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"Are Monetary Transmission Mechanisms Effective in the presence of Interest Rate Volatility: New Evidence in Latin American, the Caribbean and the United States"

We analyze the effectiveness of monetary transmission mechanism, in particular, interest rate transmission mechanism in Caribbean, Latin America, and the United States of America. Interest rate pass-through is assessed using a Dynamic Ordinary Least Squared (DOLS) model and interest rate volatility using Exponential Generalized Autoregressive Conditional Heteroskedasticity in Mean model (EGARCH-M (1,1)) augmented using DOLS. Our results showed that pass-through is dependent on a country's level of financial development. We also observed that economic stressors did not have a significant impact on pass-through and in the presence of policy rate volatility pass-through completeness reduces for less financially developed countries.

JEL Classification: C22, E52, G15

Keywords: Monetary Transmission Mechanism, Interest rates, Volatility, Pass-through

Contents

1. Introduction

Monetary policy is one of the main tools used to influence investments, prices, employment and in turn impact output. The European Central Bank defines transmission mechanism of monetary policy as the process through which monetary policy decisions affect the economy in general and the price level in particular. The transmission mechanism is characterized by long, variable and uncertain time lags. Thus it is difficult to predict the precise effect of monetary policy actions on the economy and price level.

Financial markets are central to the conduct of monetary policy, as monetary policy is implemented largely through operations in these markets[1]. In light of the fact that monetary policy works through its influence on prices in the financial system, development in the financial system could have important implications for the way monetary policy changes are transmitted through the financial system as well as their effectiveness[2].

Singh et al (2008) posit that the effectiveness of the transmission of monetary policy to the real economy is crucially dependent on a set of parameters that are influenced by the structure of the financial system. These include the existence and degree of development of financial markets, and changes in these markets that affect their functioning[3]. Krause and Rioja (2006), in their analysis of financial development and monetary policy efficiency used panel data for 37 countries across the world. They found that higher financial development is associated with increased monetary policy efficiency. There results were obtained controlling for many

[1] Singh et al. (2008), BIS Papers No39
[2] ibid
[3] ibid

other factors[4]; however it did not make a difference whether the country is industrialized or developing.

Given the Central bank's monopoly power over the issuing of money, the central bank can fully determine interest rates. The central bank manipulates its rate to impact the economy, but the impact passes through the commercial bank's rates, which is why pass-through is relevant. Jamaica for example, has been having budgetary deficit issues and the central bank has been trying to help correct this with its policies. These policies cannot be effective if pass through is low or depends on volatility. The financial crisis of 2007 disrupted the operations of the United States money market, which was reflected in the widening of the spread between the central bank policy rates and the money market rates as well as with the retail rates. This disturbance potentially impaired the monetary policy pass-through to retail rates, since many bank loan and deposit rates are linked to money market ones. As a result, the cost of credit to both firms and households declined much less than the policy rates during the crisis (Karagiannis et al., 2010). The change in the official interest rates directly affects money-market interest rates and indirectly affects lending and deposit rates, offered to bank customers.

Interest rate volatility is the extent to which the interest rate changes over time. High volatility implies rapid and large upward and downward movements in rates over a relatively short period of time, while low volatility implies much smaller and less frequent changes in value. Not surprisingly, interest rate volatility is different across countries. In the Caribbean region alone we see varying volatility regimes. According to Haughton and Iglesias (2012)

[4] These factors include: (1) Central Bank independence, (2) Inflation targeting and (3) Membership to the European Monetary Union

Jamaica, Haiti and Guyana have high interest rate regimes while the islands of Barbados, Trinidad and Tobago and St Lucia have lower interest rate regimes.

This paper is aimed at assessing three main issues: firstly we will assess the effectiveness of monetary policy in countries with varying levels of financial development. Secondly, we will analyze the impact of economic stressors on the effectiveness of monetary transmission mechanism. Finally, we will analyze the effectiveness of interest rate transmission mechanism from policy rate into retail banking in the presence of interest rate volatility.

2.1. Theoretical Review of Literature

Karagiannis et al. (2010) stated that the adjustment of retail bank interest rates (deposit and lending rates) in response to changes in wholesale rates (central bank and interbank money market rates) is a fundamental element of the interest rate transmission mechanism. Borio (1997) stated that, in recent years, virtually all central banks in the industrialized countries have conducted monetary policy through market-oriented instruments designed to influence short term interest rates. Angeloni et al. (2002) found that the interest rate channel is the most important tool for monetary policy transmission in the Euro area.

Karagiannis et al. (2010) in their analysis of interest rate pass-through in the United States and Europe stated that for an efficient monetary policy, any change in the central bank policy rate is meant to be transmitted to retail interest rates, ultimately influencing consumer and business lending rates and therefore aggregate domestic demand and output. Interest rate pass-through is defined as the degree and the speed of changes of policy or market rate into retail

banking rate (ur Rehman, 2009). In other words, interest rate pass-through is a process where changes in the official interest rate are transmitted to other interest rates (Tai et al. 2012).

If central banks can transfer all the costs associated with increases in policy rates, then we consider this to be complete pass- through. According to Wang and Lee (2009), corroborated by recent research from Haughton and Iglesias (2012), this situation is very rare since only the US economy has achieved complete pass-through on its deposit rate. If only partial effects are transferred to the retail rate then it is considered incomplete pass-through. An incomplete interest rate pass-through can lead to the violation of the Taylor principle[5] and failure of monetary policy to stabilize shocks (Marotta, 2009). There is also a case of over pass-through which is in the event that the central bank transfers more than the cost. Egert et al. (2006) believes it is crucial to assess whether or not the pass-through from monetary policy rates to long-term market and retail rates is complete, as this is the first building block for the monetary transmission mechanism. If the interest rate pass-through is not complete, the impact of monetary policy actions through the credit, interest rate or exchange rate channels will be considerably attenuated.

Numerous studies in their analysis of differences in interest rate pass-through compare their respective jurisdictions to the bench-mark United States. We aim to replicate these authors so as to deduce explanations for any incompleteness in interest rate pass-through. Sellon (2002) argued that changes[6] in the US financial system over the past three decades have led to faster and larger interest rate pass-through[7]. Singh et al. (2008) identified several types of financial developments that may affect the effectiveness of monetary policy. They include financial liberalization, financial

[5] The principle stipulates that for each one-percent increase in inflation, the central bank should raise the nominal interest rate by more than one percentage point.

[6] These changes (developments) include: (1) the removal of deposit rate ceilings and other geographical and product line barriers; (2) the trend towards consolidation within and across financial services industries; (3) the emergence and greater role of money market mutual funds and greater transaction volumes with the growth of mortgage-backed securities; (4) disintermediation from the banking system to the capital market as large corporations have started to meet their funding needs through the capital market.

[7] Sukudhew Singh et al. (2008)

disintermediation, financial innovation, financial consolidation, payment instrument technology and Islamic finance. For this study, we focus our attention however on financial liberalization, financial innovation and payment system technology.

The most essential aspect of financial liberalisation when assessing the transmission of monetary policy is the deregulation of interest rates[8]. Theoretically, the removal of prescribed interest rates (and interest rate ceilings) allows policy rates to be transmitted to retail interest rates more quickly and to a larger degree[9]. Increased capital account liberalisation[10], in recent years, has introduced greater cross-border capital flows[11]. Financial liberalisation and in turn, financial market integration, in principle, should increase the level of competitiveness in the financial market, hence there are implications on monetary transmission. de Bondt (2002, 2005), highlighted in Singh et al. (2008), in his examination of the pass-through of changes in the policy rate to bank deposits and lending rates in the Euro Area uses an Error Correction Model (ECM) and Vector Autoregression (VAR). He found that there was a quicker retail interest rate pass-through after the introduction of a common monetary policy in 1999. Sander and Kleimeier (2004) also found that financial integration in the Euro Area has produced more competitive markets that improve the pass-through to deposit rates. This is concurrent with other literature[12] that investigates the impact of increased competition on interest rate pass-through.

Singh et al. (2008) posits that the development of the capital markets is accompanied by increases in innovation in the financial sector. Tufano (2002) broadly categorises financial innovations into two types, product[13] and process[14] innovations.

[8] ibid
[9] ibid
[10] This is the removal of restrictions on the flow of foreign capital into and out of their countries.
[11] Sukudhew Singh et al. (2008)
[12] Carlino and DeFina (1998), Heinemann and Schüler (2002), Kwapil and Scharler (2006), Sorensen and Werner (2006) and Chionis and Leon (2005).
[13] Product innovation can be illustrated by corporate securities or derivative contracts
[14] Process innovation can be demonstrated by new means of distributing securities, processing transactions or payment system technologies

In recent times there has been tremendous development in terms of derivative instruments and securitization[15]. According to Singh et al. (2008), securitisation enables the transformation of illiquid financial assets into highly liquid, marketable capital market assets. This enables financial institutions to repackage and off-load their loans in the form of bonds, hence making their lending activities less confined and ultimately more standardized to market conditions[16]. Gomez et al (2005), as seen in Singh et al. (2008), posits that monetary policy has lost some effectiveness in influencing real variables in the short run, due to the partial dilution of the main monetary transmission channels(the credit channels). This they deduced is caused by the completion of financial markets that derivative instruments imply. They believe that given greater securitization the traditional bank lending channel will become less important. This was further substantiated by Fender (2008) estimation of a partial equilibrium model of firm investment behaviour. Loutskina and Strahan (2006) and Edwards and Mishkin (1995) also found evidence of reductions in the bank lending channels due to financial innovation[17] .

Payment systems are defined as an arrangement that facilitates the transfer of 'money' from one user to another[18].Developments in payment systems have seen the introduction for more sophisticated institutional and regulatory framework as well as innovative payment instruments. The degree of sophistication of payment systems directly impacts the velocity of money circulation, thus influencing monetary policy itself. Majority of innovations in payment instruments have been focused on Real Time Gross Settlements (RTGS) and electronic forms of payment instruments (more common in retail payment system developments). Here we focus on innovative payment instruments. Arnone and Bandiera (2004) analyzed the issues of to electronic money, central banks' operations and monetary policy effectiveness and concluded however, that as long as central banks continue to operate and retain control over short-term interest rates and money supply is used only as an information variable,

[15] The process through which an issuer creates a financial instrument by combining other financial assets and then marketing different tiers of the repackaged instruments to investors
[16] Sukudhew Singh et al. (2008)
[17] ibid
[18] http://www.boj.org.jm/financial_sys/payments_systems.php

the impact of digital money on monetary transmission is unlikely to be of concern. Hawkins (2001) as seen in Singh et al. (2008) suggests that electronic money, finance, broking and trading affect the behaviour of agents in that they encourage greater consumption and investment. Singh et al. (2008) believes the lower transaction costs resulting from the introduction of payment technologies may induce small investors to invest directly in the equity markets, thus emphasizing the role of the wealth channel in transmitting monetary impulses. We should however point out that due to the lack of empirical work in assessing the impact of payment system development (innovation) on monetary policy, arguments from the literature remain speculative.

Edwards and Susmel (2003) in their analysis of interest rate in emerging markets identified that the causes for increased interest-rate volatility in emerging markets take on three forms: first a number of authors have argued that increased interest-rate volatility is largely the result of "excessive" capital mobility[19] (see Stiglitz (1999)). According to this view the imposition of controls on capital inflows, similar to those used by Chile during 1991–1998, would help countries reduce externally induced financial instability (Krugman, 1999). Secondly some authors have argued that increased interest-rate volatility is inherent in floating exchange rate regimes. Thirdly, there is the extent of markets' instability—and, in particular, of changes in volatility (see Edwards and Susmel, 2003).

2.2. Empirical Review of Literature

Early empirical studies on interest rate pass-through undertaken by Cottarelli and Kourelis (1994) investigated differences in the size of the immediate and long-run pass-through across developed

[19] This is the ability of the private funds to move across national boundaries in pursuit of higher returns. (http://www.businessdictionary.com/definition/mobility-of-capital.html#ixzz2fZqBBHOW)

and developing countries, and the factors that would explain the differences in that pass-through[20]. They deduced that "the degrees of competition in the banking system, the extent of money market development, private-public ownership of banking institutions and barriers to foreign competition were among the possible explanations for the differences in interest rate pass-through". (Cottarelli and Kourelis (1994) as see in Singh et al. (2008)). Cottarelii and Kourelis (1994) also assessed used GDP per capita as a proxy in identifying the differences in the level of interest rate pass-through. They however were unable to find evidence to suggest that interest rate pass-through was dependent of a country's level of economic development. Majority of studies done on the European area seeks to assess the difference in the speed and magnitude of pass-through for the countries in the Euro Area, and to determine if there was uneven transmission of policy rate changes across these countries following the adoption of the single monetary policy[21]. The consensus is that there are significant differences in the speed and magnitude of pass-through in Euro Area countries, and most authors tended to associate these differences to the differences in the structure of the banking and financial systems[22].

Tai et al (2012) studied the effectiveness of interest rates transmission mechanism from money market rate into retail banking rates in several Asian countries[23] by using a Seeming Unrelated Regression model to identify the difference in the degree of pass-through from policy rate to banking rates. Their results suggest that the transmission rate from money market rate into deposit and lending rates is slow and sluggish across the Asian economies. We intend to replicate the model employed in Haughton and Iglesias (2012) analysis of asymmetric interest rate pass-through and monetary transmission in the Caribbean. In measuring the degree of pass-through from policy rate to deposit/lending rates Haughton and Iglesias (2012) employed a Dynamic Ordinary Least Square (DOLS). The degree of pass-through was then deduced using a Wald test of significance. Their

[20] Singh et al. (2008)
[21] ibid
[22] ibid
[23] Hong Kong, Indonesia, Korea, Malaysia, Philippines, Singapore and Thailand

results showed complete pass-through from Treasury bill rate to lending rate in Trinidad and Tobago, St. Lucia and all the countries in the Organization of Eastern Caribbean States (OECS) but not in the other countries of the CSME. This method of identifying the interest rate pass-through was chosen cause of its simplicity and also, the fact that we aim to use the DOLS to augment our Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH) model[24] to assess the level of pass-through in the present of volatility.

We adopt the methodology of Tai et al (2012) who compare the interest rate pass-through between the pre- and post- Asian financial crisis of 1997. The pass-through of money market rate into deposit and lending rates of each country is investigated in the afore mentioned two sub-periods. We aim however, to identify the natural structural changes rather than prescribe a break date.

Egert et al (2007), analyzed interest rate pass-through in five European countries where he identified that interest rate pass-through can be decomposed into two stages. The first stage measures how changes in the monetary policy rate are transmitted to short- and long-term market rates, while the second stage describes how changes in the market rates influence bank deposit and lending rates. Their study used a cointegrated VAR model and error correction procedure instead of the standard cointegration and error correction procedure. Their results showed that short to long run deposit rate have higher pass-through than overnight deposit rates. Also the money market rate pass-through more to the corporate lending rate than to households' deposit and lending rates, which he predicts will continue to decline in the future. Haughton and Iglesias (2012) however state that this is contrary to modern developments where the interest rate pass-through should increase as financial markets developed in these countries.

[24] This will be explained fully later

Edwards and Susmels (2002) examined interest rate volatility in Latin American and Asian countries: Argentina, Brazil, Chile, Hong Kong and Mexico using the Switching Regime Autoregressive Conditional Heteroskedasticity (SWARCH) model. This univariate technique is well suited to address issues arising such as whether volatility and correlation coefficients significantly change due to a foreign event. A particularly attractive property of the SWARCH approach is that it allows us to date periods of high volatility (Edward & Susmels, 2002). Edwards and Susmels (2002) interpret the results presented as providing evidence of significant interconnection across financial markets in the emerging nations. What is particularly interesting is that these connections go beyond geographical proximity. They found evidence that the volatility increased to high at approximately the same time in Hong Kong and Chile. We however, are interested in the cross country effects on volatility. Also we are not just focusing on volatility. We aim to assess the effect of monetary policy in the presence of volatility.

Haughton and Iglesias (2012) examined interest rate pass-through in the countries of the Caribbean Single Market and Economy (CSME). They analyzed asymmetric interest rate pass-through, the impact of interest rate volatility on interest rates and the monetary transmission mechanism in the CSME. Haughton and Iglesias (2012) used the Threshold Autoregressive (TAR) and Momentum Threshold Autoregressive (MTAR) models recommended by Enders and Siklos (2001) and followed the EC-EGARCH-M (1,1) model used by Wang and Lee. We however are not interested in the asymmetric pass-through in our analysis. We aim to replicate Wang and Lee (2009), as well as Haughton and Iglesias (2012) examination of the impact of interest rate volatility on interest rate using an Error Correction Exponential Generalized Autoregressive Conditional Heteroskedasticity in mean (EC-EGARCH-M (1,1)) model. The EC-GARCH-M (1,1) addresses the issue of heteroskedasticity in the cointegrating errors and

volatility in the model. Wang and Lee (2009) results showed pass-through for the US deposit rate but not in the rate of the Asian countries. Results showed relationship in the three selected Asian countries' lending rate and the deposit rate in the five Asian countries. The results of Haughton and Iglesias (2012) EC-GARCH-M (1, 1) showed that both rates for Jamaica displayed upward adjustment rigidity and both rates in Guyana and St. Lucia displayed downward adjustment rigidity.

3. Data & Methodology

This section briefly describes the data and outlines the methods that will be undertaken in our analysis.

3.1. Data

Interest rate transmission mechanism effectiveness in the presence of interest rate volatility in the Caribbean, Latin America and the United States is analyzed using monthly data from 2002:01 to 2012: 02 collected from the International Monetary Fund (IMF) International Financial Statistics (IFS). Data includes Treasury bill rates and commercial banks' lending and deposit rates for six countries; Brazil and Mexico in Latin America, Barbados, Jamaica and Trinidad and Tobago in the Caribbean. These countries were selected based on three major assertions: firstly, they are ideal representations of their regional groups as they possess varying structural and political regimes which will be beneficial in our analysis. Secondly, they possess varying levels of financial development which is essential to our analysis. Thirdly, data was readily available for the above countries. These countries will be analyze and compared to the United States to assess the concurrent nature of our analysis and the literature.

Most research on interest rate pass-through uses the money market rate instead of the Treasury bill rate, however data on the money market rate for the Caribbean is not readily available specifically for Barbados and Trinidad and Tobago. Also due to the nature of these economies, the 90 day Treasury bill rate is the true rate that influences monetary policy (see Haughton and Iglesias, 2012).

Table 1: *Summary statistics of variables*

	Barbados	Brazil	Jamaica	Mexico	Trinidad & Tobago	United States
Obs=122						
			Treasury Bill Rate (TR)			
Mean	3.559	14.495	14.602	6.509	4.255	1.940
Max	6.910	28.780	33.470	9.750	7.110	5.260
Min	0.240	7.972	6.266	3.970	0.100	0.070
Std.	1.662	4.222	5.570	1.659	2.289	1.818
Skewness	-0.071	0.765	0.926	-0.023	-0.537	0.707
Kurtosis	2.396	3.270	4.141	1.883	1.991	2.088
			Deposit Rate (DR)			
Mean	3.327	13.881	7.081	2.644	3.676	1.948
Max	5.710	24.810	8.907	4.060	7.540	8.250
Min	2.530	8.072	3.370	0.940	1.130	3.250
Std.	0.978	4.467	1.459	0.981	2.028	1.819
Skewness	0.877	0.684	-1.210	-0.659	0.502	0.702
Kurtosis	2.117	2.594	3.636	1.995	1.894	2.099
			Lending Rate (LR)			
Mean	9.229	50.921	18.092	7.300	10.588	4.988
Max	10.950	74.200	21.161	10.980	14.500	5.250
Min	8.000	39.100	15.890	4.710	7.750	0.125
Std.	0.864	8.938	1.304	1.711	1.658	1.780
Skewness	0.545	0.734	0.624	0.109	-0.071	0.748
Kurtosis	1.821	2.781	2.386	1.963	1.898	2.132

It was observed that average treasury bill rate varies vastly between the selected countries, with Jamaica on average, having the highest level of policy rate. Jamaica also reported the highest level of deviation in policy rate which may speak to high levels of volatility. Brazil reported the highest deposit and lending rates on average compared to the rest of countries, as well as the highest level of deviation in the deposit rate. On observation of the skewness and kurtosis, we deduced that the variables were not normally distributed. Interest rates usually follow a leptokurtic distribution.

Tests were done to assess whether the variables meet the classical linear regression assumptions for simple regression. The Durbin Watson test indicated that the variables were

auto-correlated (See Appendix 4: TableA4.2). This was anticipated as past levels of interest rates will affect future levels of interest rates. The error terms were not normally distributed.

3.2. Methodology

In analysing the effect of monetary transmission mechanism, we employ the method of a Dynamic Ordinary Least Square (DOLS) executed by Haughton and Iglesias (2012). We however have to first test the level of stationarity of the variables to be analysed. The Augmented Dickey Fuller (1979) (ADF) and the Phillips and Perron (1988) (PP) unit root tests are the most widely used tests of stationarity and will be utilized in our analysis. The numerous unit root test are used to emphasize robustness of results.

Empirically, interest rates are found to exhibit I(1) (first order integration) behavior (Coleman & Sirichand, 2012). Coleman & Sirichand went on further to highlight, in corroboration with Tkacz (2001) and Lopez & Monteiro (2007), the theoretical implication of interest rates following a unit root process without drifts and that there are no bounds on their movements, suggesting the possibility of negative nominal rates. They also suggested that, shocks are implied to be a permanent effect.

3.2.1. Dynamic Ordinary Least Square (DOLS)

We propose the method of Dynamic Ordinary Least Square (DOLS), as seen in Stock and Watson (1993), Egert et al (2006) and Haughton and Iglesias (2012), in our times series cross-country comparison, to assess the long run relationship between the policy rate and the retail rates (the level of pass-through from the policy rate to the retail rate). This is done by incorporating leads and lags in first differences of the regressors which accounts for the potential

endogeneity of the monetary policy rate. The long run relationship between retail interest rate and the government policy rate is specified below:

$$RR_t = \beta_0 + \beta_1 PR_t + u_t \quad (1)$$

Where:

- RR_t is the retail deposit or the retail lending rate
- PR_t is the policy rate

We add leads and lags of the independent variable and specify the DOLS model below:

$$\Delta RR_t = \beta_0 + \sum_{i=1}^{M} \theta_i \Delta PR_{t+i} + \sum_{i=1}^{M} \varphi_i \Delta PR_{t-i} + u_t \quad (2)$$

Where:

θ_i is the parameter on the leads in the DOLS equation

φ_i is the parameter on the lagged values on the DOLS equation

M is the optimal number of leads/ lags.

According to Wang and Lee (2009) the parameter β_o is the fixed mark-up or mark-down in the retail interest rates depending on whether the parameter is positive or negative and β_1 measure the level of interest rate pass-through; there is complete pass-through if β_1= 1, there is incomplete pass-through if β_1< 1, and there over pass-through if β_1> 1. The DOLS allows the use of inference which permits the assessment of the actually level of pass through from policy rate to market rates. We use the Wald test determine the level of pass-through by examining the null hypothesis of complete pass-through ($h_0: \hat{\beta}_1 = 1$).

3.2.2.1. Analysis of the Impact of Economic Stressors on Interest Rate Pass-Through

The dataset was further divided into a pre-crisis and a post crisis group by performing the Zivot Andrew (Zandrew) unit root test for structural break and the DOLS was again use to estimate the long run relationship between retail interest rate and the government policy rate. Previous literature, such as Tai (2012), selected predefined dates to spit their dataset into a pre and post crises periods. We on the other hand wish to not prescribe, but first identify any structural changes then split data at the identified break date. We propose the Zandrew test to identify the natural structural break point in the data and eliminate the bias of choosing a prescribed break date.

Zivot and Andrews (1992) endogenous structural break test is a sequential test which utilizes the full sample and uses a different dummy variable for each possible break date. The break date is selected where the t-statistic from the ADF test of unit root is at a minimum (most negative). Consequently a break date will be chosen where the evidence is least favorable for the unit root null. The critical values in Zivot and Andrews (1992) are different to the critical values in Perron (1989). The difference is that the selecting of the time of the break is treated as the outcome of an estimation procedure, rather than predetermined exogenously.

Since this procedure can identify the date of the structural break, it facilitates the analysis of whether a structural break on a certain variable, in our case the Treasury bill rate, is associated with a particular event such as a change in government policy, a currency crisis, war and so forth. In this test, the null hypothesis is that the series has a unit root with structural break(s) against the alternative hypothesis that they are stationary with break(s).

The pre-crisis and post-crisis DOLS models are specified below:

$$\Delta RR_{1t} = \beta_0 + \sum_{i=1}^{M} \theta_i \Delta PR_{1t+i} + \sum_{i=1}^{M} \varphi_i \Delta PR_{1t-i} + u_{1t} \quad (3)$$

$$\Delta RR_{2t} = \beta_0 + \sum_{i=1}^{M} \theta_i \Delta PR_{2t+i} + \sum_{i=1}^{M} \varphi_i \Delta PR_{2t-i} + u_{2t} \quad (4)$$

Where:

- RR_{1t} is the pre-crisis retail deposit or the retail lending rate
- PR_{1t} is the pre-crisis policy rate
- RR_{2t} is the post-crisis retail deposit or the retail lending rate
- PR_{2t} is the post-crisis policy rate

Equation (3) specifies the pre-crisis long run relationship between retail interest rate and the government policy rate and equation (4) specifies the post-crisis long run relationship between retail interest rate and the government policy rate.

3.2.3. Assessing the Effect of Monetary Policy in the Presence of Volatility

An Exponential Generalized Autoregressive Conditional Heteroskedasticity EGARCH in mean (1,1) model will be used to assess the existence of volatility and their impact on the completeness of pass-through. We however have to evaluate whether there is evidence of heteroskedasticity within our model. The violation of the assumption of constant variance is essential in our analysis of volatility. This will be outlined further below. We employ the widely used Breusch Pagan test for Heteroskedasticity in our analysis.

Breusch Pagan Test for Heteroskedasticity

The Breusch Pagan test is used to test whether the estimated variance of the residuals from a regression are dependent on the values of the independent variables. To assess whether the residuals have constant variance, the significance levels were observed. If the "prob>χ^2" are significant we reject the null hypothesis of constant variance, while if they are not significant then we fail to reject the null and conclude that the variables have constant variance.

EGARCH in mean (1,1) model

We recall equation (1), which characterizes the long run relationship between the policy rate and the deposit and lending rates. If there is no heteroskedasticity we expect the model to take the form:

$$\Delta RR_t = a_0 + a_1 \Delta PR_{t-1} + \varepsilon_t \quad (5)$$

On the other hand, if there is heteroskedasticity present in equation (1) then equation (5) does not provide the best short run estimate on its own. We then have to specify a EGARCH-M (1,1) model, implementing a heteroskedasticity term into the mean equation:

$$\Delta RR_t = a_0 + a_1 \Delta PR_{t-1} + s_i\sqrt{\sigma^2} + \varepsilon_t \quad (6)$$

The Augmented EGARCH-M (1,1) Model

The DOLS was incorporated (augmented) in the EGARCH-M (1,1) model so as to test the completeness in the presence of volatility. Also given that we have identified that there exists heteroskedasticity, the model is thus:

$$\Delta RR_t = a_0 + p_i \Delta PR_t + \sum_{i=1}^{M} \theta_i \Delta PR_{t+i} + \sum_{i=1}^{M} \varphi_i \Delta PR_{t-i} + \sum_{j-1}^{q} \delta_i V_{t-j} + s_i\sqrt{\sigma^2} + \varepsilon_t \quad (7)$$

$$\log(\sigma_t^2) = \omega + \alpha \left|\frac{V_{t-1}}{\sigma_{t-1}}\right| + k\frac{V_{t-1}}{\sigma_{t-1}} + blog(\sigma_{t-1}^2) \quad (8)$$

Where:

p_i is the parameter that shows the response of the retail rate changes to a changes in the Treasury bill rate

s_i is the parameter that shows the effect of interest rate volatility on the interest rates, and if significantly positive (negative) then the interest rate has a significant impact on the volatility margins of interest rate.

V_t represents the effect of volatility on the mean equation

k represents the effect of policy rate volatility on the mean equation

ω is a constant equal to γV_l , where V_l is the long run variance rate and γ is the assigned weight.

b is the weight assigned to the lagged variance (time varying variance of error term)

α is the weight assigned to the lagged squared error of the policy rate which represents the effect of interest rate volatility in the mean equation

$$\omega > 0 \; and \; \alpha, \beta \geq 0$$

4. Empirical Results & Discussion

4.1. Empirical Results

All three unit root tests confirm that the three variables (treasury bill rate, deposit rate and lending rate) for all countries are integrated of order one (I(1)). The lag lengths for both the ADF and the Zandrew test were selected using the Akaike's information criterion (AIC). This

conforms to the Coleman & Sirichand, (2012) view that interest rates exhibit integration of order one (See Appendix 2: table A2.2).

4.1.1. Results of Dynamic Ordinary Least Square (DOLS) Analysis

A Dynamic Ordinary Least Square (DOLS) model (equation 2) was used to attain the long run parameters for relationship between the Treasury bill rate and the deposit and lending rates for the countries being analysed. Results are illustrated below:

Table 2: *Results of the Dynamic OLS of long run parameters from equation (2)*

	$\hat{\beta}_0$		$\hat{\beta}_1$ TR		$H_0: \hat{\beta}_1 = 1$ Pass- through	
Barbados						
Deposit	-0.002307	(0.8995)	0.222522	(0.1042)	-5.727888	(0.0000)
Lending	-0.002725	(0.8708)	0.326407	(0.0101)	-5.412961	(0.0000)
Brazil						
Deposit	-0.022534	(0.6851)	0.671319	(0.0000)	-2.14788	(0.0341)
Lending	-0.051068	(0.7055)	1.117046	(0.0034)	0.314499	(0.7538)
Jamaica						
Deposit	-0.041254	(0.2086)	0.037011	(0.4637)	-19.13893	(0.0000)
Lending	-0.008519	(0.8595)	-0.091865	(0.2179)	-14.7369	(0.0000)
Mexico						
Deposit	-0.016935	(0.0267)	0.362183	(0.0000)	-14.73037	(0.0000)
Lending	-0.001834	(0.9471)	1.260444	(0.0000)	1.641516	(0.1038)
Trinidad & Tobago						
Deposit	0.020011	(0.5549)	1.177921	(0.0000)	0.810113	(0.4198)
Lending	-0.017622	(0.5525)	0.479194	0.0143	-2.709584	(0.0079)
United States						
Deposit	0.000396	(0.9315)	0.995576	(0.0000)	-0.125333	(0.9005)
Lending	0.001366	(0.7482)	0.985601	(0.0000)	-0.441599	(0.6597)

Level of significance in parentheses ( )

A Wald test was used to determine the level of pass-through by examining the null hypothesis of complete pass-through ($h_0: \hat{\beta}_1 = 1$). The results show that there was incomplete pass-through from policy rate to retail rates for all countries in the Caribbean with exception to

Trinidad and Tobago which showed pass-through from the policy rate to their deposit rate, also experienced by Haughton and Iglesias (2012). The Latin American countries analysed (Brazil and Mexico) both showed pass-through in their lending rates. Our analysis further showed that there was complete pass-through from Treasury bill rate to both the deposit and lending rates in the United States which is in tandem with the literature.

There was only a significant mark down in deposit rate for Mexico of -0.0276. A mark down indicates that average changes in retail rates are negative. All other mark ups (downs) were insignificant. This signifies that there are no average changes in retail rates. Retail rates are dependent on the policy rate with is in agreement with the cost of borrowing theory.

4.1.2. Results of the Dynamic OLS accounting for structural breaks

Given the changing financial structures over time we decided to conduct structural break tests which search for an unknown, endogenously determined break point in the Treasury bill rate, using the Zandrew unit root test for structural breaks. The DOLS procedure was then conducted on both pre and post crises periods. The results are illustrated in Table 4.

Table 3: *Results of the Dynamic OLS accounting for structural breaks from equations (3) and (4)*

		Pass-through Ho: β_1=1			**Pass-through Ho: β_1=1**
Barbados					
Pre-crisis	Deposit	No	*Post-crisis*	Deposit	No
	Lending	No		Lending	No
Brazil					
Pre-crisis	Deposit	Yes	*Post-crisis*	Deposit	No
	Lending	Yes		Lending	Yes
Jamaica					
Pre-crisis	Deposit	No	*Post-crisis*	Deposit	No
	Lending	No		Lending	No
Mexico					
Pre-crisis	Deposit		*Post-crisis*	Deposit	No
	Lending			Lending	No
Trinidad & Tobago					
Pre-crisis	Deposit	Yes	*Post-crisis*	Deposit	Yes
	Lending	Yes		Lending	Yes

United States					
Pre-crisis	Deposit	Yes	*Post-crisis*	Deposit	Yes
	Lending	Yes		Lending	Yes

Results show that countries experiencing pass-through in the pre-crisis period still had pass-through in the post crisis period, with the exception of Brazil. Brazil showed pass-through in the pre-crisis period but the pass-through became incomplete in the post crisis period for its deposit rate. It was however observed that the impact of the policy rates (the coefficients on β_1) in terms of the impact of the deposit rate all decreased. This is concurrent with the literature (see Tai et al, 2012) .

4.1.3 Summary Results of DOLS and EGARCH-M (1,1) Analyses

In this section we summarized the results of the DOLS and analyze the results of the EGARCH-M (1,1) analysis. Recall the EGARCH_M (1,1) was augmented, incorporating the DOLS to show the impact of volatility on interest rates and by extension pass-through.

Table 4: *Summary table of DOLS and EGARCH-M (1,1) analyses*

	Mark up/Mark down β_0	**Pass-through Ho: $\beta_1 = 1$**	**Impact of Interest rate volatility (*s*)**	**Conditional Variance (*k*)**	**Relationship Between retail rates adjustment margins and policy rate (*p*)**	**Pass-through in the presence of volatility Ho: $\beta_1 = 1$**
Barbados						
Deposit Rate		No		Negative	Positive	No
Lending Rate		No		Negative	Positive	No
Brazil						
Deposit Rate		No			Positive	No
Lending Rate		Yes			Positive	No
Jamaica						
Deposit Rate		No		Positive	Negative	No
Lending Rate		No			Negative	No
Mexico						
Deposit Rate	Mark Down	No	Negative		Positive	No
Lending Rate		Yes		Positive	Positive	Yes
Trinidad & Tobago						
Deposit Rate		Yes	Positive			No

Lending Rate	No	Positive		No
United States				
Deposit Rate	Yes		Positive	No
Lending Rate	Yes		Positive	Yes

It was observed that all Latin American and Caribbean showed a positive and significant relationship between the retail rates adjustment margins and the policy rate (*p)* with the exception of Jamaica. This is similar to the significantly positive relationship existing in the US. There was not a significant relationship reported for Trinidad and Tobago. The impact of interest rate volatility on the retail rate margins was not statistically significant for all countries analyzed except Mexico and Trinidad and Tobago. There was a significantly negative impact of the policy rate on the deposit rate of Mexico while there was significantly positive impact on the deposit rate of Trinidad and Tobago. The coefficient *k* (conditional variance) was statistically positive for the lending rates of Mexico and Trinidad and Tobago as well as the deposit rate for Jamaica. Barbados however, reported a statistically negative coefficient for both retail rates. It was also observed that the Latin American and Caribbean deposit rates pass-through became incomplete in the presence of policy rate volatility which is similar to the results observed in the US. On the other hand the US and Mexico lending rates still showed signs of pass-through in the presence of policy rate volatility.

4.2. Discussion

Concurrent with the literature, our results showed that countries in Latin America and the Caribbean experience incomplete pass-through from policy rate to retail (deposit and lending) rates. This may be due to the level of development and sophistication of their financial systems. Weak competition within the banking sector[25] and in the financial sector[26] reduces the sensitivity

[25] Among banks

of the demand for deposits and loans to the interest rate. High switching costs may also lead to lower demand elasticity (see Egert et al, 2006). Evidence of this can be seen in Jamaica, Trinidad and Tobago and Barbados, where the market share in the banking sector is dominated by few commercial banks, thus lowering the level of competition. This is also true for Brazil and Mexico, as the six largest banks in Brazil and the seven largest banks in Mexico account for 80%[27]and 82%[28] of the assets in the banking system in the respective countries.

Haughton and Iglesias (2012) stated that for countries with incomplete pass-through, their markets are too small to be perfectly competitive (see appendix 1 for comparison). They went on to state that for countries showing incomplete pass-through, interest rates are not determined by the market but by external factors (for example Government intervention in the retail lending rate). This may cause monetary policy to be less effective (see Haughton and Iglesias, 2012). The low pass-through in retail banking rates could imply that the monetary policies in these economies are very weak in influencing the retail banking rates. The monetary policy in these economies cannot effectively control the economic transmissions and the financial market integration is weak in these economies (see Tai et al, 2012).

There was complete pass-through reported from the policy rate to both the US deposit and lending rates. This is in accordance with the previous studies (Wang and Lee (2009) and Haughton Iglesias (2012)). This is expected in the US given that its financial system is more developed, more functioning and sophisticated, and there is symmetry of information within the financial market contrary to Latin American and Caribbean countries. Trinidad and Tobago also showed pass-through in their deposit rate, in tandem with Haughton and Iglesias (2012) results.

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[26] Between banks and non banking financial intermediaries

[27] See FSAP report: Stress Testing the Banking Sector-Brazil (2012)
[28] See FSAP report: Financial System Stability-Mexico (2011)

In the case of Trinidad and Tobago, they are a part of the monetary union, Organization of Eastern Caribbean States (OECS). Monetary policy is more coordinated among the countries monetary unions. The interdependence between countries in the union ensures more efficiency in monetary policy as policies are carried out in the best interest of all countries in the union (see Haughton and Iglesias, 2012). Complete pass-through may also exist because the elasticity of demand for loans to the deposit rate is higher than one (1). Perfect substitution between bank deposits and other money market instruments of the same maturity will cause demand elasticity to be higher than one.

With the exception of the US and Mexico lending rate, it was observed that in the presence of policy rate volatility pass-through was incomplete. The coefficient (*p)* shows how the Treasury bill rate adjustments affects retail rate. The Latin American and Caribbean countries, with the exception of Jamaica, showed positive significant relationships between policy rate and retail rate adjustments. This indicates that increases in the policy rate will cause increases in the retail rates in these countries. The converse is also true. This is similar to the results of the US. In Jamaica it was observed that there is an inverse relationship between the policy rate adjustments and retail rates. The coefficient *(k)* represents the effect of policy rate volatility on the mean equation. The significantly positive impact reported for Jamaica (deposit rate), Mexico (lending rate) and Trinidad (lending rate) indicate that there is an asymmetric effect in the conditional variance, while the significantly negative impact reported by Barbados (deposit and lending rates) indicates a leverage effect (see Haughton and Iglesias, 2012). The coefficient (*s)* represents the effect of policy rate volatility on retail rates. In the case of Mexico there is a significantly negative impact of the policy rate volatility on the deposit rate, while in Trinidad and Tobago there is a significantly negative impact on their deposit rate.

5. Conclusion

This paper assessed the level of interest rate pass-through and the impact of policy rate volatility on the retail rates. It also analyzed whether a countries' level of financial development impacts the effectiveness of monetary transmission mechanisms, in particular, interest rate transmission mechanisms. The methods used were DOLS and the augmented EGARCH-M (1,1)-M.

The analysis showed that the Caribbean (Jamaica and Barbados) experienced incomplete pass through in retail rates. Trinidad experienced pass-through in their deposit rate but not in their lending rate. This was also the case for the Latin American (Mexico and Brazil) countries experienced incomplete pass-through. The United States being more financially developed alone experienced full pass-through in both the deposit and lending rates over the period of study, which conforms to Wang and Lee (2009) who found similar pass-through for the United States deposit rate.

In the presence of economic stressors such as government policy, wars, currency crisis and recessionary periods, our analysis confirms that interest rates transmission mechanisms will be less effective. Our DOLS analysis showed that countries experiencing pass-through in the pre-crisis still had pass-through, with the exception of Brazil's deposit rate. It was however observed that the coefficients of the policy rate all decreased for the deposit rates.

Our volatility analysis showed that in the presence of interest rate volatility, pass-through is incomplete. This is substantiated by the reduction in the level of pass-through observed in our analysis of the United States' deposit rates when exposed to volatility. The incompleteness observed in the countries selected, is significantly linked to macroeconomic and political

instability in these countries, as well as uncertainty which cause high volatility in the interest rates.

Appendix

Appendix 1: Country comparison of Financial Sectors

Table A1: *Comparison of Financial Sector Development*

	Caribbean			Latin America		
	Barbados	Jamaica	Trinidad & Tobago	Brazil	Mexico	United States
5-bank asset concentration (%)	-	100	100	73.01	71.21	46.98[2011]
Bank concentration (%)	100	89.99	98.78	61.71	53.28	35.38[2011]
Financial system deposits to GDP (%)	117.49	38.98	56.71	59.94	25.03	78.76
Percentage of foreign bank assets among total bank assets (%)	100[2009]	96[2009]	54[2009]	22[2008]	75[2009]	18[2009]
Percentage of foreign banks among total banks (%)	100[2009]	71[2009]	67[2009]	38[2009]	48[2009]	32[2009]
H-statistic	-	0.431	0.541	0.751	-	0.689[2010]
Lerner index	-	0.404	0.342	0.224	-	0.223[2010]

Sourced from: The World Bank – Data is from 2010 unless specified

Appendix 2: Unit Root Results

Table A2.1*: Unit root tests results of the interest rate of all countries*

	Levels			
	ADF Test Statistics	PP Test rho	Z(t)	Zandrew
Barbados				
Treasury Bill Rate	-1.343 (5)	-4.356 (4)	-1.629	-4.217 (2) **2004m7**
Deposit Rate	-1.578 (5)	-2.189 (4)	-1.002	
Lending Rate	-1.523 (3)	-3.127 (4)	-1.283	
Brazil				
Treasury Bill Rate	-1.422 (4)	-4.378 (4)	-1.412	-3.588 (0) **2009m10**
Deposit Rate	-1.435 (8)	-3.084 (4)	-1.238	
Lending Rate	-1.646 (4)	-2.864 (4)	-1.252	
Jamaica				
Treasury Bill Rate	-1.988 (6)	-6.149 (4)	-1.628	-3.189 (1)

									2007m9
Deposit Rate	-0.302	(1)		-0.691	(4)		-0.261		
Lending Rate	-2.344	(2)		-13.215	(4)		-2.701		
Mexico									
Treasury Bill Rate	-1.464	(2)		-5.541	(4)		-1.549	-3.958	(1)
								2004m5	
Deposit Rate	-0.902	(9)		-0.936	(4)		-0.486		
Lending Rate	-2.243	(3)		-7.937	(4)		-1.863		
Trinidad & Tobago									
Treasury Bill Rate	-0.581	(5)		-0.705	(4)		-0.347	-7.707	(3)
								2009m1	
Deposit Rate	-1.631	(3)		-4.794	(4)		-1.615		
Lending Rate	-1.555	(5)		-4.594	(4)		-1.81		
United States									
Treasury Bill Rate	-2.465	(9)		-1.261	(4)		-0.669	-3.908	(1)
								2007m11	
Deposit Rate	-2.608	(9)		-1.284	(4)		-0.679		
Lending Rate	-2.648	(9)		-1.341	(4)		-0.703		

Lag lengths in parentheses * **p<0.01, ** p<0.05, *p<0.1

Table A2.2*: Unit root tests results of the interest rate of all countries*

	First Difference								
	ADF Test Statistics			PP Test rho			Z(t)	Zandrew	
Barbados									
Treasury Bill Rate	-6.162	(2)**		-96.851	(4)**		-9.376	-9.355	(1)
								2007m2	
Deposit Rate	-3.652	(3)**		-149.474	(4)**		-11.51		
Lending Rate	-3.743	(3)**		-142.304	(4)**		-10.705		
Brazil									
Treasury Bill Rate	-4.884	(3)**		-129.873	(4)**		-11.662	-11.768	(0)
								2007m3	
Deposit Rate	-4.148	(7)**		-136.503	(4)**		-10.006		
Lending Rate	-3.578	(3)**		-78.779	(4)**		-7.336		
Jamaica									
Treasury Bill Rate	-3.969	(10)**		-73.813	(4)**		-7.584	-8.017	(0)
								2009m1	
Deposit Rate	-11.89	(0)**		-124.18	(4)**		-11.969		

Lending Rate	-6.616	(2)**	-144.381	(4)**	-13.798		
Mexico							
Treasury Bill Rate	-3.651	(10)**	-101.332	(4)**	-9.419	-9.691 **2003m9**	(0)
Deposit Rate	-3.857	(9)**	-97.556	(4)**	-8.789		
Lending Rate	-3.733	(10)**	-110.771	(4)**	-9.651		
Trinidad & Tobago							
Treasury Bill Rate	-3.669	(4)**	-58.318	(4)**	-6.299	-6.753 **2008m12**	(2)
Deposit Rate	-5.296	(2)**	-165.622	(4)**	-12.644		
Lending Rate	-3.675	(3)**	-131.128	(4)**	-10.729		
United States							
Treasury Bill Rate	-3.47	(2)***	-36.678	(4)**	-4.662	-6.117 **2006m8**	(0)
Deposit Rate	-3.257	(2)***	-35.031	(4)**	-4.519		
Lending Rate	-3.228	(2)***	-35.558	(4)**	-4.561		

Lag lengths in parentheses *** p<0.01,
**p<0.05, *p<0.1

Appendix 3: Line graphs of the variables analysed.

Figure A3.1: *Graph of Barbados interest rates in levels.*

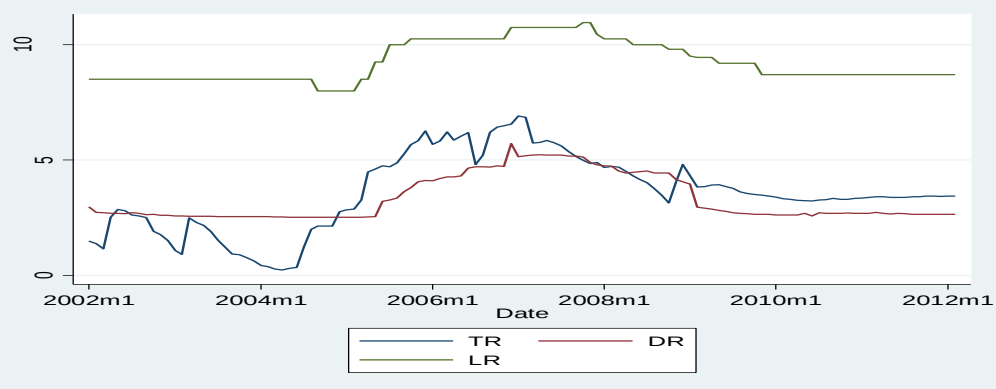


Figure A3.2: *Graph of Barbados interest rates in first difference.*

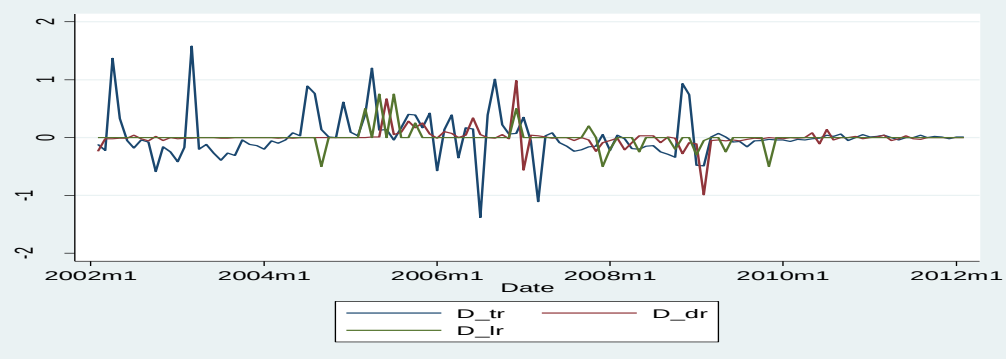


Figure A3.3: *Graph of Brazil interest rates in levels.*

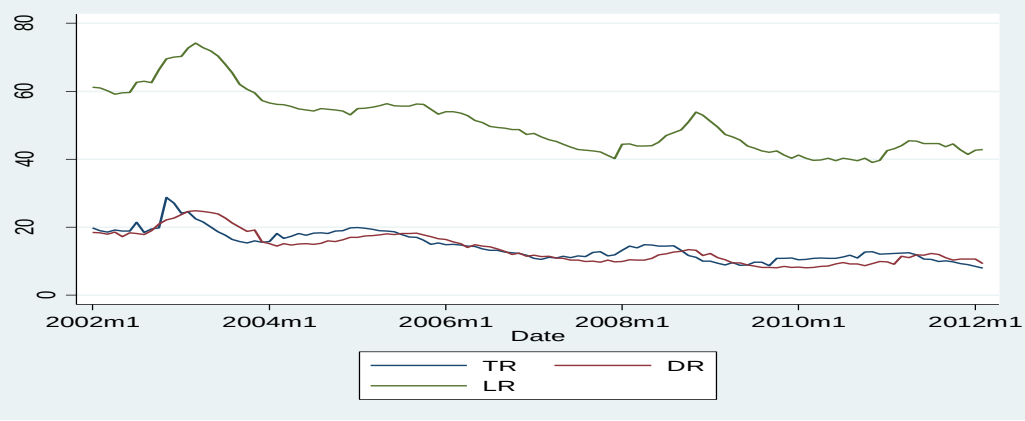
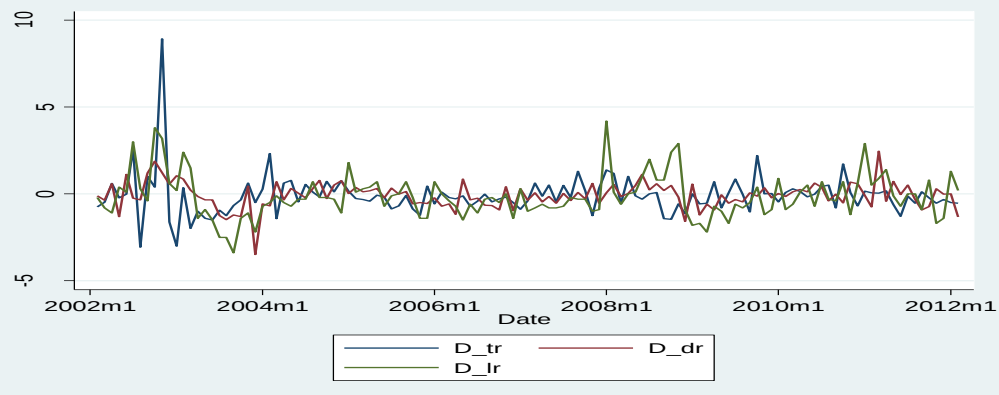


Figure A3.4: *Graph of Brazil interest rates in first difference.*



FigureA3.5: *Graph of Jamaica interest rates in levels.*

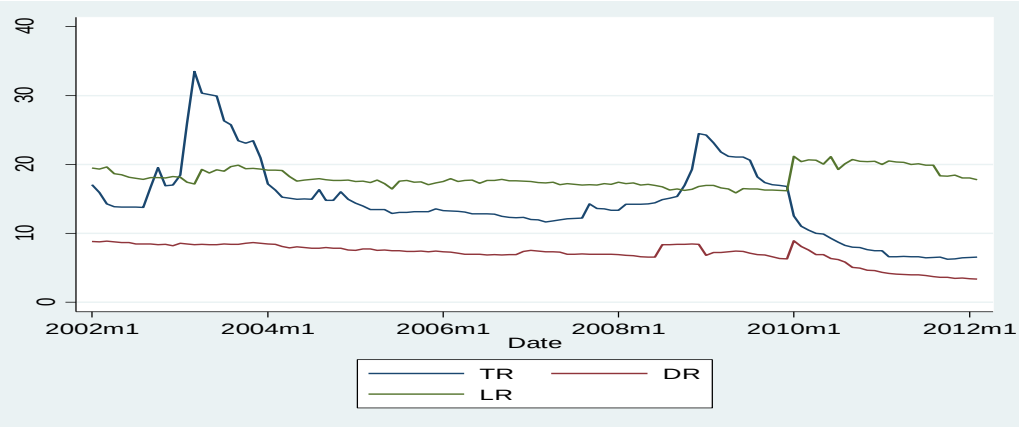


Figure A3.6: *Graph of Jamaica interest rates in first difference.*

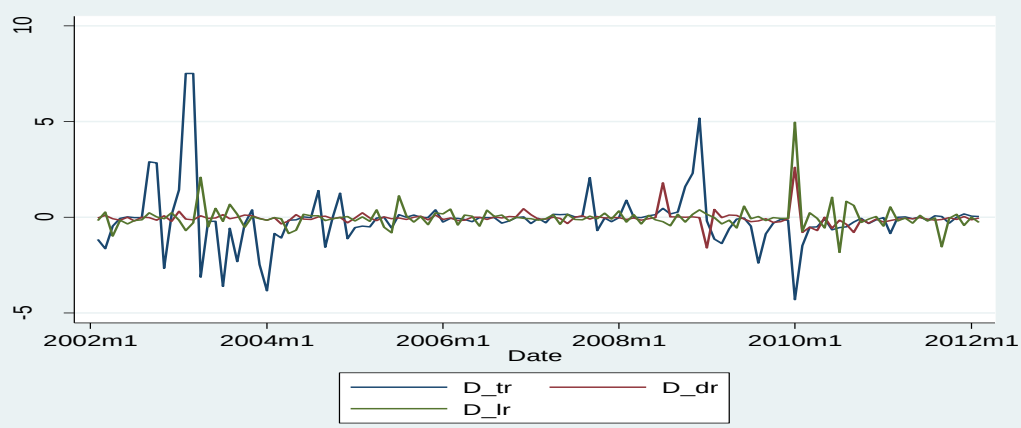


Figure A3.7: *Graph of Mexico interest rates in levels.*

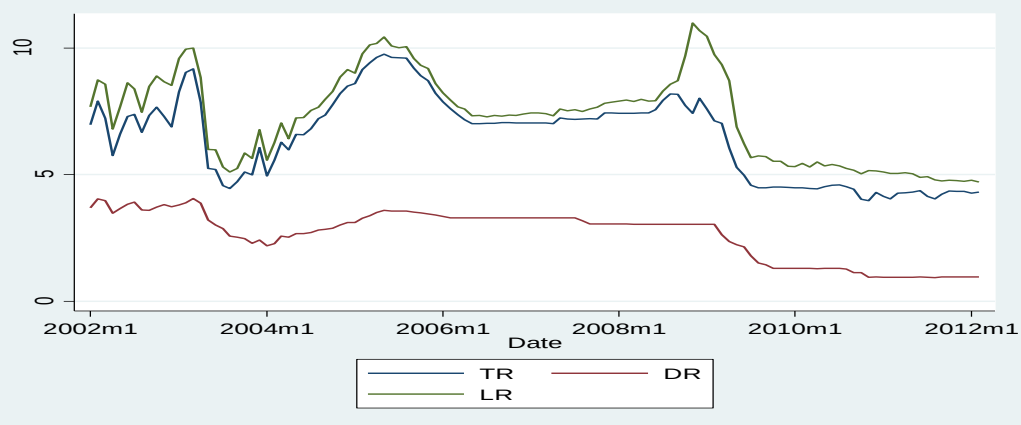


Figure A3.8: *Graph of Mexico interest rates in first difference.*

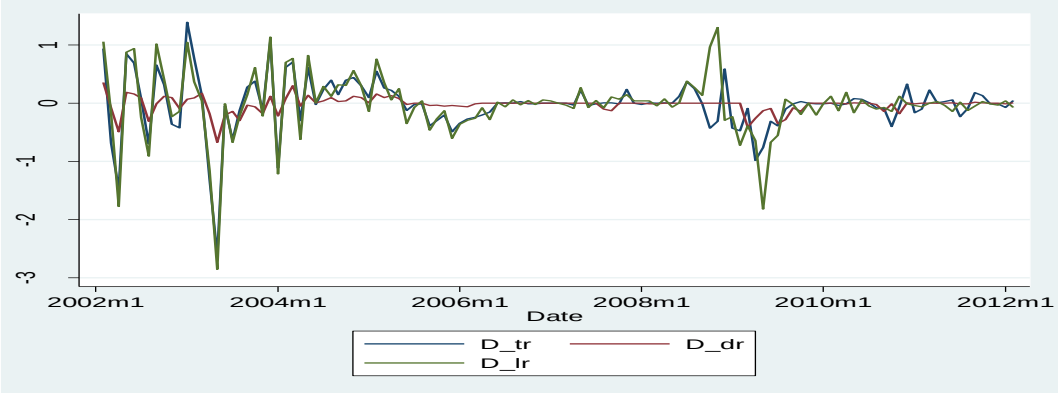


Figure A3.9: *Graph of Trinidad and Tobago interest rates in levels.*

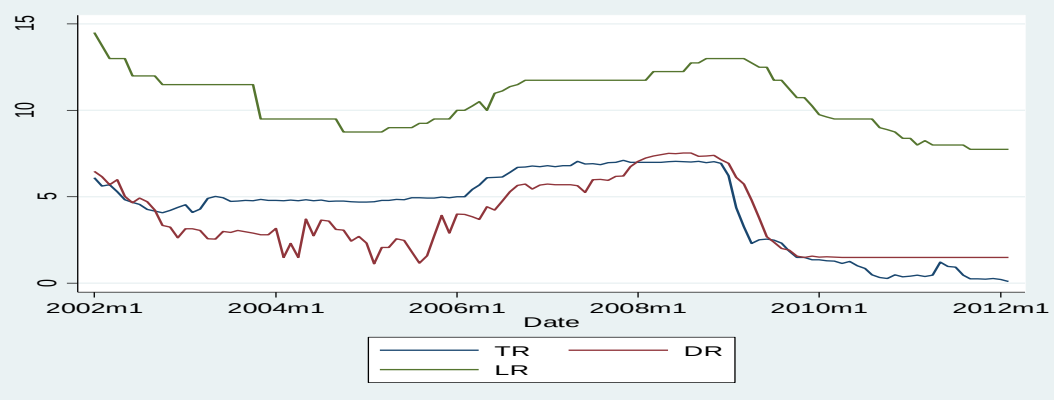


Figure A3.10: *Graph of Trinidad and Tobago interest rates in first difference.*

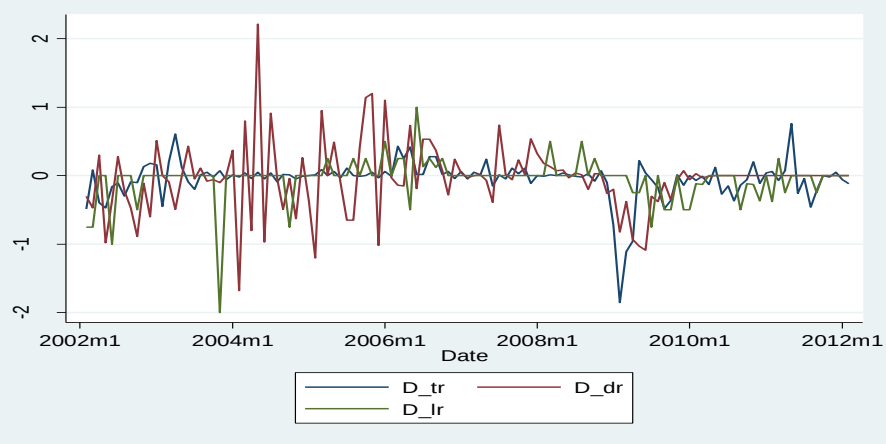


Figure A3.11: *Graph of United States interest rates in levels.*

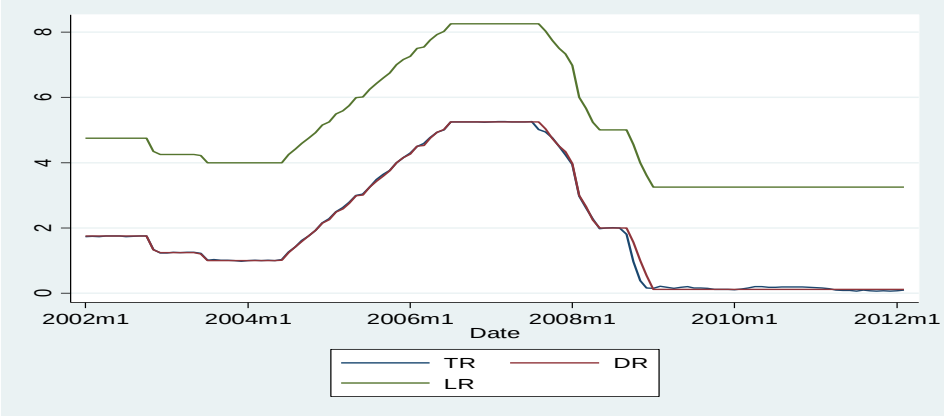
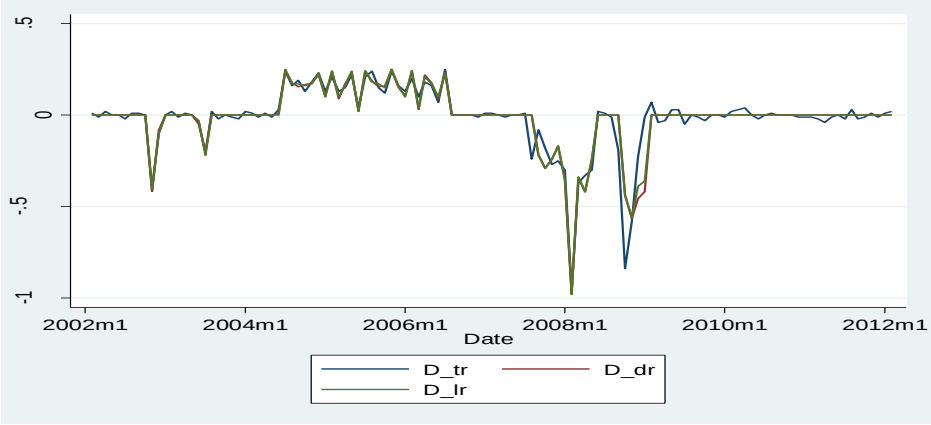


Figure A3.12: *Graph of United States interest rates in first difference.*



Appendix 4: Results of the Classical Linear assumptions tests for simple regressions

Table A4.1: Results of the Breusch-Pagan test for Heteroskedasticity. H_0: *constant variance*

	Deposit			Lending		
	χ^2		Prob > χ^2	χ^2		Prob > χ^2
Barbados	26.08	(1)	0.0000	44.13	(1)	0.0000
Brazil	3.30	(1)	0.0693	1.58	(1)	0.2088
Jamaica	25.52	(1)	0.0000	80.37	(1)	0.0000
Mexico	14.43	(1)	0.0001	17.16	(1)	0.0000
Trinidad & Tobago	3.69	(1)	0.0548	1.27	(1)	0.2594
United States	138.75	(1)	0.0000	146.43	(1)	0.0000

df in parentheses ( )

To assess whether the variables have constant variance, the significance levels were observed. If the "prob>χ^2" are significant we reject the null hypothesis of constant variance, while if they are not significant then we fail to reject the null and conclude that the variables have constant variance. The results show that both the lending

Table A4.2: Results of the Durbin Watson test for autocorrelation

Obs=122 Num of Parameters= 2	D-statistic	
	Deposit rate	Lending Rate
Barbados	0.143	0.207
Brazil	0.310	0.209
Jamaica	0.208	0.246
Mexico	0.117	8.510
Trinidad & Tobago	0.173	0.067
United States	0.532	0.451

The Durbin Watson test assumes that the error terms are normally distributed with a mean of zero and a constant variance. The test assessed the null hypotheses that the error terms are uncorrelated against the alternative that the error terms are AR(1). If the errors are strongly auto correlated then the D-statistic will be far from 2. The results show that all the variables had strong positive auto correlated.

Table A4.3: Results of the Shapiro-Wilks test of Normality

	Obs=122					
		Variable	W	V	Z	Prob>Z
Barbados	Deposit rate	e_dr	0.973	2.668	2.200	0.014
	Lending Rate	e_lr	0.973	2.668	2.200	0.014
Brazil	Deposit rate	e_dr	0.937	6.169	4.080	0.000
	Lending Rate	e_lr	0.937	6.169	4.080	0.000
Jamaica	Deposit rate	e_dr	0.920	7.796	4.605	0.000
	Lending Rate	e_lr	0.920	7.796	4.605	0.000
Mexico	Deposit rate	e_dr	0.917	8.109	4.693	0.000

	Lending Rate	e_lr	0.917	8.109	4.693	0.000
Trinidad & Tobago	Deposit rate	e_dr	0.876	12.066	5.584	0.000
	Lending Rate	e_lr	0.876	12.066	5.584	0.000
United States	Deposit rate	e_dr	0.855	14.184	5.947	0.000
	Lending Rate	e_lr	0.855	14.184	5.947	0.000

The Shapiro-Wilks test here is testing the null hypothesis, that the error term follows a normal distribution. If the "Prob>Z" is less than 0.05 then the null hypothesis is rejected and concludes the error are not following a normal distribution. The results show that all the errors are not normally distributed.

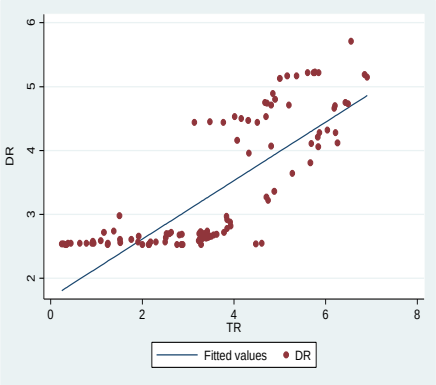


Figure A4.1: Scatter plot showing the relationship between deposit rate and Treasury bill rate for Barbados.

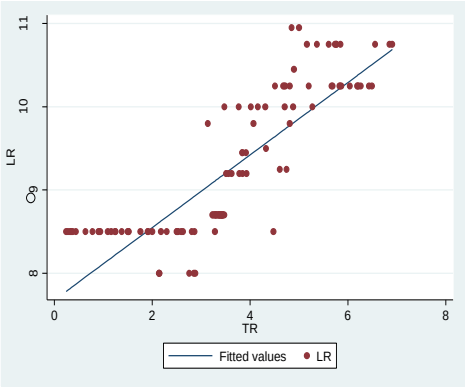


Figure A4.2: Scatter plot showing the relationship between lending rate and Treasury bill rate for Barbados.

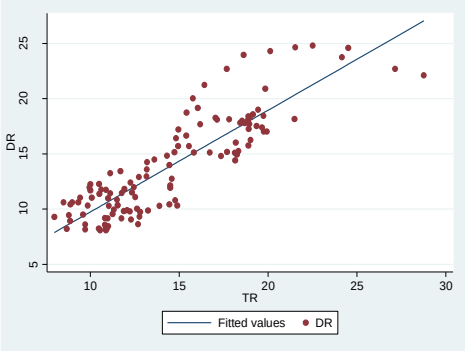


Figure A4.3: Scatter plot showing the relationship between deposit rate and Treasury bill rate for Brazil.

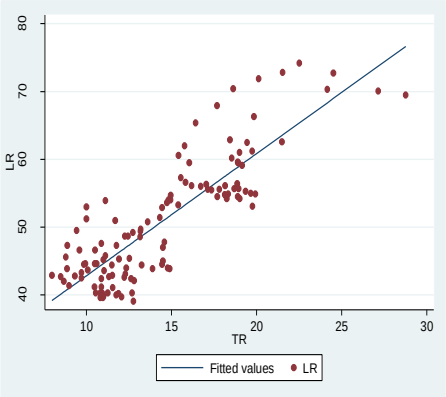


Figure A4.4: Scatter plot showing the relationship between lending rate and Treasury bill rate for Brazil.

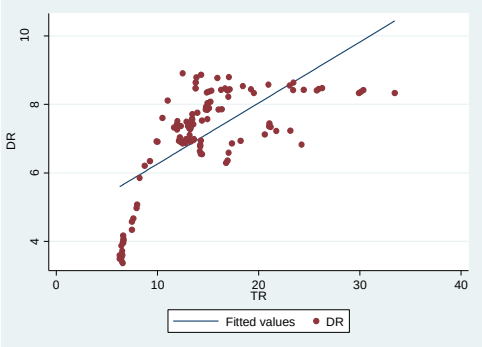


Figure A4.5: Scatter plot showing the relationship between deposit rate and Treasury bill rate for Jamaica.

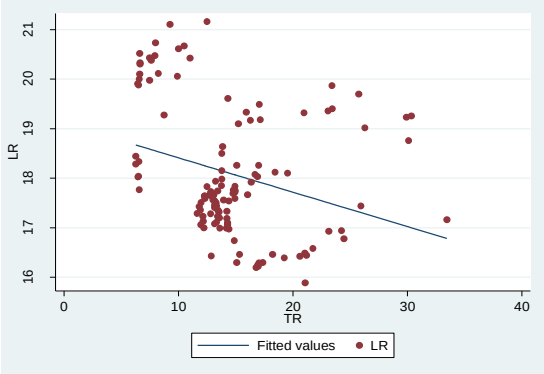


Figure A4.6: Scatter plot showing the relationship between lending rate and Treasury bill rate for Jamaica.

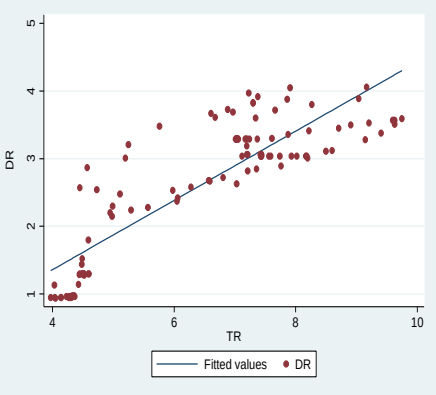


Figure A4.7: Scatter plot showing the relationship between deposit rate and Treasury bill rate for Mexico.

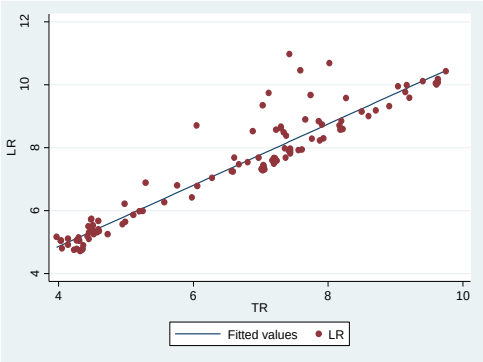


Figure A4.8: Scatter plot showing the relationship between lending rate and Treasury bill rate for Mexico.

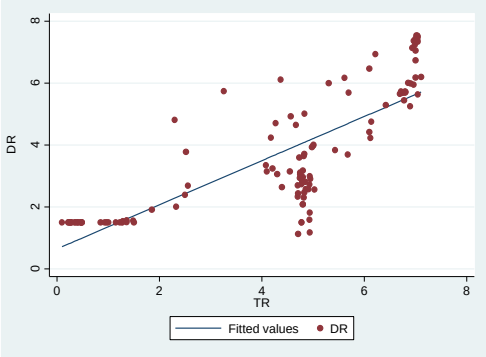


Figure A4.9: Scatter plot showing the relationship between deposit rate and Treasury bill rate for Trinidad and Tobago.

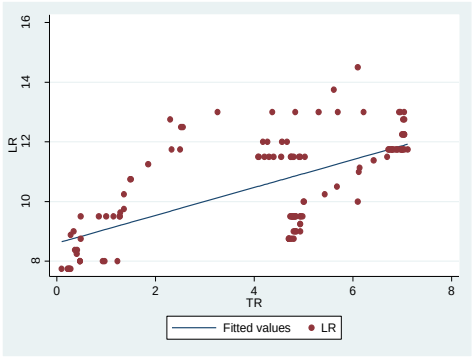


Figure A4.10: Scatter plot showing the relationship between lending rate and Treasury bill rate for Trinidad and Tobago.

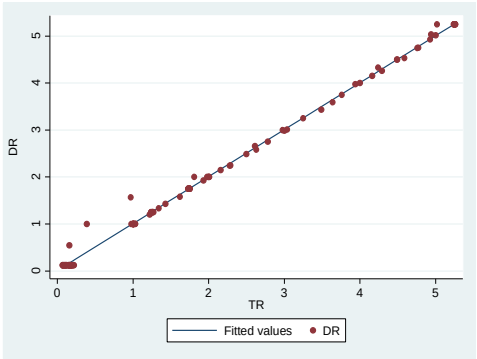


Figure A4.11: Scatter plot showing the relationship between deposit rate and Treasury bill rate for United States.

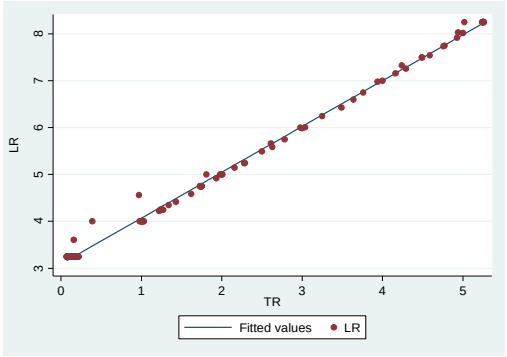


Figure A4.12: Scatter plot showing the relationship between lending rate and treasury bill rate for United States.

Appendix 5: Summary Statistics

Table A4.1: Summary statistics of the first difference *I(1)* interest rate for each country.

	Barbados	**Brazil**	**Jamaica**	**Mexico**	**Trinidad & Tobago**	**United States**
Obs=121						
			First Difference Treasury Bill Rate (D_TR)			
Mean	0.0161	-0.0973	-0.0868	-0.0219	-0.0496	-0.0135
Max	1.5800	8.9300	7.5100	1.3900	0.7600	0.2500
Min	-1.3800	-3.0600	-4.3000	-2.6100	-1.8500	-0.9600
Std.	0.3813	1.1913	1.5188	0.4751	0.2867	0.1762
Skewness	0.9714	3.5525	2.0145	-1.3902	-2.6009	-2.5396
Kurtosis	8.1064	29.1299	13.5400	10.5827	16.9685	13.0281
			First Difference Deposit Rate (D_DR)			
Mean	-0.003	-0.076	-0.045	-0.022	-0.041	-0.013
Max	0.980	2.464	2.613	0.360	2.210	0.250
Min	-0.990	-3.480	-1.600	-0.670	-1.680	-0.976
Std.	0.168	0.735	0.374	0.132	0.508	0.172
Skewness	0.257	-0.445	3.215	-1.562	0.441	-2.214
Kurtosis	23.406	6.745	29.309	9.061	6.495	11.327
			First Difference Lending Rate (D_LR)			
Mean	0.002	-0.151	-0.014	-0.025	-0.056	-0.012
Max	0.750	4.200	4.967	1.300	1.000	0.250
Min	-0.500	-3.400	-1.832	-2.850	-2.000	-0.980
Std.	0.152	1.253	0.638	0.546	0.310	0.170
Skewness	1.557	0.941	3.997	-1.352	-2.312	-2.231
Kurtosis	15.176	4.821	33.426	9.637	16.224	11.806

Appendix 6: DOLS Results

Table A6.1: *Results of DOLS accounting for structural breaks in policy rate*

		$\hat{\beta}_0$		$\hat{\beta}_1$		$H_0: \hat{\beta}_1 = 1$	
	Barbados						
Pre-crisis							
	Deposit	0.029163	(0.2018)	0.176844	(0.1603)	-6.659626	(0.0000)
	Lending	0.017059	(0.6270)	0.271078	(0.1648)	-3.805119	(0.0005)
Post-crisis							
	Deposit	-0.062105	(0.0501)	-0.157604	(0.7376)	-2.478475	(0.0176)
	Lending	-0.024497	(0.1850)	0.431331	(0.1262)	-2.060435	(0.0461)
	Brazil						
Pre-crisis							
	Deposit	-0.025383	(0.7984)	0.75656	(0.0014)	-1.103538	(0.2761)
	Lending	-0.001926	(0.9916)	1.663411	(0.0002)	1.629615	(0.1107)
Post-crisis							
	Deposit	-0.014027	(0.8021)	0.515258	(0.0142)	-2.418112	(0.0205)
	Lending	-0.044904	(0.7768)	-0.09929	(0.8620)	-1.937847	(0.0601)
	Jamaica						
Pre-crisis							
	Deposit	-0.004152	(0.8842)	0.047007	(0.2782)	-22.17117	(0.0000)
	Lending	-0.018793	(0.4195)	0.040101	(0.2564)	-27.41035	(0.0000)
Post-crisis							
	Deposit	-0.162997	(0.2160)	-0.138726	(0.4896)	-5.804955	(0.0000)
	Lending	-0.364976	(0.1438)	-0.841203	(0.0363)	-5.001843	(0.0001)
	Mexico						
Pre-crisis							
	Deposit	-	-	-	-	-	-
	Lending	-	-	-	-	-	-
Post-crisis							
	Deposit	-0.012802	(0.1017)	0.315234	(0.0000)	-13.37374	(0.0000)
	Lending	-0.001558	(0.9594)	1.17659	(0.0000)	0.873971	(0.3848)
	Trinidad & Tobago						
Pre-crisis							
	Deposit	0.003154	(0.9542)	1.569202	(0.0563)	0.705408	(0.4832)
	Lending	-0.033637	(0.3991)	1.545793	(0.0103)	0.933978	(0.3539)
Post-crisis							

	Deposit	0.01799	(0.5438)	0.631568	(0.0383)	-1.309912	(0.2077)
	Lending	-0.08489	(0.0594)	0.819837	(0.0601)	-0.442589	(0.6636)
	United States						
Pre-crisis							
	Deposit	-0.000372	(0.8755)	0.99776	(0.0000)	-0.110505	(0.9126)
	Lending	-0.000215	(0.9245)	0.998791	(0.0000)	-0.062392	(0.9506)
Post-crisis							
	Deposit	0.000191	(0.9867)	0.991743	(0.0000)	-0.107811	(0.9146)
	Lending	0.001277	(0.9049)	0.979141	(0.0000)	-0.292869	(0.7710)

Level of significance in parentheses ( )

Appendix 7: Results of the EGARCH-M (1,1) model

Table A7.1: *Results of the EGARCH-M (1,1) test for Barbados*

Deposit Rate			Lending Rate		
Coefficients	Estimates	Prob.	Coefficients	Estimates	Prob.
s	-0.934579	0.1099	s	-0.01892	0.9654
θ_1	0.031481	0.0198	θ_1	0.021961	0.0285
θ_2	-0.030725	0.0048	θ_2	0.002126	0.6280
θ_3	0.024217	0.1106	θ_3	0.006857	0.6689
θ_4	0.083539	0.0000	θ_4	0.012743	0.3656
p	0.029072	0.2299	p	0.015846	0.0317
φ_1	0.058171	0.0087	φ_1	-0.04283	0.0105
φ_2	0.03644	0.0918	φ_2	-0.01808	0.0188
φ_3	0.02551	0.1511	φ_3	0.045797	0.0027
φ_4	0.072449	0.0000	φ_4	-0.01534	0.0040
			Variance Equation		
ω	-6.688332	0.0000	ω	-5.69314	0.0000
α	1.512735	0.0000	α	-1.68262	0.0000
k	-0.290356	0.0299	k	-1.1161	0.0000
b	-0.203249	0.1155	b	-0.35772	0.0000
Durbin-Watson stat	2.143982		Durbin-Watson stat	1.929968	
Wald Stat	-40.0952	0.0000		-133.43	0.0000

Table A7.2: *Results of the EGARCH-M (1,1) test for Brazil*

Deposit Rate			Lending Rate		
Coefficients	Estimates	Prob.	Coefficients	Estimates	Prob.
	-			-	
s	0.031758	0.8802	s	0.124572	0.2597
θ_1	0.128773	0.0105	θ_1	0.040228	0.5626
	-				
θ_2	0.022139	0.6383	θ_2	-0.19196	0.0137
				-	
θ_3	-0.15501	0.0081	θ_3	0.295241	0.0055
	-				
θ_4	0.164014	0.0007	θ_4	0.012513	0.8571
p	0.113965	0.0219	p	0.312329	0.0015
φ_1	0.115626	0.0426	φ_1	0.143093	0.1986
				-	
φ_2	0.132353	0.0001	φ_2	0.008504	0.9288
φ_3	0.158834	0.0001	φ_3	0.397034	0.0000
φ_4	0.148814	0.0000	φ_4	0.280682	0.0235
			Variance Equation		
	-			-	
ω	1.532977	0.0000	ω	0.639951	0.0339
α	1.1036	0.0000	α	0.631409	0.0096
k	0.082364	0.6559	k	0.166864	0.1955
				-	
b	0.498369	0.0869	b	0.365122	0.1383
Durbin-Watson stat	2.178945		Durbin-Watson stat	1.294652	
	-				
Wald Stat	17.82556	0.0000		-6.98851	0.0000

Table A7.3: *Results of the EGARCH-M (1,1) test for Jamaica*

Deposit Rate			Lending Rate		
Coefficients	Estimates	Prob.	Coefficients	Estimates	Prob.
s	-1.07E-05	1.0000	s	-0.03286	0.9000
θ_1	0.07663	0.0001	θ_1	0.02399	0.7442
θ_2	-0.00871	0.7575	θ_2	-0.01911	0.7803
θ_3	0.005661	0.8339	θ_3	-0.00784	0.9043
θ_4	0.002761	0.9390	θ_4	-0.02526	0.6903
p	-0.08564	0.0019	p	-0.14066	0.0067
φ_1	0.033032	0.2477	φ_1	0.134061	0.0148
φ_2	0.020369	0.3871	φ_2	-0.01119	0.858
φ_3	0.042804	0.0736	φ_3	0.057062	0.3924
φ_4	0.000288	0.9910	φ_4	-0.02309	0.6948
			Variance Equation		
ω	-2.47785	0.0000	ω	-0.20026	0.5626
α	0.423213	0.0108	α	-0.13046	0.0931
k	0.945043	0.0000	k	0.06051	0.5108

b	-0.0547	0.8122	*b*	0.756043	0.0211
Durbin-Watson stat	2.156779		Durbin-Watson stat	2.48411	
Wald Stat	-39.2841	0.0000		-21.9763	0.0000

Table A7.4: *Results of the EGARCH-M(1,1) test for Mexico*

Deposit Rate			Lending Rate		
Coefficients	Estimates	Prob.	Coefficients	Estimates	Prob.
s	-3.119827	0.0300	*s*	0.05849	0.8719
θ_1	-0.045238	0.0000	θ_1	-0.04169	0.2013
θ_2	-0.003398	0.6357	θ_2	0.088837	0.0355
θ_3	0.031777	0.0000	θ_3	-0.06537	0.0282
θ_4	-0.000433	0.9595	θ_4	0.040758	0.1253
p	0.147861	0.0000	*p*	1.056743	0.0000
φ_1	0.084721	0.0000	φ_1	-0.07033	0.0169
φ_2	0.009503	0.1903	φ_2	0.015522	0.6310
φ_3	0.042646	0.0001	φ_3	0.041288	0.1521
φ_4	0.013744	0.1979	φ_4	-0.06083	0.0280
		Variance Equation			
ω	-6.163152	0.0000	ω	-2.05991	0.0003
α	1.55788	0.0000	α	1.150943	0.0000
k	0.248945	0.1859	*k*	0.48423	0.0008
b	0.123041	0.2169	*b*	0.696249	0.0000
Durbin-Watson stat	2.100295		Durbin-Watson stat	1.945199	
Wald Stat	-57.06241	0.0000		1.378355	0.1712

Table A7.5: *Results of the EGARCH-M (1,1) test for Trinidad & Tobago*

Deposit Rate			Lending Rate		
Coefficients	Estimates	Prob.	Coefficients	Estimates	Prob.
s	0.314048	0.0475	*s*	-0.094565	0.847
θ_1	0.104846	0.2233	θ_1	-0.036238	0.7481
θ_2	0.050136	0.7478	θ_2	0.283931	0.0161
θ_3	-0.000749	0.9953	θ_3	-0.151922	0.1276
θ_4	0.074214	0.2526	θ_4	0.114555	0.3647
p	0.147258	0.0582	*p*	0.043977	0.6272

φ_1	0.08266	0.4126	φ_1	0.227196	0.0538
φ_2	0.109308	0.2142	φ_2	0.078401	0.5395
φ_3	0.122671	0.3589	φ_3	0.261538	0.0027
φ_4	0.086531	0.2435	φ_4	0.08309	0.3122
			Variance Equation		
ω	-1.3604	0.0000	ω	-0.210333	0.1328
α	1.294899	0.0000	α	-0.294576	0.0033
k	-0.010005	0.9254	k	0.335025	0.0010
b	0.834281	0.0000	b	0.866283	0.0000
Durbin-Watson stat	2.201891		Durbin-Watson stat	1.891215	
Wald Stat	-10.96851	0.0000		-10.55779	0.0000

Table A7.6: *Results of the EGARCH-M (1,1) test for the United States*

Deposit Rate			Lending Rate		
Coefficients	Estimates	Prob.	Coefficients	Estimates	Prob.
s	-1.58388	0.1345	s	-1.17635	0.1957
θ_1	-0.02384	0.0862	θ_1	-0.0268	0.0554
θ_2	-0.01384	0.1239	θ_2	-0.00358	0.7493
θ_3	0.003558	0.8447	θ_3	0.016821	0.2371
θ_4	-0.01137	0.3841	θ_4	-0.0327	0.0028
p	0.954173	0.0000	p	1.003907	0.0000
φ_1	-0.00839	0.7727	φ_1	-0.04163	0.0093
φ_2	0.097469	0.0000	φ_2	0.128702	0.0000
φ_3	-0.01293	0.6067	φ_3	-0.03909	0.0482
φ_4	-0.03058	0.2070	φ_4	-0.03581	0.0158
			Variance Equation		
ω	-3.79722	0.0000	ω	-5.59049	0.0000
α	2.036645	0.0000	α	2.479234	0.0000
k	-0.35288	0.0641	k	-0.20708	0.2689
b	0.690764	0.0000	b	0.508995	0.0000
Durbin-Watson stat			Durbin-Watson stat	1.624745	
Wald Stat	-2.36402	0.020		0.239659	0.8111

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