The Effect of Monetary Policy on Private Money Market Rates in Jamaica: An Empirical Microstructure Study

Derek Leith[⊥]

Research Services Department
Research and Economic Programming Division
Bank of Jamaica

Abstract

This paper provides a first attempt at estimating the effects monetary policy has on interest rates in the private money market using market microstructure variables. It also examines the impact of policy announcements on these rates. The nature of the relationship between monetary policy and/or policy announcements on money market interest rates is investigated by examining the volatility of interest rates. Volatility is estimated by the GARCH model. The study uses daily data from the private money market, Bank of Jamaica Open Market Operations and announcements of interest rate changes, for the period June 9, 2005 to May 29, 2009. The results show that monetary policy has a mixed impact on the volatility of interest rates in the private money market. The overnight segment of the money market is least affected by monetary policy changes. In addition, there is volatility spill-over from the thirty-day money market to the inter-bank segment but not to the overnight segment of the private money market. This lack of spill over to the overnight market suggests that developments to that segment of the market may be limited.

Keywords: Monetary Policy; Market Microstructure; Volatility; Private Money Market.
JEL Classification: E52, G19, G12,

[⊥] Mr. Leith is a summer intern in the Research Services Department at the Bank of Jamaica. The views expressed are those of the author and do not necessarily reflect those of the Bank of Jamaica.

1.0 Introduction

Monetary policy has become the central tool of economic management in most countries around the globe (Mishkin, 1995). It is therefore important that the channels through which changes in monetary policy impact on the economy are well understood. The money market, which is the medium in which large institutions and governments manage their short-term cash needs, has emerged as an important means by which monetary operations are conducted by central banks. In these markets, banks borrow and lend reserves, central bank money. These loans are short term loans, especially overnight loans, and contribute to a better allocation of central bank money. The short term interest rate in the economy is formed in these markets and it influences the term structure of interest rates. It is common knowledge that most central banks operate mainly at the short end of the money market and transmit policy impulses to the longer end of the financial system through the term structure of interest rates. Due to the increased role of targeting short term interest rates in the transmission mechanism, empirical research establish that the most commonly pursued operating target in the conduct of monetary policy is the overnight rate (see Ghosh and Bhattacharyya, 2008). The reason being that information about the expectations of future movements in interest rates is extracted from the prevailing market rates.

Central Banks implement their monetary policy by affecting interest rates in the money market, primarily through the yield in its transactions with credit institutions. Their monetary policy objectives are realized by careful management of liquidity conditions which facilitate money market transactions. While, central banks operate at the short end, financial intermediaries operate over the entire length of the term structure. Therefore, to ensure orderly market behavior from a financial stability perspective, it is imperative for central banks to understand what goes on in the entire market, especially in periods of excess volatility.

The development of the money market (as well as credit, bond and foreign exchange markets) is important to the transmission mechanism of monetary policy and improvements in market microstructure. Due to the volatility of short-term rates, particularly those in emerging market economies, a detailed analysis of market microstructure is pertinent (Ghosh and Bhattacharyya, 2008). Market microstructure

exploits the structure provided by specific trading mechanisms to model how price-setting rules evolve in markets. This provides the ability to characterize how different trading protocols affect price formation, as well as to see why prices exhibit particular time-series properties. Market microstructure seeks to explain how latent supply and demand for financial assets are transformed into transactions, and how this process drives asset-price dynamics. Microstructure analysis investigates the institutional structure of financial markets, including information distribution patterns and the resulting incentives faced by market participants. This approach therefore can yield a deeper understanding of how markets operate and how they react to and impound economic news and shocks. Furthermore, market microstructure research is able to extract essential information contained in these markets in order to inform central banks on the thinking of market players.

This paper is similar in scope to Ghosh and Bhattacharyya (2008), who study the transmission effects of monetary policy to the Indian money market. However, it differs in that it focuses not only on the overnight money market rates, but the entire spectrum of interest rates. The most recent research pertaining to Jamaica is Jackson (2008) and McLeod (2008). In Jackson (2008), the pass-through relationship between market rates and bank retail rates across the Jamaican banking sector is examined, in order to ascertain the extent to which their price setting behavior influences the pass-through. The Bank of Jamaica (BOJ) rates form the base on which the interest rate structure of the economy is built and consequently, adjustments effected by the BOJ to its rates should have a powerful influence on private money market rates. McLeod (2008) examines the transmission of monetary policy to the private money market. The results reveal that there is no direct correlation and/or causation operating between the BOJ interest rates and the money market rates, implying that macroeconomic and microeconomic factors not examined, may have a stronger influence on these rates. McLeod (2008) recommends that other influences on private money market rates need to be empirically tested, for example, information such as banks or primary dealers whose behavior have a significant influence on money market rates on a particular day and other microeconomic factors which could possibly influence market rates.

The motivation for this paper is twofold: first, the study arises from the need to address the failings in McLeod (2008) by employing microstructure variables (volatility, and trade volumes).[1] Second, the actions taken by policy-makers to adjust interest rates have been affected by concerns relating to the effect on the exchange rate and interest rates in the money market. These concerns relate large interest rate movements to increased volatility in exchange rates and money market rates. We contribute to the literature by examining the effect of BOJ interest rates on the private money market interest rates by focusing on the entire spectrum of policy instruments. A unique feature of this study is that we examine the impact of Government's presence in the market, as well as any announcements to adjust policy rates.

The rest of the paper is organised as follows. Section 2.0 reviews the relevant literature. Section 3.0 develops the empirical model along with the estimation methodology. This is followed by the description of the data in section 4.0. Section 5.0 provides the empirical analysis, while section 6.0 contains concluding remarks and policy implications.

2.0 Literature Review

Theoretical research into the pricing of instruments traded on the short-term money markets has been rather sparse and incomplete; however, there is considerable literature on the pricing of securities in the equity, bond and foreign exchange markets (Ho and Saunders, 1995). The reason for this paucity of research, according to Ho and Saunders (1995), is the difficulty involved in modeling a market which is so intimately linked to banks' (and other depository institutions') reserve management decisions and therefore to monetary policy uncertainty. Additionally, it is the centrality of this market to the transmission of monetary policy which makes modeling important, especially if the consequences of alternative strategies for conducting monetary policy are to be rigorously compared.

Some theoretical work on the microstructure of money markets by Bhattacharya and Gale (1987) and Bhattacharya and Fulghieri (1994) explain the existence of private

[1] Data availability precludes an analysis using bid-ask spreads.

interbank markets for short-term funds with the need by banks to re-insure against idiosyncratic liquidity shocks coming from their retail depositors. More recent theoretical work addresses the issue of whether this type of liquidity insurance causes systemic risk in the banking system (see De Bandt and Hartmann, 2000, for a survey). Freixas and Holthausen (2001) study the functioning of the international money markets, when information about foreign banks is asymmetric. This theoretical money market literature in general does not tackle the role of monetary policy, central bank operations, and regulations in the money market. There, however, is research that relates the responses of the overnight interbank market rates by a representative bank to monetary policy operational procedures and money market accounting conventions (see Ho and Saunders, 1985; Campbell, 1987; Spindt and Hoffmeister, 1988). Bartolini et al., (1998) introduce a role for central bank liquidity provision and study the interaction of profit-maximizing banks with a central bank targeting interest rates at high frequency.

Research on the empirical aspects of the microstructure of money markets, despite being limited, focuses on modeling volatility. In his seminal paper Hamilton (1996) shows that the level and the volatility of the Federal funds rate exhibit empirical regularities that may be associated with the monetary policy framework. Further, with respect to the US fed funds market, Cassola and Morana (2006a, 2006b) estimate the underlying factors accounting for the volatility of the euro overnight interest rate and its transmission along the euro area money market yield curve. The estimates show repetitive intra-day, daily and monthly patterns that can be explained by the microstructure of the money market. Furfine (1999) exploit the use of transaction-level data, which allow for a closer look at the microstructure of the US fed funds market. This is done by exploring the relationship between bank size and participation, concentration, intra-day timing and analyses of bank relationship patterns.

Investigations into how well the markets are able to anticipate monetary policy actions of the Fed (Poole and Rasche, 2000), indicate that improved federal reserve transparency and improved market understanding of policy have increased the accuracy of market forecasts of Fed policy decisions. According to Bernhbarden and Kloster (2002), transparency and predictability can contribute to strengthening monetary policy credibility and enhance its effectiveness. They provide cross-country comparison of some

OECD countries and find that market participants in advanced economies are better able to anticipate monetary policy decisions, given the increased public availability of information about how monetary policy decisions are taken.

A well functioning money market is essential for conducting indirect, market-based monetary policy operations and for providing the necessary liquidity for a market in government and corporate bonds. Studies on the microstructure of the money market in the euro area, for example, show that it is heavily influenced by the institutional environment of the European Central Bank (ECB) and its monetary policy operations (Hartmann et al., 2001). Research on the Euro-area money market typically finds that the overnight market rate volatility and spreads are relatively high on days with ECB monetary policy announcements, particularly during mid-day when the ECB's interest rate decisions are released. Related work done by Prati et al. (2003), and Bartolini et al. (2002), link the behavior of very short-term interest rates to the operating procedures of central banks, suggesting that short-term interest rates are more strongly influenced by institutional arrangements rather than by extensively researched market frictions. Bartolini and Prati (2003) show that the volatility of short-term interest rates reflects differences in central banks commitment to interest rate smoothing. Ayuso et al. (1997) observe that countries with lower (higher) reserve requirements tend to have higher (lower) interbank interest rate volatility and this effect shows up at all points on the money market yield curve- not just the short end. Thus, there are some institutional details influencing money market rates and their volatility.

Ghosh and Bhattacharyya (2008) estimate conditional volatility in the Indian money market. Using the GARCH model (Bollerslev, 1986), they find that the spread in the money market is positively related to conditional volatility. The empirical results suggest that expansionary monetary policy reduces volatility of spreads and weighted call rate. In addition, announcements of Cash Reserve Ratio (CRR) changes have a negative impact on the volatility of spreads and call rate, while other policy variables like bank rate, repo and reverse repo rates have mixed impact on the volatility of call rate and spreads.

To determine whether very short-term volatility is transmitted to the rest of the yield curve, Durré and Nardelli (2006) and Blanco and Alonso (2005) uses different

approaches to model volatility. In particular, Durré and Nardelli (2006) construct daily volatility series using a sample of intraday observations. The volatility transmission is studied using a vector autoregression across different countries. Blanco and Alsonso (2005) base their rationale on a conditional volatility model. The conditional volatility of the overnight rate is first estimated, and then used as an explanatory variable in the representations of the conditional volatility of longer-term interest rates. The findings of these two articles suggest that volatility is not transmitted from very short-term to long-term interest rates. More importantly, the volatility of the overnight rate does not appear to influence that of interest rates beyond three months.

Stability in financial and exchange rate markets is a vital objective for Central Banks, particularly the Bank of Jamaica, as large movements in short-term interest rates historically has significant implications for the stability of these markets. Large movements in interest rates tend to cause volatility in exchange rate markets as well as money markets asset prices, which increases the risks of holding domestic-currency-denominated assets. Additionally, they also affect liquidity available to financial institutions and private agents. In instances where short-term debt finances long-term investment, a credit crunch may evolve. As a result, policy-makers are always keen in ascertaining as much information as possible regarding the impact of policy actions on financial markets, before adjusting interest rates. This is primarily due to uncertainty surrounding the effects of these decisions. Indeed, it is typical for policy makers to delay taking action until ample information is acquired about the possible effects of a shock to financial markets or that the actions taken are those with outcomes they are confident about.

3.0 Methodology

To estimate volatility in the private money market, we use the Generalised Autoregressive Conditional Heteroskedasticity (GARCH) model (Bollerslev, 1986). This model is chosen based on its ability to capture volatility patterns of high frequency financial time series. The main assumption behind this class of models that makes it suitable for this study is the relative homogeneity of the price discovery process among

market participants at the origin of the volatility process. In other words, the conditional density of the GARCH process is assumed to adequately capture all the information and news in the market. For this GARCH model, an autoregressive (AR) moving average (MA) - ARMA model, must be assumed for the error variance. The GARCH (1, 1) model involves a mean equation and the conditional variance equation with first lag of squared residuals and the conditional variance. It is also a weighted average of past squared residuals with declining weights which never assumes a zero value. The GARCH (1, 1) model is considered most parsimonious of alternate variations of the GARCH (*p*, *q*) model and will be employed in this framework. The GARCH (1, 1) model is specified as the following:

$$Y_t = \phi_0 + \phi_1 Y_{t-1} + \varepsilon_t \qquad (1)$$

$$\varepsilon_t / \psi_{t-1} \sim N(0, h_t) \qquad (2)$$

$$h_t = \alpha + \beta_i \varepsilon^2{}_{t-1} + \beta_j h_{t-1} \qquad (3)$$

In the above model, the dependent variable is the private money market rate while the BOJ OMO rates and the corresponding trading volumes will be modeled as the independent variables. The GARCH (1, 1) model (equation 3) is augmented to include these BOJ instruments and the corresponding trading volumes. This is depicted in equation (4). φ'_κ Captures the changes in volatility while β'_j reflects the persistence in volatility.

$$h'_t = \alpha' + \beta'_i \varepsilon'^2{}_{t-1} + \beta'_j h'_{t-1} + \varphi'_k V_{tk} \qquad (4)$$

To capture the impact of policy announcements on the volatility of money market interest rates, the GARCH volatility equation (3) is augmented with dummy variables. The augmented GARCH (1, 1) model is specified as follows:

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \varepsilon_t \qquad (5)$$

$$\varepsilon_t / \psi_{t-1} \sim N(0, h_t) \qquad (6)$$

$$h^*_t = \alpha^* + \beta^*_i \varepsilon^2_{t-1} + \beta^*_j h^*_{t-1} + \tau^*_f D_f \qquad (7)$$

where D_f is a dummy variable which takes the value 1 on the date of announcement of monetary policy changes but 0 otherwise. Dummy variables are created to explain the changes in the announcements of various policy instruments, including: the CRR, OMO rate. We also examine the impact of announcements of GOJ issues, both fixed and variable rate instruments. For this exercise, we will pay close attention to the changes in volatility patterns of the money market rates as it relates to changes in policy announcements. This is done in order to assess the impact policy announcements may have on the underlying volatility of the interest rates in the private money market.

A priori we expect that volatility persistence should be higher in the thirty-day segment of the money market because of the BOJ's perceived targeting of interest rates at the longer end of the term structure, particularly the 180-day interest rate. Consequently, it would be interesting to see if this is so, and if it is, whether there are volatility spill-over to the other segments of the money market. This spill-over analysis is important to ascertain whether or not monetary policy is transmitted to other segments of the market, particularly the 30-day segment of the market. To estimate the volatility spill-over we augment the conditional variance from the segment of the market that has the lesser (or no) impact from monetary policy with the conditional variance from the segment of the market that has the greatest monetary policy impact.[2]

4.0 Data

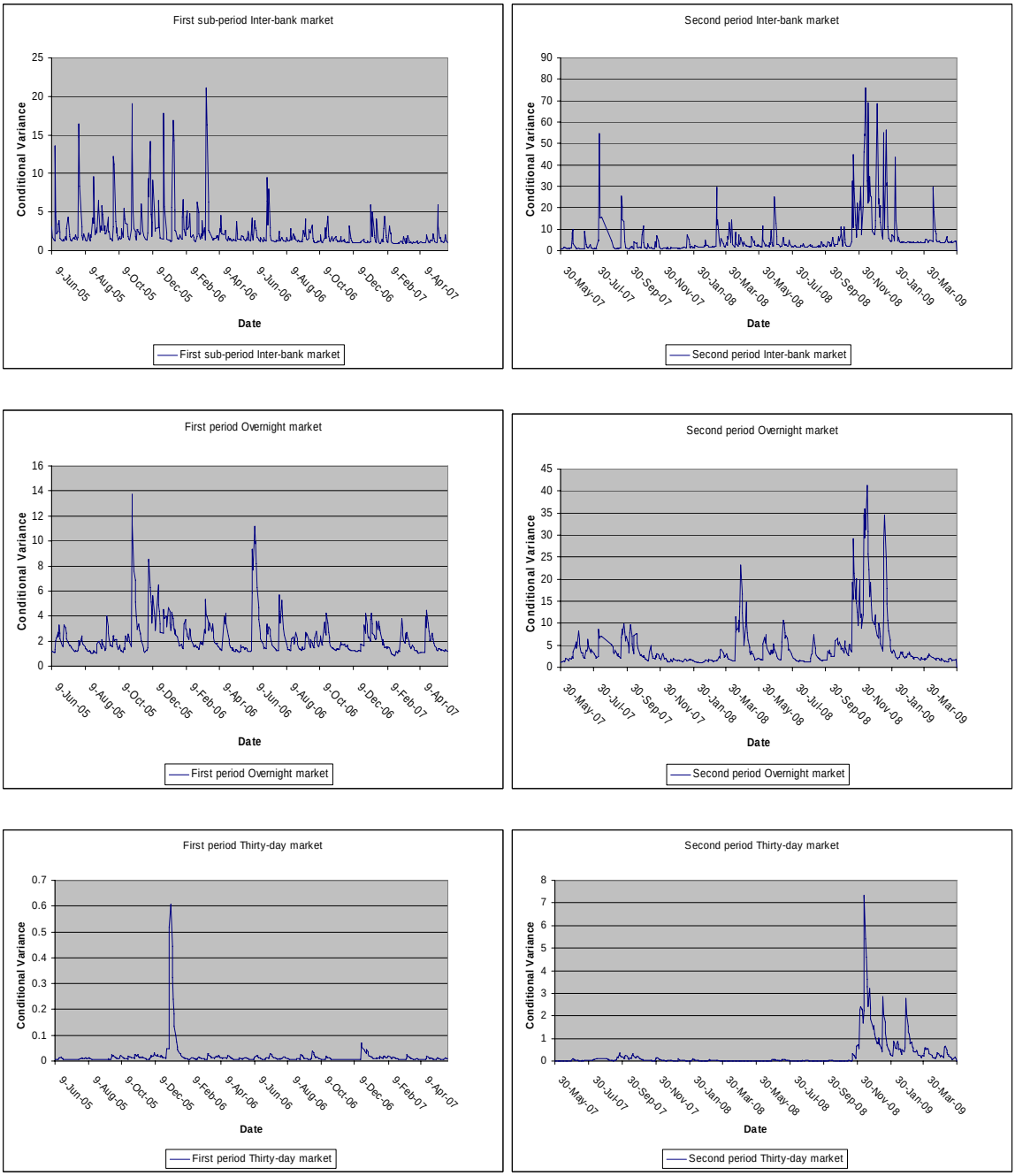
This paper utilises daily data from the largest primary dealers in the private money market, which includes the overnight, thirty-day and inter-bank interest rates.[3] The data cover the period June 9, 2005 to May 29, 2009 containing 972 observations. However, for comparative purposes, we divide the data into two sub-periods: sub-period one is from June 9, 2005 to May 29, 2007, while the second period is from May 30, 2007 to May 29, 2009. This is done in an attempt to capture the evolution of volatility in money market interest rates, which clearly shows the highly volatile nature of interest

[2] Little or no effect from monetary policy is signaled by an insignificant or smaller (compared to other segments) β_j.

[3] See McLeod (2008) for a detailed discussion on the private money market in Jamaica.

rates in the second sub-period as compared to the first sub-period. Figure 1 show how volatility evolves in the private money market.

Figure 1. Volatility of money market interest rates for two sub-periods



The first period of the data (6/9/05-05/29/07) show GARCH (1,1) effects of -0.0499, 0.6239 and 0.4195 for the inter-bank, overnight and thirty-day private money

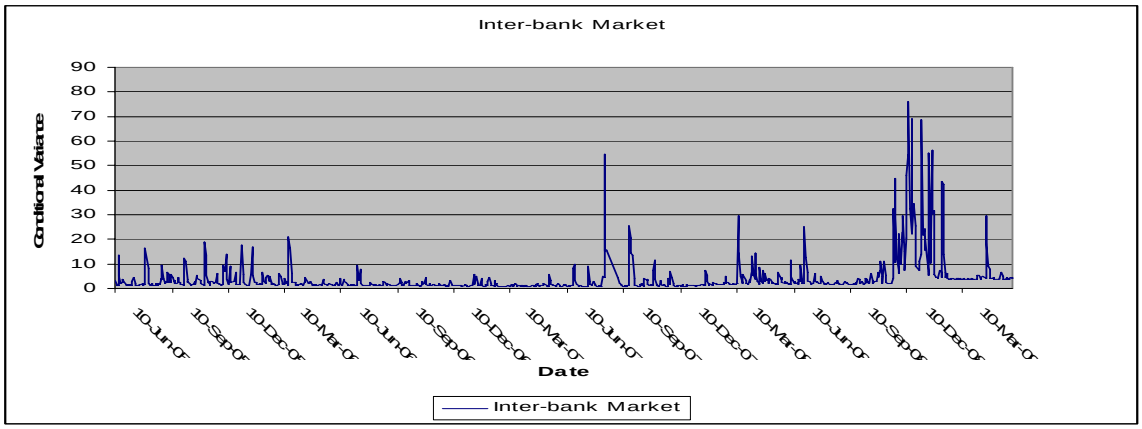
market interest rates respectively. These figures increased considerably during the second period, with the β_j coefficients reaching 0.6306 in the inter-bank market, 0.7331 in the overnight market and 0.7849 in the thirty-day market (table 1).

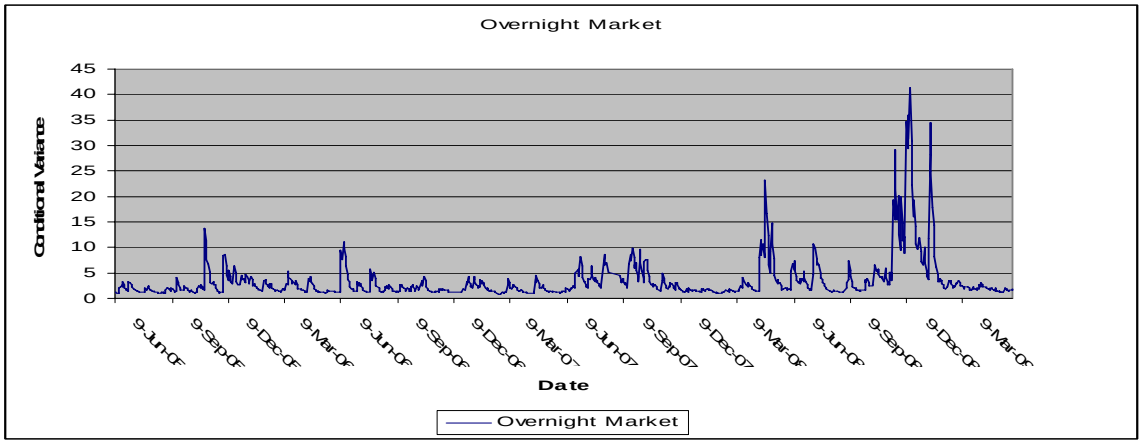
Table: 1. Results of the GARCH (1, 1) model for Sub-periods.

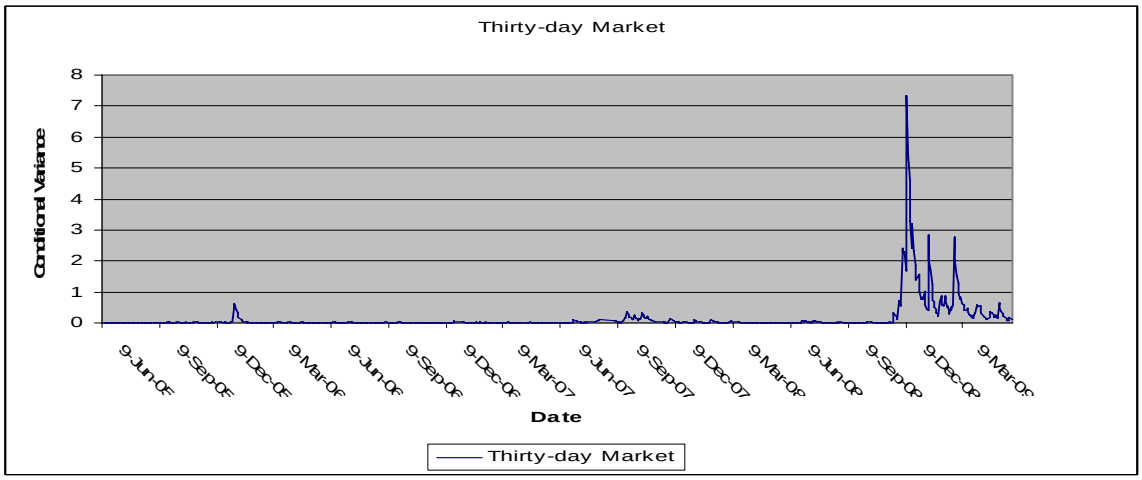
SEGMENT	GARCH(1,1)	Z-STATISTIC
1st Sub-period		
Inter-bank	-0.087453	-1.558753
Overnight	0.616536	7.677644
Thirty-day	0.413240	4.305290
2nd Sub-period		
Inter-bank	0.436339	15.34677
Overnight	0.739132	19.53160
Thirty-day	0.796794	55.91428

These results coincide with the second period being characterized by increased volatility estimates pertaining to the financial crises emanating from the U.S. and the underlying uncertainties existing in the domestic economy. The conditional variance from the GARCH equation is graphed for each segment of the private money market for the entire period highlighting the trend in the GARCH volatility estimates, see figure 2.

Figure 2. Volatility in the Private Money Market







The above graphs provide us with information regarding the differences in the volatility patterns between the different segments of the private money market. Volatility persistence is highest in the thirty-day segment and the latter part of the graphs illustrates how volatility patterns have increased over the years. The graphs also indicate volatility clustering. We therefore examined the interest rates in each segment of the market with focus on the Kurtosis and Skewness, we also test for GARCH effects (heteroskedasticity). This was done to determine if the data follow a normal distribution and to verify that the variance is time-varying. The results (table 2) show that the data is indeed non-normal.

Table 2: Summary Statistics of Interest rates

	INTERBANK	OVERNIGHT	THIRTYDAY
Mean	0.101076	0.063165	0.027437
Std. Dev.	0.995854	0.998142	0.999910
Skewness	1.152375	1.212064	0.868000
Kurtosis	9.609095	6.468418	12.70532

Liquidity management in the banking system is essential for the smooth operation of payments and in particular the real time gross settlement (RTGS) system. The BOJ normally aims to satisfy the liquidity needs of the banking system via its open market operations (OMOs). To determine the impact of monetary policy instruments on the money market rates, we consider the full spectrum of the Bank of Jamaica (BOJ) Open Market Operations (OMO) interest rates. The 270-day and the 540-day OMO rates were excluded from this study due to insufficient data spanning that sample period. The maintenance of optimal liquidity levels is crucial for central banks. Changes in the volume of money market instruments affect liquidity and interest rates. Central Bank deposits as well as purchase of reverse repurchases will affect the level of money and credit in the banking system in the short-term. Therefore, by looking at the volumes of certificate of deposit (fixed and variable), the central bank deposits, and the total volumes traded, we can identify the impact these volumes have on the volatility of interest rates in the money market. The Central Bank can take actions to influence the monetary base either through adjusting interest rates it offers on securities or through adjusting the volumes of OMOs that it trades.

Other institutional factors may be determinants in deriving interest rates in the money market, for example, changes in policy announcements (announcements of rate changes). Thus, the announcement dates of Cash Reserve Ratio (CRR), OMO rate changes, and Government of Jamaica (GOJ) bond issue (fixed and variable) is used, in the form of dummy variables, to identify any impact these announcements may have on the volatility of interest rates in the money market.

5.0 Empirical Analysis

5.1 Inter-bank market

We first look at the daily volatility estimated by the GARCH (1, 1) model for the interbank money market, for which the results are summarized in table 3. The β_j coefficient in equation (3), which indicates the persistency in the volatility estimate, is reported in panel A. Generally, a high coefficient ($0.7 < \beta < 0.9$) indicates that volatility is very persistent. The reported β_j's in table 3 (between 0.25 and 0.48) suggests fairly low persistency in volatility of interest rates in the inter-bank market. The effect of OMOs on volatility is presented in panel B and is represented by the φ_k'. For the inter-bank money market rate, the certificate of deposits (CD) fixed volumes and the total volumes reduce volatility, while the BOJ OMO rates and Central Bank (CB) deposits increase volatility. The variable rate CD, however, is insignificant suggesting that it does not have an impact on money market rates. Volatility persistence has increased with the introduction of the fixed rate CD's, but has, however, decreased with the CB deposits, volume total and the BOJ OMO's. Regarding changes in policy announcements, panel C, the BOJ OMO rate change provided the only increase in volatility persistence in the inter-bank rate, and has also increased its volatility. The presence of the GOJ in the money market (variable rate instrument and issue date) increases the volatility of interest rates in the interbank market. The announcement of fixed rate GOJ instruments and the CRR are insignificant implying that these announcements have no impact on rates in the inter-bank segment of the private money market. The 120 and 180-day BOJ OMO rates provided the strongest positive influence on the persistence of volatility of interest rates in the inter-bank money market.

Table 3. Results of the GARCH (1, 1) model for the Interbank Market

Panel A. **INTER-BANK MARKET RESULTS***				
$h_t = \alpha + \beta_i \varepsilon^2{}_{t-1} + \beta_j h_{t-1}$				
VARIABLES	β_j	**Z-STATISTIC**	α	**Z-STATISTIC**
GARCH(-1)	0.469337	20.48100	-	-
Panel B. **INTEREST RATES AND TRADING VOLUMES**				
$h'_t = \alpha' + \beta'_i \varepsilon'^2{}_{t-1} + \beta'_j h'_{t-1} + \varphi'_k V_{tk}$				
VARIABLES	β'_j	**Z-STATISTIC**	φ'_k	**Z-STATISTIC**
CB DEPOSIT	0.453782	16.92539	0.626897	11.23339
CD's FIXED	0.475675	19.48203	-0.573098	-3.197622
CD's VARIABLE	0.473552	19.75174	0.008601	1.501423
VOLUME TOTAL	0.468803	19.66968	-1.222439	-2.739688
30-DAY OMO	0.267115	6.521450	0.322545	7.323441
60-DAY OMO	0.263323	6.404607	0.308031	7.395695
90-DAY OMO	0.258241	6.173528	0.245725	7.042205
120-DAY OMO	0.253586	6.048446	0.249131	7.160933
180-DAY OMO	0.253677	6.025463	0.224609	7.007851
365-DAY OMO	0.345574	9.525426	0.085599	5.381923
Panel C. **ANNOUNCEMENTS**				
$h^*{}_t = \alpha^*{}_0 + \beta_1^* \varepsilon^2{}_{t-1} + \beta_2^* h_{t-1} + \tau_f^* * D_f$				
VARIABLES	β_2^*	**Z-STATISTIC**	τ_f^*	**Z-STATISTIC**
CRR	0.466995	20.44024	22.964930	0.884168
OMORATECHANGE	0.473773	21.33422	1.156223	1.928778
GOJ ISSUE DATE	0.453618	21.06737	0.879059	4.825167
GOJ FIXED	0.468788	20.69654	0.149765	0.930656
GOJ VARIABLE	0.453448	20.29702	1.587261	4.509637

5.2 Overnight market

In terms of the overnight money market, announcements of the GOJ (issue date and variable instrument) increases volatility, while the CRR announcement reduces volatility in the overnight segment of the money market (see table 4). With respect to the

other variables, central bank deposits increase volatility while the BOJ OMO, the CD's (fixed and variable) and the volume total were all insignificant, having no impact on the volatility of interest rates in the overnight money market.

Table 4. Results of the GARCH (1, 1) model for the Overnight Market

Panel A **OVERNIGHT MARKET RESULTS**				
$h_t = \alpha + \beta_i \varepsilon^2{}_{t-1} + \beta_j h_{t-1}$				
VARIABLES	β_j	**Z-STATISTIC**	α	**Z-STATISTIC**
GARCH(-1)	0.718645	22.70867	-	-
Panel B **INTEREST RATES AND TRADING VOLUMES**				
$h'_t = \alpha' + \beta'_i \varepsilon'^2{}_{t-1} + \beta'_j h'_{t-1} + \varphi'_k V_{tk}$				
VARIABLES	β'_j	**Z-STATISTICS**	φ'_k	**Z-STATISTICS**
CB DEPOSIT	0.703187	22.34139	0.110158	2.564578
CD's FIXED	0.723920	23.19274	0.074225	0.614241
CD's VARIABLE	0.722749	23.27153	-0.004330	-1.212389
VOLUME TOTAL	0.742080	24.66265	0.514864	1.418125
30-DAY OMO	0.719116	22.69086	-0.001456	-0.091185
60-DAY OMO	0.719336	22.72990	-0.001966	-0.134080
90-DAY OMO	0.723160	23.22015	-0.006669	-0.645409
120-DAY OMO	0.723103	23.20855	-0.006476	-0.636168
180-DAY OMO	0.724333	23.35162	-0.006744	-0.765528
365-DAY OMO	0.723924	23.25999	-0.005093	-0.672425
Panel C **ANNOUNCEMENTS**				
$h^*{}_t = \alpha^*{}_0 + \beta_1^* \varepsilon^2{}_{t-1} + \beta_2^* h_{t-1} + \tau_f^* * D_f$				
VARIABLES	β_2^*	**Z-STATISTIC**	τ_f^*	**Z-STATISTIC**
CRR	0.708222	21.85564	-2.306054	-1.976966
OMORATECHANGE	0.707662	22.26402	0.440298	1.182484
GOJ ISSUE DATE	0.677863	28.01597	1.604609	8.405772
GOJ FIXED	0.725024	23.72832	0.273872	1.216803
GOJ VARIABLE	0.659542	24.36532	2.270107	7.053837

This result is consistent with McLeod (2008) which finds that the variation in the overnight money market rates was not explained by BOJ interest rate adjustments. Our results therefore support the argument for identifying determinants of interest rates in the overnight market. This is essential for the development of this segment of the money market. The only variable that is significant and increases volatility of interest rates in the overnight market is the CB deposits.

5.3 Thirty-day market

With respect to the thirty-day segment of the private money market, Central bank deposits provided a positive impetus to volatility and volatility persistence (table 5). This result may be attributed to the reduction market liquidity when deposits increase. The fixed rate CD's and total volumes reduce volatility and volatility persistence while the other variables increase volatility. The 180-day BOJ OMO rate has the strongest influence on 30-day private money market rates.[4] This result is not surprising, since the 180-day OMO rate is generally the Central Bank's signal rate. Announcements of CRR and OMO rate changes increases volatility of interest rates, panel C - Table 5. The GOJ variable rate instrument is insignificant while the GOJ fixed rate instrument decreases volatility. The main channel through which the central bank manages liquidity is through the domestic money market, where short-term debt instruments are used to smooth the level of money and credit in the system (indirect monetary tools). If there is no excess supply or demand for liquidity and there are no shocks to the market, then volatility patterns should be well behaved (no excess volatility).

We conduct a volatility spill-over analysis to examine if volatility in the 30-day market is transmitted to the over-night segment of the market. This is relevant to identifying the transmission of monetary policy to different segments of the money market. A direct impact of BOJ OMO instruments in the over-night market is not readily apparent, based on the insignificant coefficients in table 4. To assess volatility spill-over to the over-night segment of the market we augment the GARCH equation of the over-night market with the conditional variances from the 30-day segment of the market.

[4] This result is similar to results in McLeod (2008).

Table 5. Results of the GARCH (1, 1) model for the Thirty-day Market

Panel A THIRTY-DAY MARKET RESULTS				
$h_t = \alpha + \beta_i \varepsilon^2{}_{t-1} + \beta_j h_{t-1}$				
VARIABLES	β_j	**Z-STATISTIC**	α	**Z-STATISTIC**
GARCH(-1)	0.727606	55.37328	-	-
Panel B INTEREST RATES AND TRADING VOLUMES				
$h'_t = \alpha' + \beta'_i \varepsilon'^2{}_{t-1} + \beta'_j h'_{t-1} + \varphi'_k V_{tk}$				
VARIABLES	β'_j	**Z-STATISTIC**	φ'_k	**Z-STATISTIC**
CB DEPOSIT	0.769882	78.18637	0.001355	7.060114
CD's FIXED	0.645554	33.69414	-0.009360	-9.714167
CD's VARIABLE	0.659849	35.92715	0.000179	8.309175
VOLUME TOTAL	0.634339	32.25000	-0.034470	-10.58396
30-DAY OMO	0.680730	40.11538	0.000609	6.602475
60-DAY OMO	0.679381	39.82374	0.000569	6.516280
90-DAY OMO	0.668812	37.95322	0.000631	7.161882
120-DAY OMO	0.669352	38.03478	0.000602	7.009430
180-DAY OMO	0.665426	37.41803	0.000616	7.203744
365-DAY OMO	0.668935	39.09352	0.000540	6.564674
Panel C ANNOUNCEMENTS				
$h^*{}_t = \alpha^*{}_0 + \beta_1^* \varepsilon^2{}_{t-1} + \beta_2^* h_{t-1} + \tau_f^* * D_f$				
VARIABLES	$\beta_2{}^*$	**Z-STATISTIC**	τ_f^*	**Z-STATISTIC**
CRR	0.754607	59.84726	2.764281	2.344301
OMORATECHANGE	0.634248	42.29329	0.042878	5.374546
GOJ ISSUE DATE	0.721386	50.06371	-0.002112	-4.025721
GOJ FIXED	0.718253	52.41806	-0.004335	-9.109065
GOJ VARIABLE	0.729228	53.38922	0.000379	0.561494

The results indicate that there is no volatility spill-over from the 30-day segment of the market to the overnight segment of the money market. However, there is a spill-over to the inter-bank market. The implication of the result of no volatility spill-over is that monetary policy action that affects volatility in the 30-day money market has no effect on volatility in the overnight money market.

Table 6 provides a summary of the results of the GARCH (1, 1) model augmented to include policy announcements and variables that increase the volatility of interest rates. The volatility in the private money market has varying levels of persistence across the different segments, inter-bank, overnight, and the thirty-day rate. The results reveal that persistence in volatility of the inter-bank rate is less than the overnight and thirty-day money market rates. This result is consistent with prior expectations, since the rates offered in the inter-bank market is the rate that is used in trading between banks, thus limiting the scope of competition for profit making. The GARCH effects for the inter-bank rate is 0.4693 compared to that for the overnight and the thirty-day money market rates which are 0.7186 and 0.7276 respectively.

Table 6. Summary of Variables and Announcements – Increase Volatility

VARIABLES INCREASING VOLATILITY		
MKT SEGMENT	**ANNOUNCEMENTS**	**VARIABLES**
Inter-bank	OMO Rate change GOJ Issue date GOJ Variable	CB Deposits BOJ OMO's (full spectrum)
Overnight	GOJ Issue date GOJ Variable	CB Deposits
Thirty-day	CRR OMO Rate change	CB Deposits CD'S Variable BOJ OMO's (full spectrum)

The salient implications arising from the results is that volatility in the money market is affected directly by monetary policy tools, news announcements of interest rate changes and the presence of the GOJ in the market. The thirty-day market is more directly affected by monetary policy tools, while the overnight market is more directly affected by the GOJ's presence in the market. While it is evidently clear about the effect of BOJ OMOs on the 30-day market, the lack of effect of GOJs presence in the 30-day market requires some explanation. The underlying rationale here is that since there is a penalty attached to breaking an investment prior to maturity, the issuance of GOJ instruments would see investors readily using liquid funds available from the overnight

market rather than from the thirty-day market to invest in those instruments. Hence the volatility in interest rates in the overnight market increases whenever GOJ is present in the market.

6.0 Conclusion and policy implications

This paper provides the first attempt to explore the transmission of monetary policy to the private money market using microstructure analysis. The study utilises the GARCH model as well as microstructure variables in determining the relationship between BOJ policy instruments and the rates offered in the private money market.

The results show that generally volatility is highest in the thirty-day segment of the private money market and lowest in the inter-bank segment. The BOJ open market operations have no impact on the overnight money market rates. However, OMOs increase volatility in the inter-bank and thirty-day segments of the money market. There appears to be volatility spill-overs from the thirty-day market to the inter-bank but none to the overnight market. Interestingly, this spill-over is positive for the inter-bank. In other words, an increase in the volatility in the thirty-day market (possibly from monetary policy action) causes an increase in the volatility of interest rates in the inter-bank money market.

Monetary policy and GOJ issue announcements are also found to impact the rates offered in the money market. In particular, the OMO rate change, GOJ issue date, GOJ variable instrument and the CRR, all had mixed impacts on the volatility of interest rates in the respective money market segments. This result highlights the need for a more comprehensive understanding concerning the relationship between policy announcements and money market microstructure, with the aim of improving the efficiency and effectiveness of monetary policy initiatives.

The issue of the volatility spill-over along the money market yield curve shows that there is no empirical evidence supporting the hypothesis that volatility of the thirty-day interest rate is transmitted to the volatility of the overnight interest rates. This suggests that monetary policy geared at liquidity management via liquidity shocks to the market is not transmitted to the overnight segment of the money market. One primary

implication here is that a lack of volatility spillover insulates the yield curve from developments in the overnight money market.

In general, the functioning of the money market and its interaction with monetary policy receives little attention. The relationship between the policy rates determined by the BOJ and money market interest rates is typically close, stable and predictable. This is testimony to the design of the tools and procedures used to implement monetary policy decisions, and to the effectiveness of the liquidity policy conducted by the BOJ. However, with the stability of the relationship in normal times means that the functioning of the money market and its interaction with monetary policy are awarded little prominence in the analysis and discussion of monetary policy. The money market plays a unique role in signaling the stance of the monetary policy and in transmitting monetary policy decisions to financial markets. The transmission mechanism occurs more generally to private spending and saving decisions, and ultimately to the determination of the price level.

References

Ayuso, J., Haldane, A.G. and Restoy, F., 1997. Volatility Transmission along the Money Market Yield Curve, Review of World Economics 133, 56-75.

Bartolini, L., Bertola, G. and Prati, A., 1998. Day-to-day Monetary Policy and the Volatility of the Federal Funds Interest Rate, EUI Working Paper ECO 98/35, European University Institute.

Bartolini, L., and Prati, A., 2003b. Cross-Country Differences in Monetary Policy Execution and Money Market Rates Volatility, Federal Reserve Bank of New York Staff Report No. 175, October.

Bartolini, L., Bertola, G., and Prati, A., 2002. Day-To-Day Monetary Policy and the Volatility of the Federal Funds Interest Rate, Journal of Money, Credit and Banking 34 (1), 137-159.

Bernhardsen, T. and Kloster, A., 2002. Transparency and Predictability in Monetary Policy, Economic Bulletin q2, Norges Bank.

Bhattacharyya, I., Roy, M., Josh, H., and Patra, M.D., 2009. Money Market Microstructure and Monetary Policy: The Indian Experience, Macroeconomics and Finance in Emerging Market Economies 2 (1), 59-77.

Bhattacharya, S. and Fulghieri, P., 1994. Uncertain Liquidity and Interbank Contracting, Economics Letters 44, 287-294.

Bhattacharya, S. and Gale, D., 1987. Preference Shocks, Liquidity, and Central Bank Policy. In W.A. Barnett and K.J. Singleton eds. New Approaches to Monetary Economics, Cambridge, U.K.: Cambridge University Press, 69-88.

Blanco, R. and Alonso, F., 2005. Is the Volatility of the Eonia Transmitted to Longer Term Euro Money Market Interest Rates? Banque d'Espange, Working Paper No. 0541.

Campbell, J.Y., 1987. Money Announcements, the Demand for Bank Reserves, and the Behavior of the Federal Funds Rate within the Statement Week, Journal of Money, Credit, and Banking 19, 56-67.

Cassola, N., and Morana, C., 2006a. Volatility of Interest Rates in the Euro Area: Evidence from High Frequency Data, The European Journal of Finance.

Cassola, N., and Morana, C., 2006b. Comovements in Volatility in the Euro Money Market, ECB Working Paper No. 703.

De Bandt, O., and Hartmann, P., 2000. Systemic Risk: A Survey, ECB Working Paper 35.

Durré, A., and Nardelli, S., (2006), Volatility in the Euro Market: Effects from the Monetary Policy Operational Framework, International Journal of Finance and Economics 13, 307-322.

Ehrmann, M., and Fratzscher, M., 2004. Taking Stock: Monetary Policy Transmission to Equity Markets, Journal of Money, Credit and Banking, 36(4), 719-737.

Freixas, X., and Holthausen, C., 2001. Interbank Market Integration Under Asymmetric Information, Mimeo, Frankfurt.

Furfine, C.H., 1999. The microstructure of the Federal Funds Market, Financial Markets, Institutions and Instruments 8(5), 24-44.

Gaa, C., and Thurlow, P., 2001. 2001 Conference: Financial Market Structure and Dynamics, Bank of Canada, November 2001.

Ghosh, S., and Bhattacharyya, I., 2009. Spread, Volatility and Monetary Policy: Empirical Evidences from the Indian Overnight Money Market,

Gurrola, P., and Herrerias, R., 2009. Monetary Policy Announcements and Interest Rates Volatility: Evidence from the Mexican TIIE Futures Market, Working Paper Series, February 9.

Hamilton, J. D., 1996. The Daily Market for Federal Funds Market, Journal of Political Economy, 104(1), 26-56.

Hartmann, P., Manna, M., and Manzanares, A., 2001. The Microstructure of the Euro Money Market, Journal of International Money and Finance, 20, 895-48.

Ho, T.S.Y., and Saunders, A., 1985. A Micro Model of the Federal Funds Market, Journal of Finance, 40 (3), 977-990.

Jackson, S.D., 2008. The Dynamics of Bank Spreads in the Jamaican Banking Sector: An Empirical Assessment. Financial Stability Department, Research and Economic Programming Division, Bank of Jamaica.

McLeod, R., 2008. The Lead-lag Structure of Interest Rate Relationships in Jamaica, Monetary Analysis and Programming Department, Research and Economic Programming Division, Bank of Jamaica, June.

Mishkin, F.S., 1995. Symposium on the Monetary Transmission Mechanism, Journal of Economic Perspectives, Vol. 9, No. 4 (Autumn), pp.3-10.

Moore, R.W., and Williams, M.L., 2008. Evidence on the Sectoral Monetary Transmission Process under a Fixed Exchange Rate Regime, Department of Economics, University of The West Indies, Barbados and Jamaica.

Poole, W., and Rasche, R.H., 2000. Perfecting the Market's Knowledge of Monetary Policy, Journal of Financial Services Research, Vol. 18, No. 2/3, pp. 255-298.

Prati, A., Bartolini, L., and Bertola, G., 2003. The Overnight Interbank Market: Evidence From the G-7 and the Euro Zone, Journal of Banking and Finance, 27, 2045-2083.

Spindt, P.A., and Hoffmeister, J.R., 1988. The Micromechanics of the Federal Funds Market: Implications for Day-of-the-week Effects in Funds Rate Variability, Journal of Financial and Quantitative Analysis, 23(4), 401-416.

Srour, G., 2001. Why Do Central Banks Smooth Interest Rates? Bank of Canada Working Paper 2001-17, Research Department, Bank of Canada.