87.0*

International Banks	*25.3*	*29.7*	*35.0*	*39.7*	*41.5*	*41.5*	*46.2*	*33.8*	*29.2*	*29.4*	*15.7*
Credit Unions	*16.1*	*18.1*	*19.1*	*19.8*	*20.7*	*22.3*	*22.5*	*23.2*	*24.9*	*25.3*	*27.1*
Domestic Insurance Companies	*6.2*	*6.7*	*6.9*	*7.1*	*6.8*	*7.0*	*7.3*	*7.1*	*7.5*	*7.7*	*7.6*
Other Financial Institutions	*1.2*	*5.6*	*5.7*	*3.5*	*3.2*	*2.9*	*2.7*	*2.9*	*2.9*	*2.9*	*2.8*

The banking system is small in size, with only five market participants currently in operation. Between 2013 and 2016 there were six banks in the local system, however, in January of 2016, a local subsidiary of a foreign bank (First Caribbean International Bank) ceased operations. Of the five domestic banks, one is a subsidiary of a foreign bank, one is government owned, and the remaining three all have majority foreign ownership. Excluding the asset share of the one government owned bank, 98.4%[4] of the banking system assets are under the majority control of proprietors outside the country.

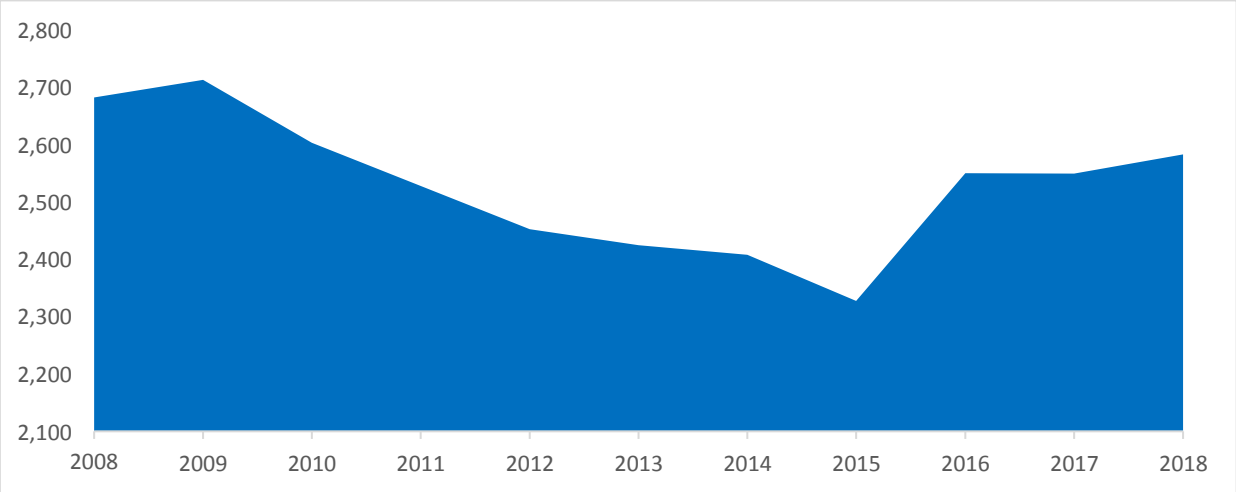
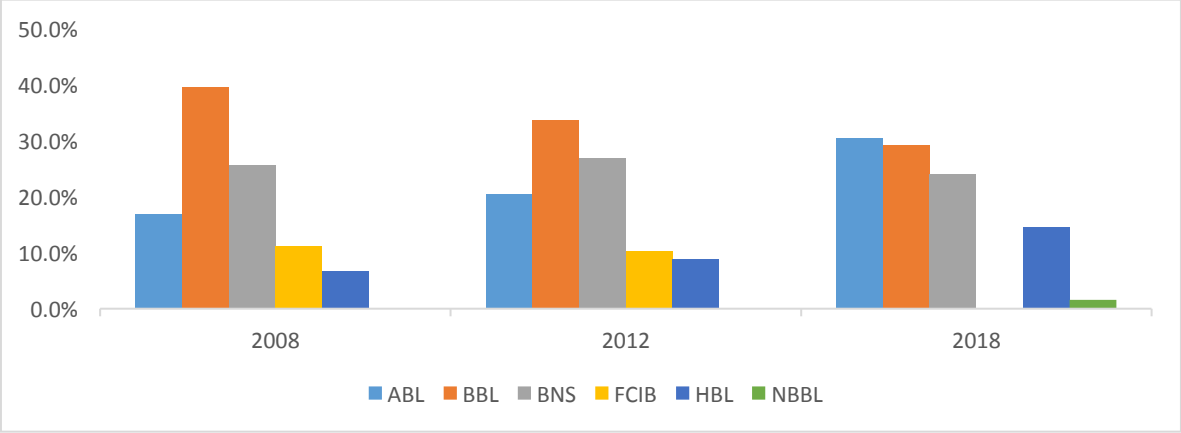


Figure 4: Trends in the Hirschmann-Herfindhal Index between 2008 and 2018.

The concentration of the banking market may also affect the transmission mechanism due to the oligopolistic market structure of the financial system. The two measures of concentration

[4] The total market share in assets of Atlantic Bank, Belize Bank, Bank of Nova Scotia and Heritage Bank.

employed, the Hirschmann-Herfindhal Index (HHI)[5] and the market share of the top three banks[6], indicated that the banking system had a highly concentrated market structure. An HHI of above 1,800 indicates a high level of concentration, and the ratio for the system has been above 2,500 on average in the past decade (See Figure 4). Although the HHI was trending downwards until 2015, the index started to rise thereafter largely due to sale of First Caribbean International Bank's (FCIB) assets to Heritage Bank prior to the former's closure. Also of note over the past decade is the sharp rise in the assets of the Atlantic Bank of Belize (ABL). The Belize Bank had traditionally been the largest bank in the system but a period of high loan growth was followed by a high incidence of non-performing loans. This in turn lead to substantial balance sheet repairs as provisioning standards tightened and stricter lending conditions, which contributed to a gradual decline in the bank's asset base (see Figure 5). Simultaneously, ABL ramped up their intermediation activities and became very aggressive in increasing its loan portfolio. In 2017, ABL became the biggest bank, asset wise in the system.



[5] The HHI measures market concentration through the size of the market share of the banks in the system. It is calculated by summing the squares of the market share (measured in asset size relative to the entire system) and multiplying the result by 10,000. An index below 1,000 means the market is competitive, between 1000 and 1800 means the system is reasonably competitive and a value above 1,800 indicates low levels of competitiveness.
[6] The market share of the top three banks were used instead of the top four banks because of the relatively small size of the system, both indicated significant levels of concentration

Figure 5: Market Share of Domestic Banking System

Despite the issues that may be derived from the market structure of the banking system, it does provide a significant amount of credit to the Belizean economy[7]. Net credit to the private sector has grown by 3.1% in the past five years despite significant write offs of non-performing loan (NPL's) and the diversion of funds to create increasing capital buffers. Credit growth has been particularly strong in Transport, Tourism, Manufacturing, and Utilities over the period growing by 8.4%, 10.1%, 35.1% and 54.9%, respectively. Since 2014, in contrast to the 2008 to 2012 period, there has been a reduction in the non-performing loans to total gross loan ratio and an increase in the loan loss coverage of the domestic banks (see Figure 6). The former fell by more than half, falling from 14.3% to 6.2% since 2014[8].

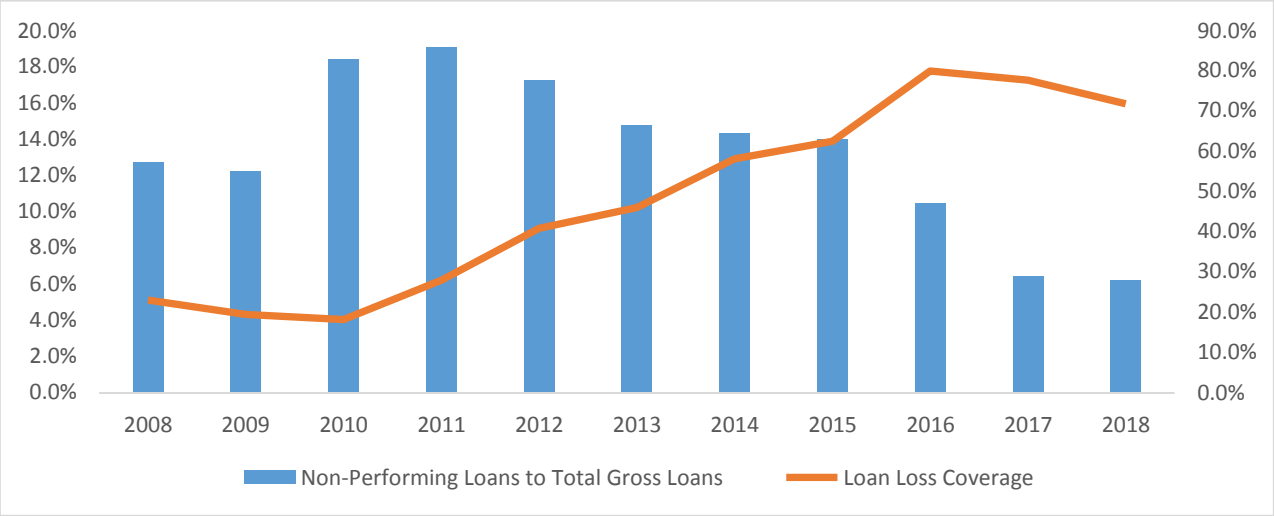


Figure 6: NPL Ratio vs Loan Loss Coverage 2008 -2018

Of the credit extended as at the end of 2018, 46.2% represented lending to households in the form of personal loans and mortgage facilities, while government received a minimal 0.4% of

[7] 76.2% of the total loans provided to the economy by three sectors, domestic banks, credit unions and the DFC
[8] See additional financial soundness indicators in Appendix Table 2

the total[9]. The remaining 53.4% of the portfolio funded productive activities, with tourism, agriculture and distributive trade taking up a large share of these facilities. The majority of credit to households in the economy are provided by domestic banks. Households play a significant role in the determination of aggregate demand for consumption expenditures, hence changes in credit available to this sector can definitely alter the movements in overall activity. Additionally, the extension of credit to the agricultural, distribution and tourism sectors underpin economic activities that have a significant impact on the growth cycle of the country. Controlling the flow of financing to these areas do impact economic activities, once again hinting that the transmission mechanism will be active in Belize.

The **liability structure** also bodes well for the monetary policy transmission mechanism, with deposits increasing their share from 74.7% of total liabilities in 2008 to 83.2% at the end of 2018 (see Appendix Table 3). High reliance on deposit liabilities imply that banks, under contractionary policies that limits the available deposits would not be able to provide the same amount of loans (as compared to before the policy implementation) to the economy. The fact that the reliance on deposits are so high, imply that those alternate sources of funds are scarce, so monetary policies would have a greater impact. Banking liquidity will also impact the transmission mechanism in the system as well with more liquid banks being less responsive to policy changes than those with limited liquidity. The liquid asset reserves of the banking system rose from $491.3mn in 2008 to $1,057.3mn in 2015 where it peaked and then declined steadily to $863.4mn in 2018 due in part to a moderate uptick in credit growth and an increase in the holdings of government debt instruments. Despite the aforementioned factors, the level of

[9] The value solely includes direct credit by the domestic banks to the central government and excludes government securities holdings and lending to other public sector entities.

excess statutory liquidity and excess cash reserves remains high at 38.6% and 85.4% above the legal requirements at the end of 2018.

The different characteristics of Belize's banking system indicate differing inferences on the overall impact that monetary policies would have on the domestic economy. Indicators including the banks' **market share** in the financial system, **credit growth** in the presence of the NPL 'clean-up', the distribution of **credit** across major industrial categories, and the **liability structure of banks' balance sheet** all imply that the transmission mechanism would be effective. However, the lack of financial deepening, the oligopolistic structure, and excess liquidity could all serve to hinder the performance of the mechanism as well (Mishra et al, 2010). The differing factors will be evaluated empirically in the current research to properly quantify the monetary policy transmission mechanism for the country of Belize.

3. Literature Review

The monetary policy transmission mechanism has been analysed in a plethora of research papers over the years (Sims, 1972; Christiano and Eichenbaum, 1995; Bernanke and Gertler, 1995; Kishan and Opiela, 2000; Boivin et al, 2010; Ananchotikul and Elkan, 2015 to name a few), with a number finding that the policy signals do have a significant impact on prices and real GDP. There are several established monetary policy transmission channels identified in the literature, most commonly the interest rate, credit, exchange rate, and asset price channels postulated by Mishkin (1996). The empirical assessments provide strong evidence that monetary policy does have an influence on real activities, however this analysis has been mainly done for countries at an advanced stage of development. Mishra et al (2010) in an assessment of the research carried out on developing nations conclude that the transmission mechanism can be stymied by characteristics that are common to countries at a low level of financial and economic

development. Despite those evaluations, the transmission mechanism does hold significance for economic stabilization purposes and identifying the magnitude and timing of its effects still remain significant for policy purposes (Ghazanchyan, 2014). Of the established transmission channels, the asset price mechanism is difficult to measure for Belize, given the absence of capital markets data and as such will not be evaluated.

Mishkin (2006) states that the **interest rate channel** implies that contractionary monetary policies decrease money supply, which increases nominal and real long-term interest rates due to its impact on liquidity. This increases the cost of capital to borrowers, which by extension increases the rate of return required for business investments and similarly the cost of private expenditures to households. The combined effect of that increase will be a reduced level of consumption and investments leading to lower aggregate demand, output, and prices (Rocabado, 2018). The interest rate channel is seen as the 'traditional' channel of monetary policy, however earlier empirical works like that of Bernanke and Gertler (1995) exhibited the fact that this channel alone could not explain large fluctuations in aggregate demand and output. This prompted a new wave of research into the alternative channels of monetary policy which could account for the unexplained deviations in GDP and prices.

The **credit channel** as identified by Bernanke and Gertler (1995) identifies two means through which this mechanism operates, the balance sheet channel and the bank lending channel. In the balance sheet channel, a contractionary monetary policy, which increases real interest rates, will reduce borrowers' net cash flows and reduce the value of assets that can be used as collateral in financing operations. The net effect is a reduction in a firm's value, which increases the premium that will have to be paid to acquire financing in the market, and in turn, lower their investment and spending activities. The main idea of the bank lending channel is that changes in

monetary policies will restrict the bank's ability to offer new loans due to a reduction in the available reserves. The demand for loans in the absence of an available supply of funds would then lead to higher interest rates and a reduction in investment, consumption and output. The bank lending channel operates on two main assumptions; monetary policy actions can impact bank loan supply and there are no perfect substitutes for bank lending that's available to borrowers. The credit channel has been referred to as a source of amplification for the traditional monetary channels, rather than a stand-alone mechanism (Davoodi, Dixit and Pinter, 2013).

In the **exchange rate mechanism**, monetary expansion reduces both short-term and long-term interest rates, causing a depreciation of the domestic currency, higher net exports, and a growth in aggregate demand (Loayza, Schmidt–Hebbel, 2002). The underlying conditions for the effectiveness of the exchange rate channel is a flexible exchange rate regime and an open capital account with the mechanism functioning in two phases (Mukherjee and Bhattacharya, 2011). A reduction in interest rates will make deposits in foreign currencies more attractive, which will cause a reduction in demand for local currency and an impending depreciation. The depreciation will cause the demand for tradable goods to increase, leading to the growth in export receipts as well as increased aggregate demand and real activity. Other areas of transmission, like the expectations/confidence channel have also been identified, though it has been proven difficult to model and quantify. The effectiveness of each channel does depend on the economic and institutional characteristics of Belize, and these imply that the interest rate and bank lending channels will be more important for the economy. The fixed exchange rate also seems to nullify the importance of the exchange rate channel, however this will also be empirically assessed using the country's real effective exchange rate.

The exchange rate regime provides a challenge for the transmission mechanism as the seminal works of Fleming (1962)[10] and Mundell (1963)[11] concluded that an economy cannot simultaneously maintain a fixed exchange rate, free capital movement, and an independent monetary policy. This theory, "the impossible trinity", implies that countries with a fixed exchange rate should align their monetary policy with the anchor country so as to not induce pressure on the peg through the capital account. Worrell (2000) states that even in the presence of capital controls, countries with a fixed regime have no real space for effective monetary policy. He mentions that "any displacement of monetary equilibrium results in capital flows rather than changes in expenditure that might alter prices or output" and even gives examples of 'floating' regimes that suffer from the same issues because they maintain a de facto peg. The aforementioned indicates that there would be some weaknesses in the transmission mechanism, however, the magnitude and an evaluation of the most effective transmission channel is still important to fully explore the country's policy toolkit.

Mishra et al (2010) examined the monetary policy transmission mechanism studies for various developing countries across the world, including, Latin America and the Caribbean, Asia and the Pacific and the Middle East and North Africa among other economic areas. The assessment concluded that at lower levels of financial development the bank lending channel tends to be the dominant transmission mechanism, however the impact is lessened because of the characteristics of developing nations. The aforementioned characteristics include ***banking industry concentration, financial market size, Central Bank independence, the quality of the institutional and regulatory environment*** **and** ***poor development of the domestic securities***

[10] Fleming, J. Marcus (1962). "Domestic financial policies under fixed and floating exchange rates". IMF Staff Papers.

[11] Mundell, Robert A. (1963). "Capital mobility and stabilization policy under fixed and flexible exchange rates". Canadian Journal of Economic and Political Science.

market among others. These sentiments were echoed by Primus (2016) in an assessment of the effectiveness of monetary policies in small open economies, particularly those in the Caribbean. The results of the study indicated that there is a weak pass through from the interest rates to the macroeconomic variables in the economies evaluated, however reserve requirements proved useful in impacting credit, excess reserves, and stabilized exchange rate pressures.

Various studies have summarised the findings in monetary policy transmission research over the years (Taylor, 2000; Kuttner and Mosser, 2003; IMF Policy Paper, 2014; Gertler and Karadi, 2015) with a vast majority of the empirical assessments being carried out in a vector auto regression (VAR) framework. The methodology has stemmed from the works of Sims (1980) and have included Bernanke and Blinder (1992) Christiano, Eichenbaum and Evans (1998), Sims and Zha (1996) who analysed the mechanism for the American economy[12]. There have been numerous analyses using the framework with its impulse response functions and variance decompositions to evaluate the timing and magnitude of monetary policy shocks to various economies and more recently studies have employed the use of Bayesian VARs to assess the mechanism. The Bayesian inference in VAR models was initially utilized by Doan et al. (1984) and Litterman (1986) and has been seen as an improvement upon the traditional VAR methodology. In light of this fact, the methodology of Davoodi, Dixit and Pinter (2013) will be utilized to overcome the VAR limitations, particularly that of inadequate degrees of freedom, which leads to over-fitting of coefficients and less robust results. This inference will be carried out in the study because the benefits the framework provides will impact the model's output, giving a more accurate depiction of the timing and magnitude of the Belizean mechanism.

[12] Other studies utilizing the VAR framework include Blanchard and Quah (1989), Peersman and Smets (2001) Angeloni et al (2003), Mojon and Peersman (2003)

Empirical assessments of the mechanism in Belize have been sparsely found in the literature and the most recent was completed by the CERT in 2019, which explored the transmission mechanisms for Caribbean countries across the region[13]. The authors' utilize a BVAR to analyse the response of the country's monetary and macroeconomic variables to international shocks and find that the transmission mechanism does exist in Belize, but its impact is almost negligible. This study however, does not fully evaluate the different transmission channels and tended to omit important variables like excess liquidity that have had a significant effect on Belize's financial sector. The impact of excess liquidity on monetary policy has been noted, as high levels of the variable provides a buffer that allows regular banking activity. This renders monetary tightening ineffective and hinders the impact of the transmission mechanism as well (CERT, 2018). Saxegaard (2006) also shows the ineffectiveness of monetary policy in the presence of 'involuntary excess reserves' within economies.

Earlier studies on the transmission mechanism in Belize found that changes in the reserve requirement ratio lead to changes in macroeconomic variables that are contrary to theoretical expectations (Kendall, 2001). Khan (1998) also studied the transmission mechanism using a VAR approach and found a very weak and short-lived impact of monetary policy on prices and real GDP in the country. Alvarez (1986), Vellos and Sosa (1996), and Garcia (2009) all examined monetary policy in Belize, with their results showing that monetary policy is indeed effective, however the degree to which it will impact the economy depends on its alignment with fiscal policies. This paper will add to the knowledge base on monetary policy transmission by evaluating the various transmission channels individually, their timing and magnitude, and their

[13] CERT WP/02/2018 – The Effectiveness of Monetary Policy Transmission Mechanisms in the Caribbean

impact given exogenous variables that include excess liquidity, international oil prices, and international monetary policy rates.

4. Methodology & Data

4.1 VAR Methodology

The VAR model was selected for the research, as most of the literature evaluated utilizes the methodology and its two main outputs, the variance decomposition and the impulse response functions. The latter allows the researchers to examine simple results, which determine the timing and magnitude of the impact of the various monetary policy transmission channels with and without exogenous variables. Traditional VAR models were first utilized by Sims (1980) and were later on enhanced as the Bayesian VAR's (BVARs), which helped to improve the estimation of model coefficients, solve the dimensionality problem and improve the out of sample forecast (Agrippino and Ricco, 2018). The general equation for a VAR model is expressed as follows:

$$Y_t = A_1 Y_{t-1} + \ldots + A_p Y_{t-p} + B_1 Z_{t-1} + \ldots + B_q Z_{t-q} + \mu_t \quad (1)$$

Where t = 1, …, p; Y_t is the vector of endogenous variables being examined in the transmission mechanism, which includes intercept, time trend and other deterministic terms; Z_t is a vector of exogenous variables; μ_t is an n-dimensional vector of one-step-ahead forecast errors assumed to be normally distributed with a mean of 0 and standard deviation of 1; A_i and B_i are matrices of coefficients, p and q are non-negative integers giving the number of lags included for the

endogenous and exogenous variables in the model. The variance-covariance matrix $\sum$ is written as $\sum = E\ \mu t\ \mu t$. Estimate of $\sum$, A_i, and B_i are obtained using ordinary least squares.

Bayesian VAR

The regular VAR framework presents a number of issues in estimation, including, the variable selection, lag length selection, and data availability. Data availability can cause issues in terms of the degrees of freedom available given the amount of parameters that would have to be estimated if the VAR contains a large number of variables with a considerable lag length[14]. In order to reduce the over parameterization in a VAR, Bayesian inference introduces prior information on the statistical or economic nature of the sample to introduce 'shrinkage' to the model

Rewriting (1) as a vector of variables

$$Y = (X \otimes I_K)\alpha + \mu \qquad 2$$

Where Y is a vector of dependent variables, X is the vector of dependent variables, I_k is the identity matrix and α is the vector of estimated parameters of the model. μ is the vector errors that are normally distributed with a mean of 0 and a variance of $\sum \otimes I_k$.

The research utilizes a Bayesian VAR estimation, using a model and variables similar to that of Davoodi, Dixit and Pinter (2013). Proof of the methodological improvements were shown in earlier studies by Sims and Zha (1998), Robertson and Tallman (1999), and Canova (2007)[15]. The prior information is summarized into a prior joint probability density function of

[14] In a VAR with N variables and with S lags, the coefficients to be estimated will be equal to N(1 + NS) and the error terms to be calculated will be equal to N(N +1)/2. This implies that if a VAR contains 4 variables and you have a lag length of 4, you have to estimate 78 parameters.

[15] Canova exhibited that BVARs outperformed comparative econometric models in forecast error evaluation

the VAR coefficients and the estimated variance-covariance matrix of the reduced form residuals. Prior information on the vector of parameters in (2) are represented by the prior joint probability distribution function g (α, ∑). The combination of the prior information and the observed data is done in line with Bayes' Theorem[16] using the likelihood function L (Y | α, ∑). Using Bayes theorem:

$$g(\alpha, \sum | Y) = \frac{g(Y | \alpha, \sum) g(\alpha, \sum)}{g(Y)} \quad (3)$$

$$g(\alpha, \sum | Y) = \frac{L(Y | \alpha, \sum) g(\alpha, \sum)}{g(Y)} \quad (4)$$

The posterior joint probability density function g (α, ∑ | Y) is proportional to the prior times the likelihood function, L. The marginal posterior g (α | Y), the estimate of the parameters given the sample data and g (∑ | Y) the variance-covariance matrix given the sample data, can be obtained by integrating these values (α and ∑) from the conditional density function g(Y, X | α, ∑). Assuming that the errors are normally distributed, a prior needs to be chosen that is represented by the prior joint probability density function g (α, ∑).

Prior & Hyper-parameters

Model performance can be impacted based on the choice of priors and the hyperparameters which govern the informational content of the priors in the estimation process. Following Davoodi, Dixit, and Pinter (2013) and numerous other analyses, this study will utilize the **Minnesota Litterman** prior[17], first developed by Doan, Litterman and Sims (1984). These

[16] For a more detailed explanation of the Bayesian inference see Canova (2007) and Agrippino and Rico (2018)
[17] Other priors and specifications were utilized to evaluate the robustness of the results

priors are usually cast as a Normal Inverse Wishart prior, which is the conjugate prior for the likelihood of a VAR with normally distributed disturbances (Kadiyala and Karlsson, 1997). This means that the prior and posterior distribution of the same family and are as a result easily computed, in comparison to priors which have different distributions and have to be calculated using more complex methodologies. The Minnesota Litterman prior assumes that

1. The behaviour of most macroeconomic variables is estimated by a random walk
2. Lags of other variables are less informative than the current variables' own lags
3. The most recent lag of a variable is more informative than more distant lags

The prior is estimated utilizing four main hyperparameters:

1. $\lambda 1$: Controls the overall tightness of the random walk prior. If the parameter is equal to 0, the prior information dominates and the VAR reduces to a vector of univariate models. If the parameter gets larger, the prior becomes less informative and the posterior mirrors the sample information.
2. $\lambda 2$: Controls the relative importance of the lags of other variables in relation to the lags of the variable under consideration. The smaller this parameter is, the more we shrink parameter estimates towards univariate time series.
3. $\lambda 3$: Controls the relative importance of the lags of the variable under consideration. The larger the value of this hyper parameter, the more quickly the importance of each previous lag of the variable dissipates. This parameter, labelled the lag decay can be calculated

   $= \frac{1}{\lambda 3} = \lambda 3$
4. $\lambda 4$: Controls the importance of the information contained in the exogenous variables and it's recommended that this value is as high as possible.

Priors have traditionally been selected based on an investigative process, as researchers have chosen them based on out of sample forecasting performance and the in sample fit among other methods of evaluation. For the purposes of the study, the latter will be used to determine the choice of parameters in the model, within chosen bounds of the individual hyperparameters, based on the literature. Other methods of choosing hyperparameter values have been found in the literature including hierarchical modelling (Agrippino and Ricco, 2018). However, this will be evaluated in further iterations of the study.

4.2 Impulse Response Function & Variance Decomposition

The identification scheme utilized is that proposed by Sims (1980) where a Choleski decomposition is used to isolate the impact of the monetary policy shocks. This places great weight on the position of the variables in the BVAR ordering and implies that the first variable in the sequence does not respond contemporaneously to any other endogenous variable, while all other variables respond contemporaneously to changes in variables in that initial position. The VAR ordering is as follows:

Endogenous Variables: (GDP, CPI, RCR, TB, LR, CRED, REER)

The ordering was used by Sims (1992), Christiano et al. (1999), and Favero (2001), which shows that monetary variables should be ordered last, as they are expected to respond faster to macroeconomic variables and not the other way around. GDP is real Gross Domestic Product (2000 base year) and is placed at the top of the ordering, which implies that it is not affected contemporaneously by any other factors except the exogenous variables. CPI, the Consumer Price Index (2011 base year), follows as movements in prices are deemed to be directly determined by changes in real GDP and other exogenous factors.

RCR is the reserve cash ratio of the domestic banks and has been one of the main tools of monetary policy as stated by the CBB. Hence, shocks to reserve cash ratio can be considered a shock to monetary policy. The 90-day Treasury bill rate, TB, is ordered after reserve cash as the Central Bank is currently starting to use the rate as a signal of the monetary policy stance[18]. When used as the policy signal, along with the reserve cash ratio, the ordering is fitting as the tools of monetary policy should respond in the same period to shocks in GDP or prices and would impact the various transmission channels (ordered after) if they are active.

The remaining variables in the baseline model represent the channels of monetary policy. LR or the real weighted average lending rate of the domestic banks represents the interest rate channel, the CRED variable is lending to the private sector and represents the bank lending channel, and the REER is the real effective exchange rate and represents the exchange rate channel. All variables are ordered after the monetary policy variables, implying that they are contemporaneously impacted by changes in policy.

The ordering is in keeping with the transmission mechanism theory. Fluctuations in the monetary policy tools are usually in response to changes in the macroeconomic fundamentals (including external shocks). These changes in the monetary policy tools, first impact the operating and intermediate targets, and then the feedback is passed on to real economic variables with a lag.

4.3 Data

The BVAR used to assess the monetary policy transmission mechanism will employ quarterly data from 1994:Q1 to 2019:Q1. The data set will include the following variables:

[18] The Treasury bill rate can also be used as an indicator of the interest rate channel of monetary policy and was used interchangeably with the weighted average lending rate of the domestic banks to identify this channel.

Table 3:

Variables for BVAR Analysis: Definition and Sources

Variables	Definition	Source
LGDP	Real Gross Domestic Product (2000 prices)	Statistical Institute of Belize
LCPI	Consumer Price Index (2011 = 100)	Statistical Institute of Belize
LTBR	Belizean 90-day Treasury bill rate	Statistical Digest: Table 24: Selected Comparative Bank Rates and Treasury Bill rates
RCR	Required cash reserves as a percentage of deposit liabilities	Central Bank of Belize
LR	Weighted average lending rate minus same period inflation	Statistical Digest: Table 23: Weighted Average Interest Rates
LCRED	Net Credit to the private sector	Statistical Digest: Table 14: Sectoral Loans and Advances
LREER	Real Effective Exchange Rate	International Financial Statistics(IFS)
WTI	WTI oil spot prices in USD/barrel	US Energy Information Administration (EIA)
FFR	US Effective Federal Funds Rate	Economic Research Division, Federal Reserve Bank of St. Louis

The baseline BVAR uses six endogenous variables, which are real GDP, CPI, reserve cash ratio, Treasury bill rate, the real effective exchange rate, and net credit to the private sector. Within the model, the reserve cash ratio is used as the monetary policy variable as changes in the rate have been used as the monetary policy signal in Belize over its economic history. Alternately, the Treasury bill rate has, in the last decade, been used as a policy signal as well and can be evaluated for its effectiveness as a tool of monetary policy[19]. The price puzzle occurs when a monetary tightening leads to statistically significant increase in the inflation rate, contrary to a priori expectations. To allocate for this phenomena often found in VAR analyses

[19] An alternative model will be used which incorporates the weighted average lending rate in the model to more formally identify the interest rate channel of monetary policy.

(Sims, 1992; Christiano et al, 1999; sims & Zha, 2006), the model will include the United States (US) West Texas Intermediate (WTI) oil price as a proxy for changes in international energy prices to account for imported inflation within the economy. The US effective federal funds rate (Hung & Wade, 2009; Cheng, 2006; Maturu, Maana, & Kisinguh, 2010) has also been included in the model as an exogenous variable to control for external economic conditions. The baseline model is estimated using quarterly data expressed in log levels in accordance with the specifications provided for in the literature. Sims, Stock, and Watson (1990) state the use of levels and not first differences preserves any long run relationships and does not affect the statistical inference of the likelihood function in the BVAR model.

5. Results

5.1 BVAR Impulse Response Monetary Policy Variables

When estimating a VAR, the optimal lag length has to be chosen. The literature dictates that when using quarterly data on monetary policy transmission, the optimal lag length tends to be between two to four. In light of this fact, a regular VAR was estimated and the lag length criteria was evaluated with the maximum lags being four. The results are listed in the Appendix Table 4. There were mixed results in the chosen lag length as the Schwarz information criterion and Hannan-Quinn information chose one lag, while the LR test statistic chose three lags. Ultimately the research proceeded with four lags as chosen by the final prediction error and the Akaike information criterion (AIC). The AIC is particularly useful as it estimates the quality of different models by comparing its results to that of the actual data generating process (observed values). Because the models will always be imprecise, the AIC chooses the best models by assessing which one minimizes the estimated information loss, or which model produces the smallest error.

The BVAR is then estimated with the Minnesota-Litterman prior with overall tightness of 0.5 and a decay factor of 2, on a sample from 1995:Q1 to 2019:Q1, given the lag length of four and the constraining variable, GDP, which wasn't available quarterly until 1994:Q1. The sample range had to be adjusted to perform the impulse response function, as the monetary policy variable, the reserve cash ratio has not been changed since 2010:Q1. This resulted in the loss of approximately 36 observations, however the 61 remaining provided a BVAR that was stable enough to provide a meaningful and stable regression. In assessing the monetary policy transmission, we have to understand the magnitude and the lag between the one standard deviation change in the policy variable and the eventual peak in the response of production and the inflation rate (see Appendix Figure 1).

Table 4:

Impulse Response of GDP to a One Standard Deviation Shock in the Reserve Cash Ratio

Period	Minnesota Litterman	Normal Flat	Sims & Zha
2	-0.08	-0.01	-0.01
4	-0.98	-0.05	-0.05
10	-1.52	-1.06	-1.16
14	-1.47	-1.32	-1.44
20	-1.28	-1.51	-1.69

Table 4 provides the reaction of real GDP to a one standard deviation shock in the reserve cash ratio over a span of 20 quarters. Exogenous shocks to both the reserve cash ratio and the Treasury bill rate can be considered as monetary policy shocks to the system. Results are provided for alternative BVAR priors to test for the robustness of the results.

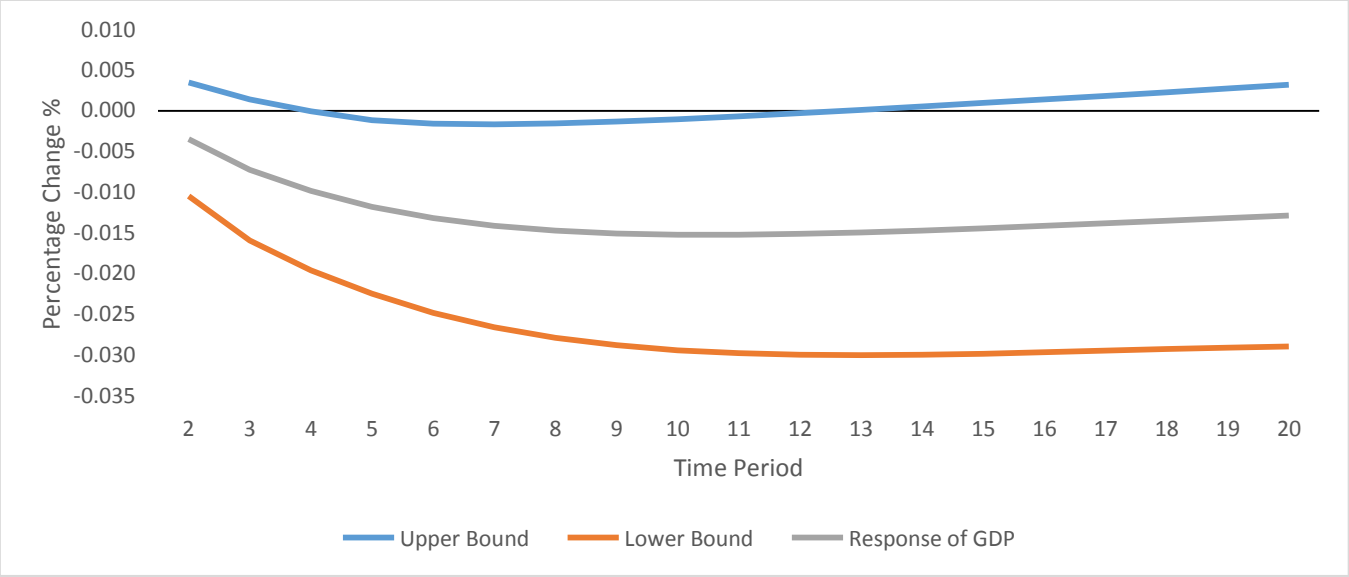


Figure 7: Response of Real GDP to Reserve Cash Ratio Shock with one standard deviation Confidence Intervals (Minnesota Litterman Prior).

The one standard deviation shock to the reserve cash ratio is a monetary tightening of approximately 15.3 basis points and is fairly persistent as the shock dies off after 10 quarters. The one standard deviation increase in the Treasury bill rate is approximately a 10.2 basis point shock to the system which is persistent over the sample. An increase in the reserve cash ratio, which represent a tightening in monetary policy, has the expected a priori impact on GDP growth. The impact of the shock on GDP is relatively minimal initially, however after three quarters, there is a notable and statistically significant reduction in real activity, which reaches its lowest point of -1.5 basis points after 10 quarters. There is an ultimate recovery in the domestic production and the negative impact on growth becomes statistically insignificant after twelve quarters. The results of the BVAR using the Minnesota Litterman prior is fairly consistent with the alternative specifications shown in Table 3. The path in which the reserve cash ratio has a significant impact on GDP is the same, as all show significant impacts after three quarters.

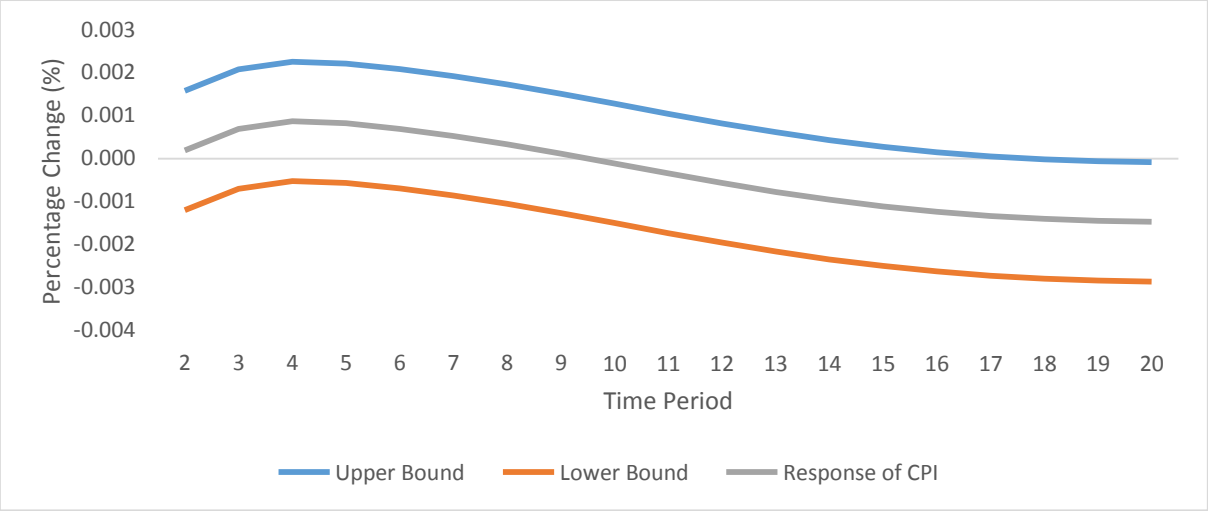


Figure 8: Response of CPI to Reserve Cash Ratio Shock with Confidence Intervals (Minnesota Litterman Prior).

The corresponding impact on prices exhibits the price puzzle, generally found in analyses of the sort, even in the presence of the exogenous WTI oil prices. Nevertheless, the impact on the overall price level is very small (0.0015 basis points) and insignificant over the evaluation period. These results indicate that the credit channel of monetary policy, impacted directly by the reserve cash ratio, is important in transmitting the impact to GDP. The impact of credit on economic growth has been shown over the years as monetary policy has been employed in an attempt alter grow rates in the Belizean economy. However its impact on prices are not significant which is expected as the inflation rate in the country is highly correlated with international oil and food prices, or the inflation is 'imported'. The international markets would therefore exert more pressure on the CPI than monetary policy activities.

Table 5

Impulse Response of GDP to a One Standard Deviation Shock in the Treasury bill rate

Period	Minnesota Litterman	Normal Flat	Sims & Zha
2	0.08	0.25	0.04
4	-0.27	0.26	-0.17
10	0.09	0.72	0.07
14	0.28	0.97	0.24
20	0.24	1.15	0.26

When the 90-day Treasury bill rate is assessed as a monetary policy variable, the results indicate a minimal response in GDP to the monetary policy shock, approximately a 0.3 basis points fall at its minimum point, five quarters later. The results are relatively consistent between the Minnesota Litterman prior and that inverse Wishart prior developed by Sims & Zha, as an increase in the policy rate leads to an initial reduction in GDP which is not statistically significant. The response of CPI to changes in the Treasury bill rate is a bit stronger, having a statistically significant impact after six quarters (see figure 9). The magnitude of the change is negligible at 0.48 basis points twelve quarters after the initial shock. It can be implied that the pricing effects of monetary policy as given by the Treasury bill rate has little impact on the transmission mechanism of Belize, inferring that economic activity is not responsive to domestic interest rates. Adjusting the sample to exclude time periods in which the Treasury bill rate was fixed did not improve the impact of the variable on the macroeconomic aggregates. The fact that the use of the Treasury bill rate as a policy tool has solely been in an environment of high excess liquidity could account for its relative ineffectiveness.

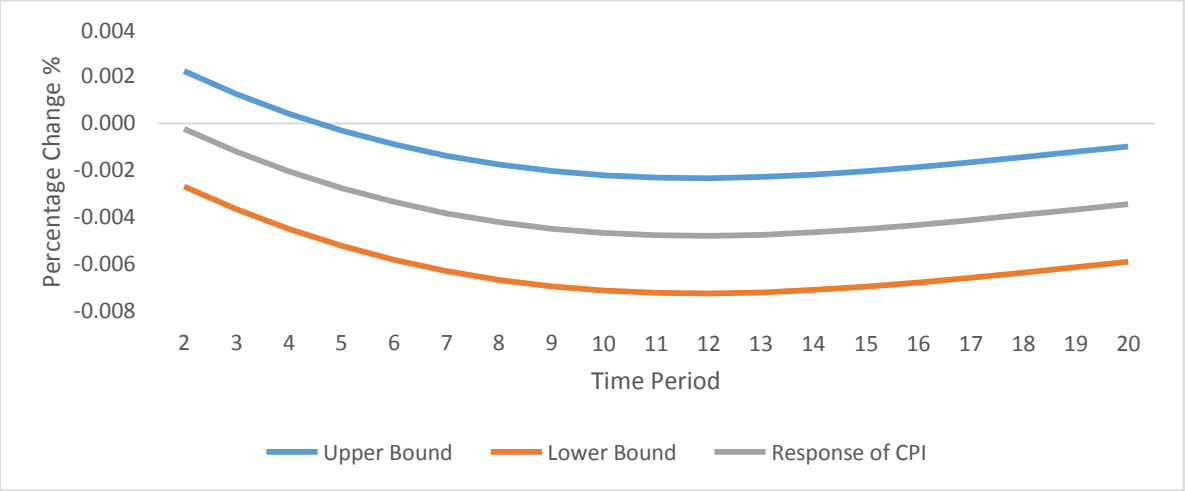


Figure 9: Response of CPI to Treasury bill rate shocks with Confidence Intervals (Minnesota Litterman Prior).

Transmission of the impact from monetary policy variable (RCR) to the real economy took ten quarters for Belize, as this is the point where the maximum impact of the policy change is felt. Real GDP also fell by 1.5 basis points in response to a 15.3 basis point increase in the reserve cash ratio, implying that reducing GDP by 10 basis points (0.1% or $5.1mn) would require a 102 (1.02%) fall in the reserve cash ratio. Monetary policy tightening is statistically significant over the 12 quarters, which indicates that the authorities should be careful in its application of contractionary policies in quick succession, which can set the economy on a lower growth path.

5.2 Impulse Response Monetary Policy Channels

Interest Rate Channel

The interest rate channel, illustrated by the dynamics of the macroeconomic variables in response to the Treasury bill rate, is of little significance to the transmission mechanism in terms of its magnitude. The policy rate does impact both CPI and GDP negatively in two and three quarters respectively, yet the response to price measures is minor. When the model is augmented

with the weighted average lending rate on new loans, the response of CPI to the interest rate variable is similar. The lending rates have a limited impact on the aggregates and even has a positive impact on real economic growth (See Figure 10). The effect of the reserve cash ratio on economic activity is however magnified in this case, with the overall impact increasing to 1.6 basis points, suggesting that the lending rate does have an impact on the mechanism. This is through the credit channel, as the lending rate rises in response to a tightening of monetary policy and negatively impacts the provision of private sector credit. It can be stated that although the market is relatively non-responsive to changes in interest rates, its impact is transmitted indirectly. The limited direct impact of the interest rate channel may be due partly to the fact that interest rates have been relatively sticky during Belize's history with the market participants adjusting slowly to policy changes.

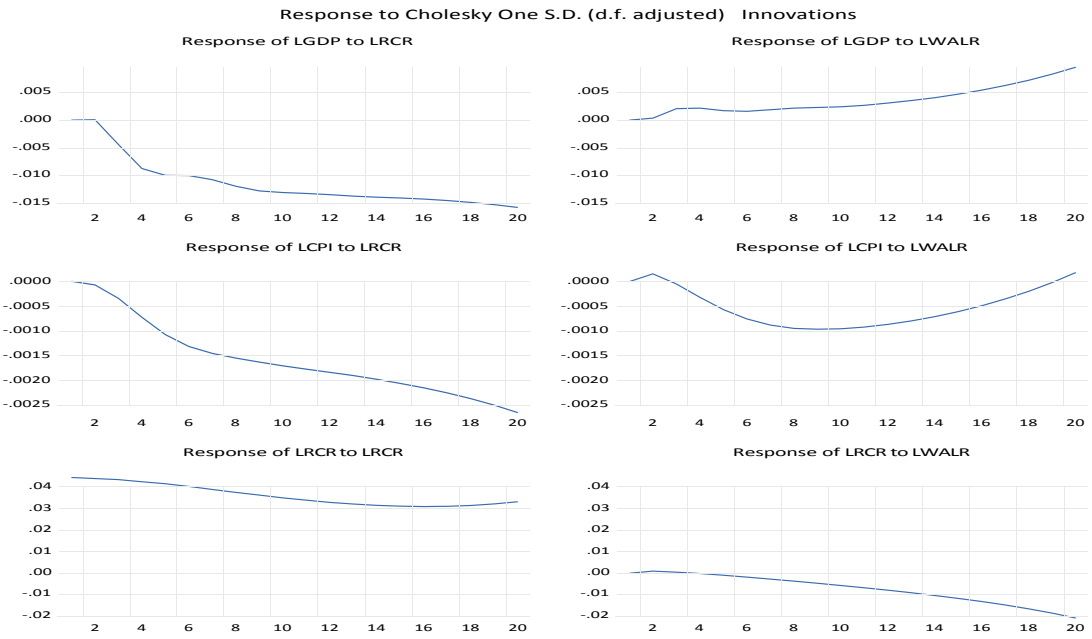


Figure 10: BVAR Impulse Response Functions to one S.D. Innovations (WALR).

The Credit Channel

The results in Appendix Figure 1 exhibit that a one standard deviation (2.4 basis point) increase in private sector credit made by the domestic banks leads to 1.5 basis point increase in real output[20]. The impact of this is however at the end of the medium term as the impact is persistent over time. A significant, positive impact occurs within four quarters of the impulse to private sector credit and keeps growing, all things remaining equal. The impact of increases in private sector credit on CPI, as with the other variables assessed are however muted with the trend in inflation exhibiting the price puzzle as well. It has been established that increases in the growth rate of GDP is positively impacted by the growth in private sector credit, now the mechanism has to be completed by tracing the impact of the monetary policy variable on the changes in credit.

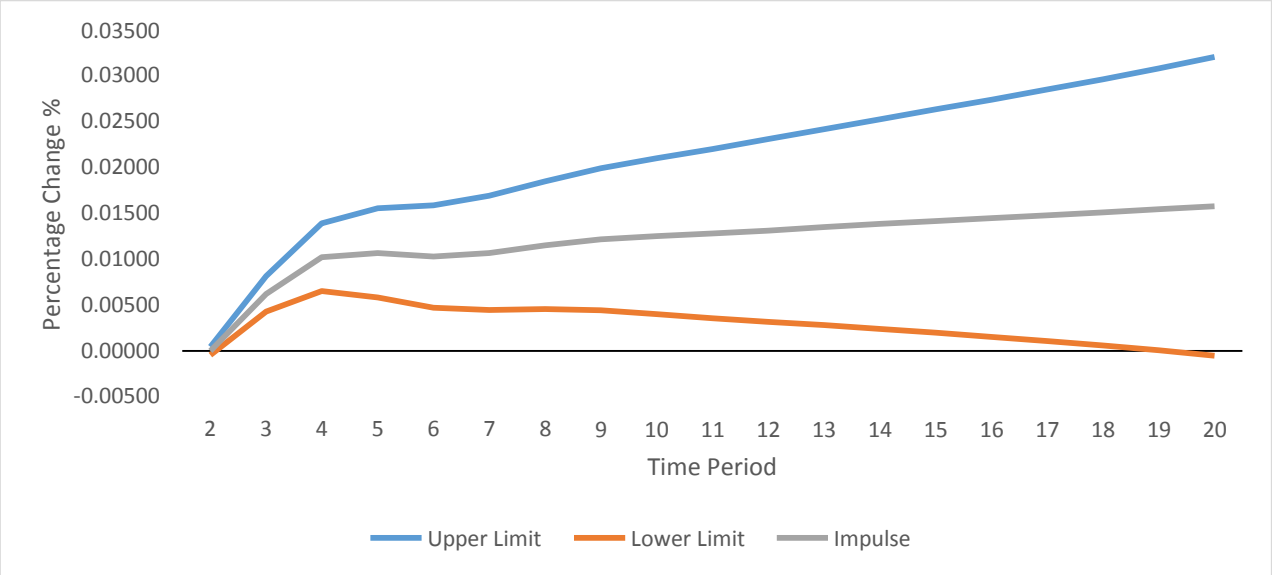


Figure 11: Response of GDP to Private Sector Credit shocks with Confidence Intervals (Minnesota Litterman Prior).

[20] The growth in private sector credit has a more muted effect on GDP growth when lending rates are included in the model, however its impact is still significant.

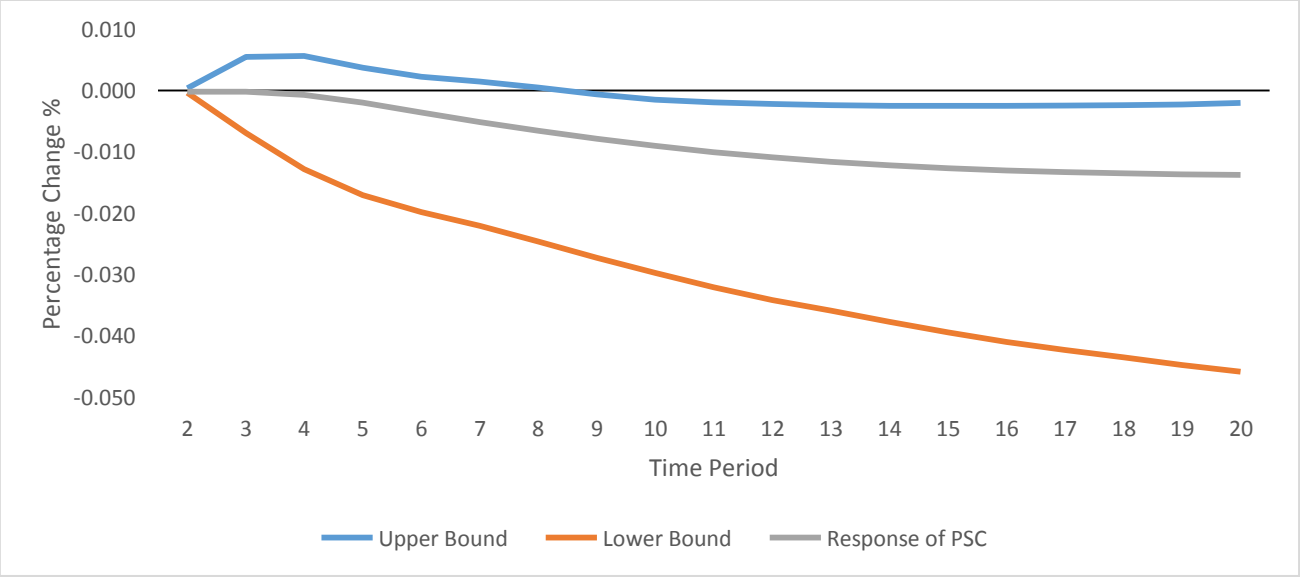


Figure 12: Response of Private Sector Credit to a one standard deviation shock to the Reserve Cash Ratio with Confidence Intervals (Minnesota Litterman Prior).

Figure 12 also shows that a policy tightening in the form of increased reserve cash ratio has a significant and persistent negative impact on private sector credit (1.4 basis point reduction). The impact gets to its peak at the end of the forecast horizon, however the significant negative impact is felt as early as nine quarters after the policy impulse. When the 90-day Treasury bill rate is used as the policy variable, the results are similar, however the impact reaches its minimum point (1.0 basis point decline) eleven quarters after the increase in the policy variable. It must be noted, that in the presence of excess liquidity, the impact of the monetary policy variables on the private sector credit is muted in the case of the Treasury bill rate (0.47 reduction) and goes against theory in the case of its response to changes in the required cash reserves (see Figure 12). This validates the Central Bank in holding its neutral stance over the years in which excess liquidity has been elevated, as policy changes would not have been transmitted effectively to the economy via the credit channel.

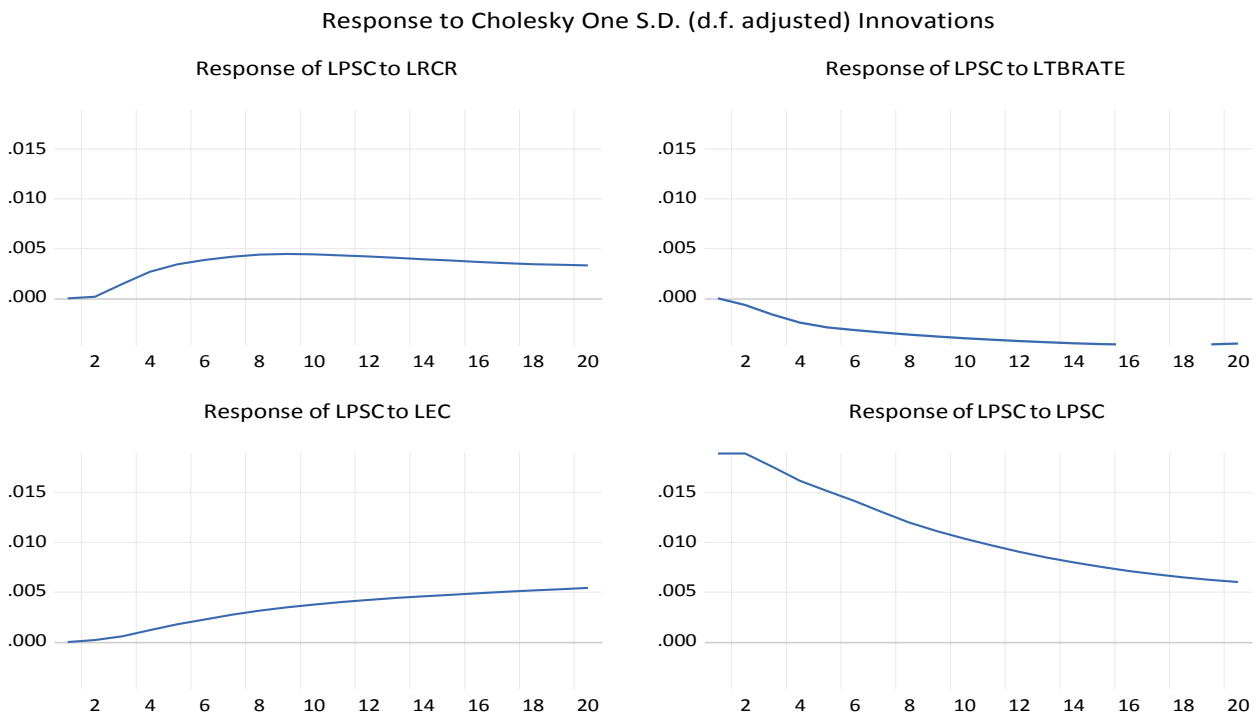


Figure 13: Response of Private Sector Credit in the Presence of Excess Liquidity.

The credit channel has been shown to be the most effective transmission channel within the economy, with the timing from the monetary policy impulse, to the impact on GDP being approximately 13 quarters. During this time, a 15.4 basis point reduction in the reserve cash ratio should lead to a single basis point decline in the private sector credit offered to the market, which corresponds to a 0.6 basis point loss in GDP holding all other factors constant. Given the fact that the impact is persistent, the impact on GDP will increase incrementally until the growth path is impacted by other economic factors.

The Exchange Rate Channel

Appendix Figure 1 shows that a 1.9 basis point increase in the REER leads to a 0.9 basis point increase in real GDP after thirteen quarters, however significant impact21 is exhibited within five quarters of the shock. "An increase in REER implies that exports become more expensive and imports become cheaper; therefore, an increase indicates a loss in trade competitiveness" (IMF, 2019). The results are out of line with the expected theory, as an increase in the REER should lead to a decline in next exports and by extension GDP. This reasoning may not hold true for a small commodity producing economy like Belize. This result however is indicative of the fact that Belize relies upon the importation of goods and services to drive economic activity in its productive industries as well as the wholesale and retail markets. However, given the fact that the monetary policy variables have an insignificant impact on the REER, the exchange rate channel would not be effective in the case of Belize.

5.3 Impulse Response Function Summary

The results of the analysis indicate that the reserve cash ratio is an important tool of monetary policy, with the 90-day Treasury bill rate moderately effective in its indirect impact through the credit channel. The credit channel has been shown to be more effective than the interest rate and exchange rate channels of monetary policy as well with impact passing from the monetary policy signal to the real economy in 13 quarters. The credit channel successfully propagates the effect of the monetary policy variable on real GDP over time and its impact is persistent over the horizon assessed. The impact of the various channels on inflation is muted at best, with the interest rate channel having the most significant impact. This however is negligible, implying that change in inflation cannot be effectively stabilized by monetary policy.

[21] The result is consistent for all three model specifications

The analysis indicates that the Central Bank should pay particular attention to changes in volumes when considering monetary policy signals, as they outperform the interest rate variables in their impact on GDP. Monetary policy tools like open market operations should be optimal because of their liquidity impact which is transmitted through the credit channel. The market instrument chosen would however have to be evaluated in term of the pricing mechanisms which would make them more attractive to the market participants. Optimal monetary policy signalling would have to take place in an environment where the excess liquidity is contained as it has been shown that its presence impacts the most effective transmission mechanism, that of the credit channel.

5.4 Variance Decomposition

Figure 13 shows the results of the impulse response function on real GDP over 20 quarters. It illustrates that in the first seven quarters, its variations in real GDP is mostly due to its own changes. Consequently, the reserve cash ratio and private sector credit become very important, being responsible for 1.2% and 1.1% of the variation, respectively in the eight quarter. While the impact of the reserve cash ratio subsequently declines to 0.8%, the impact of private sector credit becomes more important and at the end of the horizon accounts for 1.6% of the variation in real GDP. Fluctuations in CPI (see appendix figure 2) can be mostly explained by changes in the variable itself, and movements in the Treasury bill rate.

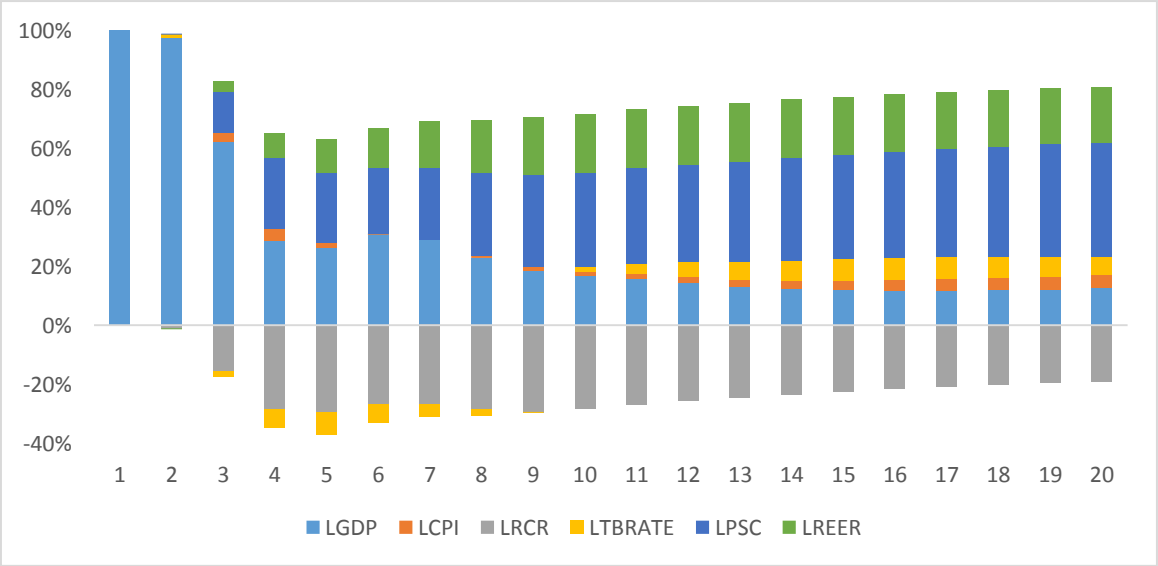


Figure 14: Variance Decomposition of GDP.

6. Conclusions

The analysis set out to examine the monetary policy transmission mechanism in Belize and identify the most significant channels in a Bayesian VAR framework. Evaluating the timing and magnitude of the impact of Central Bank's activities would provide valuable feedback to the Central Bank when employing different policy prescriptions. The results show that the monetary policy transmission mechanism does in fact exist in the Belizean economy and operates mainly through the credit channel and the interest rate channel. The robustness of the results were tested using three alternative BVAR estimations with all results indicating similar patterns and magnitudes of the impulse response functions. The results are contrary to those found in prior analyses from CERT (2019), Khan (1998), and Kendall (2002) that postulated that Belize's monetary policy transmission is short lived and produces results contrary to a priori expectations. The mechanism though, only impacts real economic activity and not the price level, indicating

that an inflation targeting regime would not be suitable for the economy, particularly given the fixed exchange rate.

The credit channel is most effective, with a 2.4 basis point increase in private sector credit eventually leading to a 1.6 basis point expansion in real economic activity after approximately 13 quarters. The interest rate channel operates indirectly and in conjunction with the credit channel to magnify the impact on the economy. Results have also shown that the reserve cash ratio that directly impacts the loanable funds of the domestic banks have been more effective than the Treasury bill rate, leaving the room open to explore further open market operations in the Belizean context. The pricing of the instruments and a communication strategy will be important to enhance the effectiveness of this tool. Finally, excess liquidity has been shown to hinder the effectiveness of the transmission mechanism and should be given the warranted attention to create an environment more responsive to monetary policy actions.

7. Bibliography

Agrippino, S., & Ricco, G. (2018, March). Bayesian Vector Autoregressions. Sciences Po OFCE Working Paper, 18.

Alvarez, Y. (1986). The Belize Experience in the Management of Monetary Policy: 1980 - June 1986. XXII Meeting of Technicians of Central Banks of the American Continent, Lima, Peru. Central Bank of Belize.

Bernanke, B., & Blinder, A., (1992), The Federal Funds Rate and the Channels of Monetary Transmission. American Economic Review, 8(4), 901-921.

Bernanke, B., & Gertler, M. (1995), Inside the Black Box: The Credit Channel of Monetary Policy Transmission. Working Papers, C.V. Starr Center for Applied Economics. New York University.

Bank of England. (2001).The Transmission Mechanism of Monetary Policy. London

Canova, F. (2007). Methods for Applied Macroeconomic Research. N.p.: Princeton University Press.

Doan, T., Litterman, R., & Sims, C. (1986). Forecasting and conditional projection using realistic prior distribution, No 93. Staff Report, Federal Reserve Bank of Minneapolis.

Caribbean Economic Research Team. (2019).The Effectiveness of Monetary Policy Transmission Mechanisms in the Caribbean.

Christiano, L., & Eichenbaum, M. (1995), Liquidity Effects, Monetary Policy, and the Business Cycle,.Journal of Money, Credit and Banking, 27(4), 1113-36.

Chronology of Monetary Policy. (n.d.). In Central Bank of Belize: Monetary Policy. Retrieved from https://www.centralbank.org.bz/financial-system/monetary-policy

Davoodi, H. R., Dixit, S. V. S., & Pinter, G. (2013). Monetary Transmission Mechanism in the East African Community: An Empirical Investigation, No 13/39. IMF Working Papers. International Monetary Fund.

Díaz-Quevedo Ó. A., & Rocabado-Palomeque, C. T. (2018). Does Monetary Policy Affect Bank Lending? Evidence for Bolivia. Monetary Policy and Financial Stability in Latin America and the Caribbean

Ehrmann, M., Gambacorta, L., Martinez-PagÈs, J., Sevestre, P., & Worms A. (2003). The Effects of Monetary Policy in the Euro Area. Oxford Review of Economic Policy. Oxford University Press, 19(1), 58-72.

Favero, C. A. (2001). Applied Macroeconometrics. Economic Notes, 31(3), 559-563.

Fleming, J. M. (1962). Domestic Financial Policies under Fixed and Floating Exchange Rates. IMF Staff Papers.

Garcia, G., Novelo A., & Vellos, C. (2009). The Evolution of the Financial Sector in Belize (1996-2007). Central Bank of Belize.

Ghazanchyan, M. (2014), Unraveling the Monetary Policy Transmission Mechanism in Sri Lanka. MPRA Paper. University Library of Munich, Germany.

International Monetary Fund. (2019, March 28). Monetary Policy and Central Banking. Retrieved from https://www.imf.org/en/About/Factsheets/Sheets/2016/08/01/16/20/Monetary-Policy-and-Central-Banking

Kadiyala, K.R., & Karlsson, S. (1989). Forecasting with Bayesian Vector Autoregressions. Purdue University Economics Working Papers. Purdue University, Department of Economics.

Kendall, P. (2001). "A VAR Approach to the Determination of Interest Rates in the Caribbean." (Caribbean Development Bank).

Khan, G. (1998). "Monetary Transmission Mechanisms: Their operation under Fixed and Floating Rate Regimes: The Experience of a Group of Countries." Occassional Paper (Caribbean Economic Research Team (Formerly Caribbean Centre for Money and Finance).

Kuttner, K., & Mosser, P. (2002). The monetary transmission mechanism in the United States: some answers and further questions. Settlements, Bank for International eds. Market functioning and central bank policy, 12, 433-443. Bank for International Settlements.

Litterman, R. (1985). Forecasting with Bayesian vector autoregressions five years of experience, No 274. Working Papers, Federal Reserve Bank of Minneapolis.

Litterman, R. (1986). The limits of counter-cyclical monetary policy: an analysis based on optimal control theory and vector autoregressions, 297. Working Papers, Federal Reserve Bank of Minneapolis

Loayza, N., & Schmidt-Hebbel K. (2002). Monetary Policy Functions and Transmission Mechanisms: An Overview. Monetary Policy: Rules and Transmission Mechanisms, Vol. 4(1), 001-020: Central Bank of Chile.

Miranda-Agrippino, S., & Ricco, G. (2017, April 21). The Transmission of Monetary Policy Shocks. Bank of England Working Paper No. 657.

Mishkin, F. S. (1996). The Channels of Monetary Transmission: Lessons for Monetary Policy. NBER Working Paper Series.

Mishkin, F. (2006). Monetary Policy Strategy: How Did We Get Here?. No 12515, NBER Working Papers. National Bureau of Economic Research, Inc.

Mishkin, F. S. (2017). Making Discretion in Monetary Policy More Rule-Like. No 24135. NBER Working Papers. National Bureau of Economic Research, Inc.

Mishra, P., Montiel, P., & Spilimbergo, A. (2010), Monetary Transmission in Low Income Countries. No 7951. CEPR Discussion Papers.

Mundell, R. A. (1963). Capital Mobility and Stabilization Policy under Fixed and Flexible Exchange Rates. Canadian Journal of Economic and Political Science.

Mukherjee, S., & Bhattacharya, R. (2011). Inflation Targeting and Monetary Policy Transmission Mechanisms in Emerging Market Economies, No 11/229. IMF Working Papers. International Monetary Fund.

Primus, K. (2016, September). The Effectiveness of Monetary Policy in Small Open Economies: An Empirical Investigation. IMF Working Paper.

Sims, C. (1980). Macroeconomics and Reality. Econometrica. 48(1), 1- 48.

Sims, C., & Zha, T. (1998). Bayesian Methods for Dynamic Multivariate Models. International Economic Review. 39(4), 949-968.

Vellos, C., & Sosa N. (1996). The Development of the Financial System in Belize (1970 - 1995).

Worrell, D., Belgrave, D., Arana, R., Croes, E., Dorinnie, H., Grenade, K., … Wright, A. (2015, April 1). Fiscal Sustainability and Debt in Small Open Economies: An Application to the Caribbean

Worrell, D. (2000, March). Monetary and Fiscal Coordination in Small Open Economies. IMF Working Paper.

8. Appendix

Appendix Table 1

Market Share of Domestic Commercial Banks & Concentration Ratios

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
ABL	16.9%	17.3%	18.4%	20.3%	20.4%	22.9%	24.1%	26.3%	28.0%	29.2%	30.5%
BBL	39.6%	40.1%	37.3%	34.3%	33.7%	31.5%	31.4%	29.0%	28.5%	27.7%	29.2%
BNS	25.7%	25.5%	26.8%	27.9%	26.8%	27.2%	26.2%	24.8%	26.8%	26.5%	24.1%
FCIB	11.2%	10.6%	10.0%	10.2%	10.3%	10.8%	9.8%	10.6%	0.0%	0.0%	0.0%
HBL	6.6%	6.5%	7.5%	7.2%	8.8%	7.3%	7.6%	7.8%	15.2%	14.9%	14.5%
NBBL	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.8%	1.4%	1.5%	1.7%	1.6%
HHI	2,682	2,713	2,603	2,528	2,452	2,424	2,408	2,327	2,550	2,550	2,583
FF Ratio	82.1%	82.9%	82.5%	82.6%	80.9%	81.6%	81.7%	80.2%	83.3%	83.5%	83.9%

Appendix Table 2

Financial Soundness Indicators

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Capital Adequacy											
Regulatory Capital to Risk Weighted Assets	19.3	20.4	21.8	21.8	22.2	24.2	24.4	24.8	24.0	24.2	24.6
Primary Capital to Risk-Weighted Assets	18.1	19.3	20.7	20.8	21.1	23.0	23.2	23.6	23.0	23.2	23.6
Non-Performing Loans (Net of Specific Provisions) to Regulatory Capital	59.2	55.5	77.6	75.1	56.8	43.5	34.5	31.4	14.4	11.1	11.9
Large Exposure to Capital	143.1	134.0	134.0	142.7	144.7	130.6	134.2	125.3	128.5	117.5	96.5
Asset Quality											
Non-Performing Loans to Total Gross Loans	12.7	12.2	18.4	19.0	17.2	14.8	14.3	14.0	10.4	6.4	6.2
Non-Performing Loans (Net of Specific Provisions) to Total Gross Loans	10.7	10.8	16.1	14.5	11.0	8.8	7.0	6.6	3.0	2.4	2.7
Loan Loss Coverage	23.1	19.5	18.2	28.0	40.8	46.0	58.1	62.4	79.8	77.6	71.7
Profitability/Efficiency											
Return On Equity (Net Income to Average Capital)	16.5	11.3	6.4	-5.5	-1.2	5.3	-2.4	7.9	4.8	9.4	19.8
Return On Assets (Net Income to Average Assests)	2.6	1.8	1.0	-0.8	-0.2	0.7	-0.3	1.0	0.6	1.3	3.1
Interest Margin to Gross Income	35.8	40.4	45.6	49.3	54.5	58.7	60.5	56.6	60.1	60.4	66.9
Non-Interest Expenses to Gross Income	42.2	35.4	38.9	43.2	46.5	50.0	46.3	63.1	56.5	55.5	61.0
Liquidity											

Liquid Assets to Total Assets	20.2	21.8	23.3	27.0	29.7	29.2	30.4	32.6	32.7	27.3	25.8
Liquid Assets to Short-Term Liabilities	47.6	60.4	56.7	53.8	56.0	50.6	50.7	52.4	51.7	41.7	38.6
Customer Deposits to total (Non-Interbank) Loans	104.5	108.3	111.4	117.5	127.0	124.3	128.1	132.3	132.3	130.5	127.8

Appendix Table 3

Banking Sector Indicators 2008 – 2018

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Loans and Advances	1,744	1,805	1,762	1,756	1,803	1,854	1,933	1,986	2,015	2,018	2,120
Of Which PSC	1,723	1,795	1,753	1,748	1,786	1,831	1,915	1,974	2,006	2,013	2,069
Total Liabilities	2,435	2,529	2,517	2,565	2,760	2,788	2,958	3,210	3,191	3,149	3,257
of which Deposits	1,820	1,955	1,962	2,065	2,290	2,305	2,476	2,628	2,667	2,632	2,709
Liquid Asset Requirement	407	446	448	473	506	522	564	594	614	600	623
Liquid Asset Holdings	491	551	608	694	816	815	903	1,047	1,057	869	863
Excess Liquid Assets	84	105	160	221	310	294	339	453	444	269	241
Cash Requirements	177	194	166	175	187	193	208	220	227	222	230
Cash Holdings	192	234	226	270	339	391	544	665	653	506	427
Excess Cash	15	40	61	96	153	198	336	446	426	284	197

Appendix Table 4

Lag Length Criteria

VAR Lag Order Selection Criteria

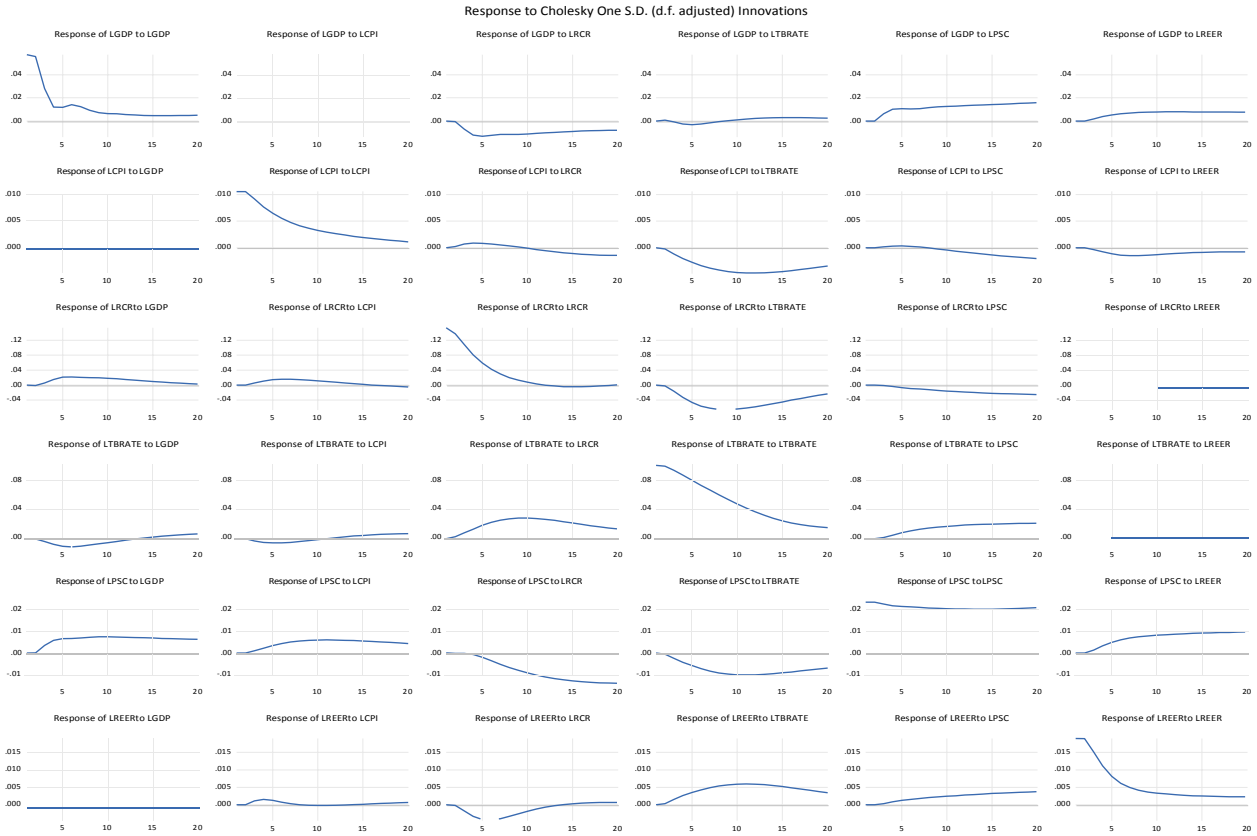
Endogenous variables: LGDP LCPI RCR LTBRATE LPSC LREER

Exogenous variables: C LFED LWTI

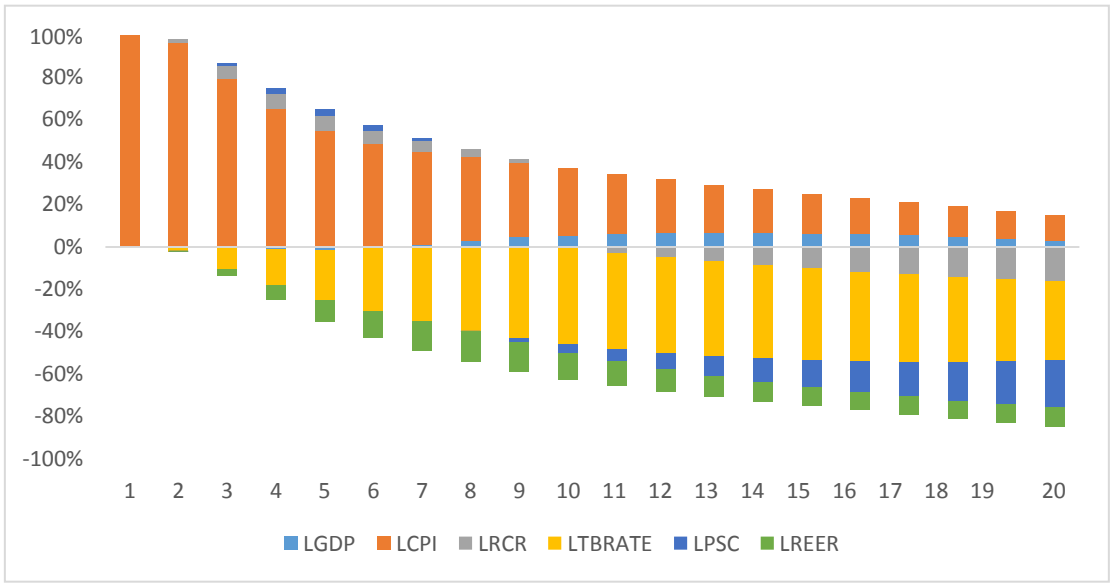
Sample: 1986Q1 2010Q1

Included observations: 61

Lag	LogL	LR	FPE	AIC	SC	HQ
0	601.1207	NA	2.01E-16	-19.11871	-18.49583	-18.8746
1	943.0682	582.9925	8.94E-21	-29.14978	-27.28114*	-28.41744*
2	990.5102	71.55184	6.45E-21	-29.52493	-26.41052	-28.30436
3	1035.071	58.44038*	5.46E-21	-29.80561	-25.44544	-28.09682
4	1078.929	48.8912	5.25e-21*	-30.06326*	-24.45733	-27.86624



Appendix Figure 1: BVAR Impulse Response Functions to one S.D. Innovations.



Appendix Figure 2: Variance Decomposition of CPI.