Impact of repos and reverse repos on interest rates: Evidence from Nepal

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Abstract

Repos and reverse repos are popular money market management tools used by the Central Bank of Nepal especially to manage liquidity crunches and surpluses which may arise from time to time. However, the evidence of the actual impact of these tools in correcting the money market is somewhat contested. This paper investigates the impact of repos and reverse repos on interbank borrowing rates in the Nepalese market using a longitudinal data set from 2007 to 2016. The paper uses an iterative approach for identifying the best model to explain the phenomenon. The main finding of this research is that the money market maturity period of repos is more significant in reducing interest rates during a liquidity crunch rather than the volume of repos issued. Further, the research also finds that reverse repos are not significant enough to mop-up excess liquidity in the market. These findings can provide guidelines for monetary policy in Nepal, insofar as the issuance of repos and reverse repos is concerned.

Keywords: repo, reverse repo, open market operations, interbank borrowing rate

Introduction

Repurchase Agreements (repos) and Reverse Repurchase Agreements (reverse repos) have been very popular worldwide during the global financial crises of 2007-2009(Adrian & Shin, 2010). Shadow banking and their components such as money market mutual funds, securitization and a run on repos are considered major culprits of the crisis (Gorton et al., 2010). A run on repos and increased trimming caused deleveraging and some banks were forced to liquidate their collaterals (Gorton & Metric, 2012). Although repos are useful interbank borrowing tools, it is suggested to take precautions before placing trust on any innovative tools in banking (Smaghi, 2009). In Nepal, repos and reverse reposare simply practiced as money market management instruments used by the Central Bank of Nepal, Nepal Rastra Bank (NRB). The NRB also uses repos in open market operations (OMO), which affect the supply of reserve balances in the banking systems, thereby influencing short-term interest rates (Fleming,Hrung & Keane, 2010). NRB's objective when using repos and reverse repos is maintaining adequate flow of liquidity. Whenever there is need for liquidity or cash injection in the market, NRB offers repos through competitive bidding systems. Its objective is to ensure that the financial system and market participants have enough funds for their operations and to reduce the liquidity crunch. Although commercial banks, development banks and finance companies are eligible to participate in OMO to get short-term loans through treasury securities, commercial banks offering higher rates tend to secure them. Based on the total liquidity available, NRB offers repos frequently.

The ultimate goal of repos is to reduce the interest rate in the market and facilitate smooth financial transactions. In contrast to repos, reverse repos are issued by NRB in periods of excess liquidity. Transactions involving reverse repos are done in a similar way to repos. The data available from the public debt management department of NRB shows that reverse repos have been used twice as often as repos. Reverse repos have been used as a liquidity mop-up technique since 2007 in Nepal. The interbank market also provides an alternative source to central bank repos for short-term funding (Bindseil, Nyborg & Strebulaev, 2009).Meanwhile liquidity and interest rate follow the fundamental law of supply and demand, i.e. when there is excess liquidity, interest rates decline whereas interest rates go up in periods of a liquidity crunch. Hence, repos and reverse repos are the intervention used by NRB to control unexpected volatility in the market.

Most of the studies undertaken on repos, liquidity and interbank borrowing rates (IBR) to date analyze data from developed markets such as the US, the UK and Europe, especially during the time of the global financial crisis of 2008 (Gorton & Metrick, 2012; Hördahl & King, 2008). Similarly, Mancini et al. (2015) using data from Europe have shown that the euro interbank repo market ensures stable bank funding acting as a shock absorber with repo lending increasing with risk. However, there are a number of studies exploring the impact of the global financial crisis on developing countries and their local economies. Sinha (2010) found that the Indian interbank repo market continued to function during the global financial crisis. However, there is a conspicuous dearth of studies on the actual impact that repos have on local liquidity crises that do not stem from global events. According to Lalon (2013) central bank manages stress on liquidity caused by excessive investment in unproductive sectors, such as luxury goods, real estate and capital markets by issuing repos. However, Lalon (2013) does not assess repos' ability to correct the situation. Similarly, a study from Kenya suggests that horizontal repos issued by the central bank help to promote interbank liquidity by overcoming problems of credit limits. Brunetti et al. (2010) meanwhile found that the announcements of repos have a negative impact as they indicate negative news to the market. Further, Heider et al. (2009) have shown that there is the possibility of

market breakdown by liquidity hoarding. In such conditions, an intervention such as issuance of repos will create only a crowding-out effect. Fiordelisi et al. (2014) also suggest unconventional monetary policy is not as effective as standard policy. Since developing countries are vulnerable to liquidity crises, it is pertinent to study the actual effect the repo market has on IBR in the context of local economies. Further, since the social cost of any financial crisis is greater in developing countries (Van Dijk, 2013), importance of the study is heightened. Also, a research gap exists in evaluating the efficacy of monetary tools applied during times of crisis. This research attempts to close these research gaps. In the Nepalese context, Maskay and Pandit (2009) analyzing interest rate pass-through using error correction models, have shown the existence of a long-run elasticity coefficient of policy rates to different market rates that include saving rates, lending rates and one-year time deposit rates. Paradoxically elasticity is negative. Hence, Maskay and Pandit (2009) argue that bank rates in Nepal are not effective in influencing the market rate and suggest there are other factors that might influence this. The paper however only used quantum bank rates and did not consider the influence of the repo rate on interbank lending rates. Further, it also did not measure the impact that repo rate maturity has on the market.

As the major role of a central bank is to ameliorate the inefficiency in IBRs (Acharya et al., 2012), repo lending is something that central banks use to handle liquidity fluctuation, and hence its influence needs to be assessed. This research analyzes whether repo issuance helps in curbing the deviation in market rates. We ask the question 'are repos helping to maintain smooth flow of liquidity and appropriate levels of interest rates?' To answer this question, we examine the influence of the increased volume of repo issued by the NRB during high liquidity crunch on IBR and the influence of increased volume of reverse repos issued by the NRB during times of excess liquidity in the market on IBR. The research aims contribute to monetary policy-setting in Nepal. It can also provide a course of action to other countries which are at a similar stage of growth and development and have similar monetary practices. Further research can provide policy recommendations to central banks when formulating monetary policies and making decisions regarding the issuance of repos and reverse repos.

The paper is organized as follows: Review of the literature provides an overview of the existing knowledge on repos in both global and Nepalese contexts. The next section entitled 'research methodology and data analysis' describes the variables and quantitative methods used. The data analysis section utilizes various models to describe the empirical relationships and presents the results of the analysis. This is followed by the conclusion and recommendation section that presents and analyzes the results, connecting them to existing theory. This section of the paper also describes potential areas for future research.

Literature Review

Repurchase Agreement (repo) and Reverse Repurchase Agreement (reverse repo) are money market instruments used by central banks to meet and offset short-term fluctuations in cash reserves (Adrian & Shin, 2010). Ascertaining the origin of repos is difficult (Lumpkin, 1987). Studies suggest that use of repos date back to the 1920s, about the time that the federal funds market evolved. There is general agreement that government securities dealers and large money managers used repos. Since the late 1960s, however, the number and types of participants in the repo market has grown considerably (Lumpkin, 1987).

A repo is a sale of securities coupled with an agreement to repurchase the same securities on a later date, typically at a higher price (Fleming et al., 2010). This obligation provides greater control over the collateral to the lender, thus making it a preferred means for risk-averse cash investors. Repos have been a primary source of funding especially for leveraged traders (Comotto, 2009). Besides, repos can be both repurchase agreements and buy/sell-backs, differing only in legal and operational ways, all the while performing the same action. Repos that are used to simply borrow cash and securities in order to cover short positions can be compared to securities lending. For securities with a strong demand, the interest foregone by the buyer is equivalent to the fee paid by the borrower in the securities lending market (Comotto, 2009). A repo rate is similar to interest rate on a loan collateralized by a specific security, and it is called 'special' when it is significantly below prevailing riskless rates (Duffie, 1996). Repo sare provided to dealers with the aim to inject additional cash reserves into the banking system.

It should be noted that repos and reverse repo always occur on a reciprocal basis. For the party who sells the eligible collateral and promises to buy back in the future the financial instrument is a repo, while for the counterparty who buys the securities and agrees to sell them back on a future date at an agreed upon price the instrument is a reverse repo (Jordan & Jordan, 1997). Reverse repos are typically cheaper and provide greater flexibility in the use of collateral, in that they can be arranged for fixed maturities while borrowing arrangements usually may be terminated at a day's notice at the will of the securities lender (Lumpkin, 1987).
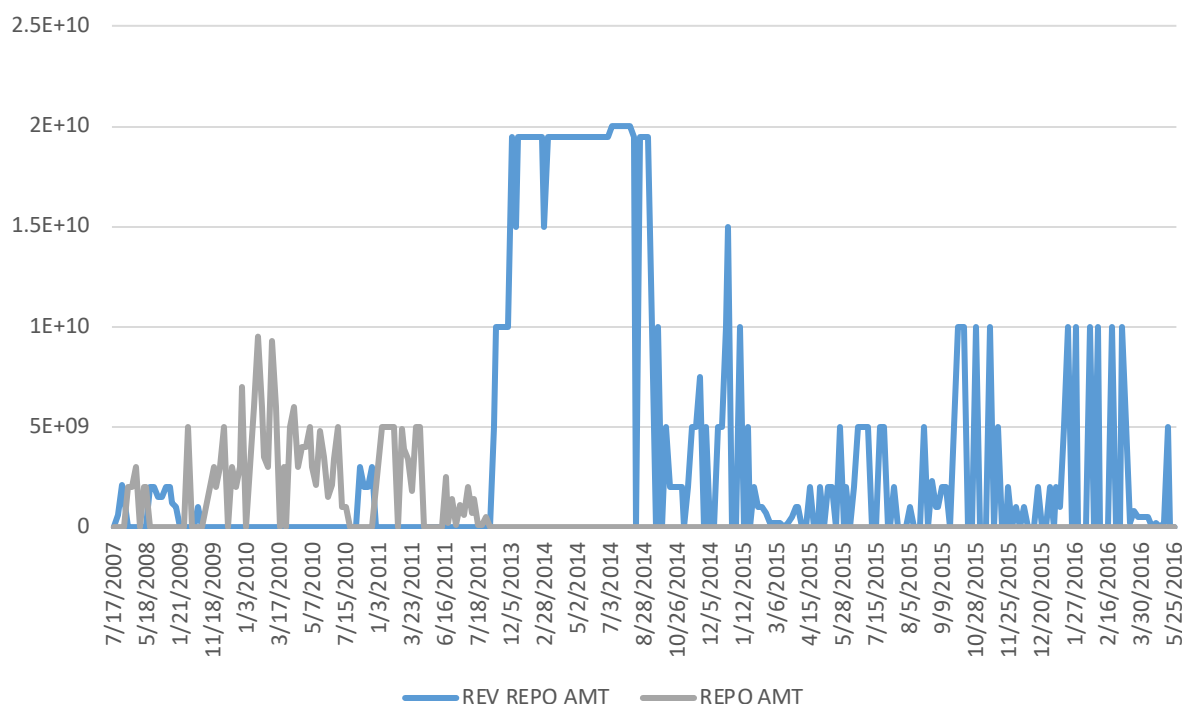
Repos and Reverse Repos in the Context of Nepal

In the context of Nepal, the OMO are major instrument of monetary policy (Shrestha, 2005). The primary objective of the central bank using OMO is to maintain appropriate level of liquidity in the country. The NRB started OMO by auctioning treasury bills in November 1988. The 91-day T-bills auction system was introduced to absorb excess liquidity in the banking system, creating market oriented interest rates. Further, in July 1989, 182-day T-bills were introduced to mop-up the excess liquidity, but they remained highly irregular until the end of 1991, and they were auctioned only twice a month. Due to the excess liquidity in the market, NRB issued bonds on December 31, 1991, as an effort to mop-up the excess liquidity, which helped correcting the negative interest rate. Thereafter the 182-day T- bills were dropped, and 364-day T-bills were introduced in July 1994. The NRB has also issued 28-day and 182-day T-bills since September 11, 2004. The issue calendar was first publicized through the bank's website on August 20, 2003, with all pertinent information (Shrestha, 2005).

The first time the NRB introduced repos as an OMO was in March 1997 (Pandit, 2010). Until July 2004, NRB used to operate the OMO, taking away the initiative from commercial banks, and solely determined its rate and magnitude. However since then under the Liquidity Monitoring and Forecast Framework, guided by the Rules on Public Debt Management, 2002, the NRB has been determining the quantity of outright sale or purchase and repo or reverse repo auctions in the secondary market as per the framework's recommendation. The main aim of the framework is to monitor and forecast the medium- and short-term (weekly) liquidity position of the economy. With the arrival of the new policy auction arrangements for outright sale/purchase, repos/reverse repos have become more market oriented. As a result, frequent and efficient OMO has been witnessed during adverse market moments. Further, since the fiscal year 2008/09 in addition to commercial banks, development banks and finance companies have been allowed to participate in OMO (Neupane, 2013). The efforts of OMO have helped the market to determine an appropriate level of interest rate, a well-functioning banking and financial

system, increased profitability, reduced risk, controlled money supply in unproductive sectors and stopped the chances of capital flight and unfair activities. The use of OMO is led by the monetary policy.

Figure 1: Supply of repos and reverse repos over from 2007 to 2016

If we look at Nepal during the last decade, repos and reverse repos have been extensively used to inject liquidity during credit crunches and to mop-up excess liquidity during gluts in the financial markets. The maximum liquidity injected using repos was during 2009-2010; the maximum liquidity mopped up using reverse repos occurred during 2014. This is demonstrated by the graph provided in Figure1. Recently, reverse repos have been used substantially to mop-up excess liquidity, but the introduction of deposit collection facilities have caused its usage to reduce. The excess liquidity mopped up by the NRB using reverse repos is more than twice the amount of repos used to inject liquidity. For instance, in 2014/15, the NRB absorbed liquidity of NPR 315.80 billion through reverse repo auctions while only NPR 155.0 billion was absorbed through deposit auctions and NPR 6.0 billion through outright sale auction on a cumulative basis (NRB, 2015).

Interbank Rates and Repos

Repos and interbank rates differ fundamentally as the former are collateralized loans against government securities and hence can be considered risk free, while the later are unsecured and depend on banks' liquidity position along with their short-term credit exposure. According to Freixas et al. (2011) interbank rates are crucial in managing uncertainty of financial institutions. Though pinpointing actual determinants governing the IBR is difficult, a study by Poskitt (2011) using decomposition analysis has shown that change in liquidity rather than the credit risk accounts for LIBOR rate volatility. Similarly, Michaud and Upper (2008) have shown that interbank markets are more affected by liquidity, owing to the reaction to central banks' liquidity provisions than to the credit risk. This relation of IBR to liquidity factors provides an intuitive linkage to central banks' monetary instruments where one of the main purposes is to manage the liquidity risk. As per Freixas et al. (2011) central banks' interest rate policy

can directly improve liquidity conditions in the interbank lending market, especially during financial crises. Several studies have corroborated this stylized fact. For instance, according to Holmström and Tirole (1998), the premium in market liquidity risk declines with government funding. Similarly, Christensen et al. (2009) have argued that an announcement of liquidity facilities by the central bank helps lower the liquidity premium in term of interbank rates. Further, McAndrews et al. (2017) have shown that Term Auction Facility, an unconventional monetary policy used by the Federal Reserve during the financial crisis, was effective in assuaging liquidity strain in the interbank market.

All these studies including that of Gorton & Metrick (2012) have analyzed the data from developed markets using Federal Rate and LIBOR. There have been only a few studies that have attempted to describe the impact of repos on policy transmission. For instance, Fadiran and Edun (2013), by applying structural-VAR methods to data from South Africa, found the repo period to be monetarily efficient because of subsequent interest rate transmissions. Further Fadiran and Edun (2013) showed that repos were applied by the central bank to minimize deviations of market rates from policy rates. Similarly, an IMF working paper by Das (2015) showed that in India pass-through of repos to the lending rate is partial with cumulative long-run elasticity of 0.43. In the context of Nepal, Neupane (2013) argues that repos and reverse repos may have lag effects on IBR. Therefore, this research serves as a validation of the existing theory, as a detailed study of the relationships between these two variables is still lacking.

Research Methodology and Data Analysis

This research is designed to establish causal relationships among the variables relating to repos/reverse repos and IBR. All the data used in this research have been collected through secondary sources. The research uses OMO statistics from reports of the public debt management department of the NRB. The research covers monthly data from September 2007 till May 2016 and the instruments covered are repos and reverse repos. Data is available on the volume, interest rates, maturity period and the date of issue of repos and reverse repos. The variables of interest are as follows:

The major variables of interest of the research are repo, reverse repo and interbank lending rate. The study starts with a simple OLS model, attempting to describe the relationship between the variables of interest. Several diagnostic checks were carried out. These include Variance Inflation Factor (VIF) test for multicollinearity (Chatterje & Hadi, 1986), Breusch& Pagan (1979) test and Cook and Weisberg (1982) test for heteroscedasticity, Durbin Alternate test for auto-collinearity (Durbin,1970) and Ramsey RESET test for misspecification and endogeniety of the model (Ramsey, 1969). Based on the outcome of diagnostic tests, models were recalibrated by introducing new variables. The recalibration process was reiterated till the final model was ascertained. Durbin Alternate test was used as it is considered to perform better when all variables are not exogenous (Durbin, 1970). The final model thus contains an interaction term (the presence of a repo interacted with the maturity period for 91 days T-Bill rate) and one period lagged IBR. Further, to address possible outliers and heteroscedasticity, regressions (Hamilton, 1992) with robust errors were used. Thus, the final regression model is as follow:

$$IBR_t = \alpha + \beta_1 IBR_{t-1} + \beta_2 T\text{-}BILLRATE_t + \beta_3 REPO_t + \beta_4 REVERSEREPO_t + \beta_5 DUMMYREPO_t * Maturity + \beta_6 DUMMYREVERSEREPO_t * Maturity + \epsilon$$

Variables	Symbol	Operational Definition
Dependent Variables		
Repurchase Agreement	$REPO_t$	Amount of repo issued during the time 't'
Reverse Repurchase Agreement	$REVERSEREPO_t$	Amount of reverse repo issued during the time 't'
Repurchase Agreement Time Dummy * Repo Maturity	$DUMMYREPO_t * Maturity$	This interacting variable identifies the impact of maturity length on repo issued
Reverse Repurchase Agreement Time Dummy * Reverse Repo Maturity	$DUMMYREVERSERREPO_t * Maturity$	This interacting variable identifies the impact of maturity length on reverse repo issued
Treasury Bill Rate	$T - BILLRATE_t$	91 days T-Bill rate, as a proxy for interest rate on risk free government debt at time 't'
Lag of Inter Bank Rate	IBR_{t-1}	One period lag of Interbank lending rate
Independent Variables		
Interbank rate	IBR_t	Interbank lending rate at time 't'

Data Analysis

To establish the causal relationship between repo/reverse repo and interest rates a rigorous process has been completed with different steps and models, starting with an OLS model for time series data analysis.

First Proposed Model: The first proposed model, considers as explanatory variables the volume of repos issued by NRB during the liquidity crunch and the volume of reverse repos issued at times of excess liquidity.

$$IBR_t = \alpha + \beta_1 REPO_t + \beta_2 REVERSEREPO_t + \epsilon \dots \dots \dots (1)$$

Table 2: Outcome of First Proposed Regression Equation

IBR	Coefficient	Std. Error	t-cal	p-value	VIF
REPOAMT	1.43	1.02e-10	13.96	0.000***	1.07
REVREPOAMT	-1.46	2.60e-11	-5.61	0.000***	1.07
Constant	2.521315	.2156461	11.69	0.000***	
R-squared = 0.5001 | Adj- R-squared= 0.4966					
RAMSEY RESET Test of model specification	F(3, 283) = 12.85 | Prob> F = 0.0000 ***				
Note: ***significant at p<0.001; **significant at p<0.005; *significant at p<0.1.					

The first model is statistically significant and provides adequate explanatory power as signified by an adjusted R-squared value of 0.4966. The VIF value is greater than four, indicating that the model does not suffer from multicollinearity. However, the Ramsey RESET test could not reject the null hypothesis that the model has no omitted variables, thus making it necessary to introduce more variables.

Second Proposed Model: The second model adds two new variables to the first model: interactions between maturity period of repos and reverse repos with the volume of repos and reverse repos issued. These variables introduce variability caused by the time factor into the model. During the periods when

repos or reverse reposare not used these two variables are pivotal in determining the interbank lending rate.

$$IBR_t = \alpha + \beta_1 REPO_t + \beta_2 REVERSEREPO_t + \beta_1 DUMMYREPO_t * Maturity$$

$$+\beta_2 DUMMYREVERSEREPO_t * Maturity + \epsilon \ldots\ldots\ldots (2)$$

Table 3: Outcome of Second Proposed Regression Equation

IBR	Coef	Std. Error	T	P>t	VIF
REPOAMT	9.14	1.63e-10	5.60	0.000***	2.86
REVREPOAMT	-1.27	2.70e-11	-4.71	0.000*	1.21
DUMMYREPO * Maturity	.1040866	.0269334	3.86	0.000***	2.98
DUMMYREPOREVERSEREPO * Maturity	-.0153729	.0353345	-0.44	0.664	1.30
Constant	2.355423	.2559408	9.20	0.000***	
R-squared = 0.5268 | Adj- R-squared= 0.5201					
Breusch-Pagan / Cook-Weisberg test for heteroscedasticity			chi2(4) = 43.59 | p-value= 0.0000***		
Note: ***significant at p<0.001; **significant at p<0.005; *significant at p<0.1.					

Even after introduction of the interaction terms, the adjusted R-squared value has not increased markedly. The new model explains 52% of variability in IBR. Furthermore, the Breusch-Pagan / Cook-Weisberg test shows that there is presence of heteroscedasticity as well. In order to tackle the heteroscedasticity issue that could have been caused by outliers, the model was run with robust errors (Li, 1985).

Table 4: Outcome of Second Proposed Regression with Heteroscedasticity Robust test

IBR	Coef	Robust Std. Error	T	P>t	VIF
REPOAMT	9.14	2.16e-10	4.22	0.000***	2.98
REVREPOAMT	-1.27	1.48e-11	-8.56	0.000***	1.21
DUMMYREPO * Maturity	.1040866	.0316745	3.29	0.001*	2.98
DUMMYREPOREVERSEREPO * Maturity	-.0153729	.0387115	-0.40	0.692	1.30
Constant	2.355423	.3242355	7.26	0.000***	
R-squared = 0.5268					
RAMSEY RESET Test for specification of model		F(3, 283) = 10.92 | Prob> F = 0.0000 ***			
Note: ***significant at p<0.001; **significant at p<0.005; *significant at p<0.1.					

Even after making it robust to heteroscedasticity, the Ramsey test shows the model still suffers from omitted variables, thus leading to endogeneity.

Analysis shows three of the proposed variables: repo volume, reverse repo volume and the interaction term for the impact of maturity length on repo issued seem to be significant. However, the signs of coefficients of repo volume and reverse repo volume are opposite to a priori expectations. When there is a liquidity crunch, a central bank issues repos to maintain a moderate amount of liquidity, which is likely to reduce the interest rate; the reverse is applicable for reverse repos.

The above regression results, especially the coefficients of both repo volume and reverse repo volume and the interaction terms, indicate the existence of endogeneity. There are many possible issues here: one could be the omission of variables, which causes changes in IBR over and above what is explained by repo volumes. Further, simultaneity may also be a problem since central banks also consider interbank rates along with liquidity available in the market while offering repos and reverse repos. Besides, the central banks may not fill the necessary cash requirement during liquidity crunches and mop-up all excess cash from the market during excess liquidity situations. As a result, the impact of repo and reverse repo may not be apparent.

Neupane (2013) shows an interaction between daily weighted average interest rates and repo and reverse repo rates of Nepali financial markets. The auction system of the NRB determines the repo and reverse repo rates under its OMO. However, IBR is a market-determined rate. All three rates - IBR, repo, and reverse repo rate - follow the same trend. The interbank rate is high when the repo rate is high. On the other hand, IBR is low when the reverse repo rate is low.

If the basic laws of demand and supply apply to Nepal's money market, then the supply of repo volume decreases/increases when the repo rate increases/decreases, indicating a negative relationship between repo/reverse repo rates and the amount of repos/reverse repos issued by the NRB. In Neupane's (2013) study, IBR and repo and reverse repo rates were found to move together, indicating an endogeneity issue in our model.

Identification Strategies

To address the issues of multicollinearity, omission of variables and simultaneity, lag of IBR has been introduced as an Instrumental Variable (IV). It is based on theory and technical analysis which explains that the prior period IBR affects the present period IBR. The graph in Figure 2 shows the IBR throughout roughly ten years. The IBR is highest during 2010 when the NRB has supplied sufficient amount of repos to control the interest rate and maintain required level of liquidity. As higher IBR causes supply of repos to increase, an adequate supply of repos should reduce the IBR. This two-way relationship thus can be addressed using the lag of IBR, which has more impact on IBR than that of the repos or reverse repos.

Figure 2: IBR and T-Bill Rate over the Years along with Repo and Reverse Repo Volumes
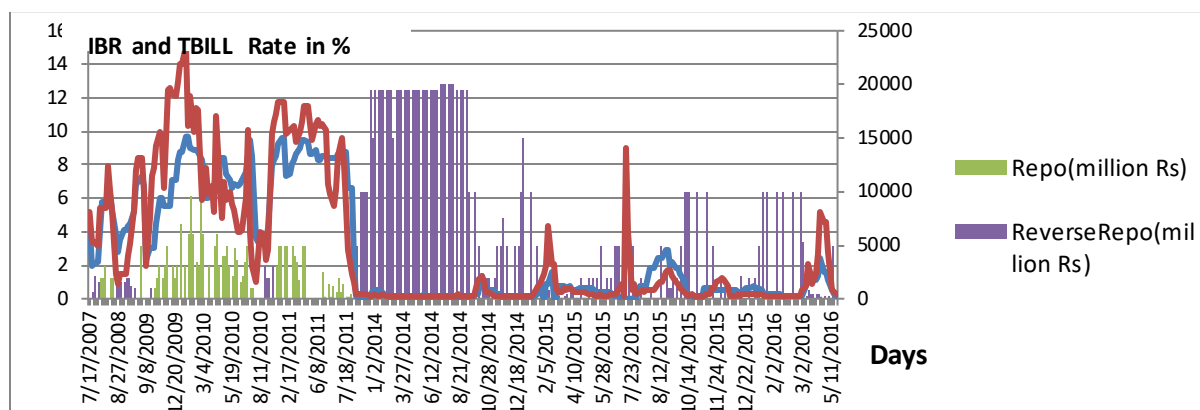
If there are no clear proxies for omitted variables, then the independent variable can be lagged (Wooldridge, 2015). However, while applying Durbin's Alternative test for serial correlation in the previous model, there was significant autocorrelation in the order of lag one. Thus, there is support

from both theoretical and econometric standpoints that an auto-regressive lag term be introduced in the model.

The Final Model and Analysis

The final model used for the analysis is as follows:

$$IBR_t = \alpha + \beta_1 IBR_{t-1} + \beta_2 T\text{-}BILLRATE_t + \beta_3 REPO_t + \beta_4 REVERSEREPO_t + \beta_5 DUMMYREPO_t * Maturity +$$

$$\beta_6 DUMMYREVERSEREPO_t * Maturity + \epsilon \ldots\ldots\ldots \quad (3)$$

The final model takes into account the lagged effect of the IBR and the 91-day T-Bill rate which it is argued have direct relationships with the IBR. The reason for using the T-Bill rate is that when the T-Bill rate increases, commercial banks also tend to increase their interbank rates and vice-versa. In order to manage the unwanted heteroscedasticity due to possible outliers, robust regression is applied.

Table 5 - Outcome of Final Proposed Model

IBR	Coef.	Robust Std. Error	T -stat	P>t	VIF
IBR_{t-1}	.6411061	.0716871	8.94	0.000***	6.09
TBILLRATE	.4242917	.0960665	4.42	0.000***	7.88
REPOAMT	2.860412	1.64234	1.75	0.082*	3.09
REVREPOAMT	-1.632351	8.22391	-0.20	0.843	1.39
DUMMYREPO * Maturity	-.0642455	.0205453	-3.13	0.002***	4.11
DUMMYREPOREVERSEREPO * Maturity	-.0106338	.0222888	-0.48	0.634	1.37
Constant	.0812643	.1480372	0.55	0.583	
R-squared = 0.8955					
RAMSEY RESET Test for specification of model	F stat= 1.14 | Prob> F = 0.3331				
Note: ***significant at p<0.001; **significant at p<0.005; *significant at p<0.1.					

As shown in the result table, the model used seems to be appropriate one. The R-squared value 0.8955 indicates that most of the independent factors causing changes on IBR have been considered. The model shows that the lagged value of the IBR along with the T-Bill rate, repo magnitude and repo maturity are significant. Meanwhile, the VIF shows no multicollinearity in the variables of interest, i.e. Repo and reverse repo. Though a moderate multicollinearity can be seen in lagged value of the IBR along with the T-Bill rate, it is still acceptable below 10 (Chatterjee & Hadi, 2015). Further, the RAMSEY RESET test also shows that the model does not suffer from omitted variables. However, the p values for the reverse repo amount and interaction with its maturity are found to be insignificant.

Conclusion and Recommendations

According to the results of the final model the coefficient for the volume of repos is 2.86, and the volume of reverse repo is -1.63. This shows that the issuance of new repos results in increases to the IBR while issuance of reverse repos decreases the IBR. The signs of the coefficients appear counterintuitive as issuance of repos is supposed to reduce the IBR while the issuance of reverse repos is supposed to increase it. This apparent contradiction could be explained by the information effect

described by Brunetti et al. (2010). They suggest that issuance of repos or reverse repos might convey negative news to the market (Brunetti, Filippo & Harris, 2010). Also as explained by Heider et al. (2009) there could have been market breakdowns caused by liquidity hoarding. In such conditions, intervention such as issuance of repos will create only a crowding-out effect. Fiordelisi et al. (2014) also suggests that unconventional monetary policy is not as effective as standard policy. Our findings clearly support the view that informational effects can dampen the policy intent. Hence, decision makers before releasing repos or reverse repo should not rely only on its magnitude to lessen the crisis; rather they should take the informational bias at face value.

The coefficient of the interaction variable for repo volume and its maturity days of -.064 indicate that it reduces the IBR, i.e., for a one unit increase in repo maturity length, the IBR decreases by 6.4% on average. This indicates that the length of the maturity period of repos but not its volume helps stabilize the IBR most. A possible explanation for this phenomenon might be that with increased length of time, the initial negative news might attenuate and hence ultimately the repo size starts to show its effect. This is the major finding of the study, and it is aligned with the policy expectation. To further investigate this effect, it is recommended that an event study of various lengths should be undertaken using a standard methodology (MacKinlay, 1997).

However, the interaction of reverse repo volume with its maturity days is found to be insignificant. This apparent insignificance might be explained by the fact that a reverse repo facility mainly puts a floor on the IBR. Further as explained by Williamson (2015) only if a central bank's balance sheet is held constant, does the margin between interest rate and the interest rate on government debt increase. Thus, because of the introduction of the T-Bill in the model, which acts as a proxy for interest rate on government debt, the reverse repos' impact may have been diminished. Further, there is a possibility of a central bank's balance sheet not being static throughout the period, which needs verification. This explanation is justified by the results of the first and second models where the T-Bill rate was absent, and the coefficient of the volume of reverse repos was significant.

The main contribution of this research is the finding that the amount of repos and reverse repos alone cannot maintain the interest rate. Nevertheless, their maturity period helps maintain the desired rate of interest. Findings of this research will be useful for central banks and participants in the repo and reverse repo markets. When central banks offer repos during liquidity crunches, the liquidity supplied over a longer period reduces the interest rates whereas short-term injections cannot reduce it. In case of reverse repos, short-term liquidity mop-ups alone cannot protect the interest rates whereas continuous or frequent reverse repos can protect the interest rates.

The findings of this research can be applied to many countries engaging in similar practices or sharing similar levels of financial development and growth. To make the findings of this research more generalizable, cross-country analysis should be carried out. Further, the research indicates that informational effects might have overpowered the liquidity effect of a repo announcement. This notion can be the basis for future research in disentangling two effects during OMOs. The study also opens the door in analyzing the efficacy of repo rates under duress of change or constancy in the size of the balance sheet of central banks.

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