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Effect of Open Market Operation on Short-Terms Interest

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Abstract: *This study attempts to analyze the effect of repos and reverse repo under open market operations on interbank rates over the time span of 19 years from August 2002 to August 2021. Interbank transaction amount and Treasury bill rate are used as independent variables. Whereas, net liquidity, credit to core capital plus deposit (CCD) ratio, and exchange rate are used as the control variables. The study is based on time series data collected from the official website of Nepal Rastra Bank. Moreover, statistical tools such as correlation and time series regression have been applied to analyze the data. The empirical results indicated that repurchase agreement, liquidity, and exchange rate have a negative effect on the interbank rate whereas reverse repo agreement (R repo) and Treasury bill rate have a positive effect interbank rate. In addition, the study found that there is no significant impact of CCD on the interbank rate. In a nutshell, it can be concluded that repo and reverse repo, liquidity, treasury bill, and exchange rate are the important determinants of the weighted average interbank rate (WAIR).*

Keywords: Open market operations, Repo, Reverse repo, Short-term interest rates, Monetary policy

I. INTRODUCTION

The main tools of central banks for controlling short-term rates are open-market operations (Carpenter & Demiralp 2006; Harvey & Huang 2002; Kopchak 2011) and open-mouth operations (Guthrie & Wright 2000; Kohn & Sack 2003; Reeves & Sawicki 2007). Under open-mouth operations, officers of Central Banks try to guide the market rate through communications or announcements. The most straightforward and objective tool for adjusting market interest rates is the open market operation (OMO). The OMO is

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a principal tool of monetary policy used by central banks to influence short-term interest rates and the supply of money in an economy. They involve the buying and selling of government securities in the open market, which ultimately affects the reserve position of the central bank, thereby influencing the money supply. The primary objectives of OMO are to regulate the money supply and maintain financial stability (Mishkin, 2018). Central banks typically use OMO to achieve macroeconomic goals such as inflation control, currency value stability, and increasing employment levels.

When a central bank buys security, it adds them to its portfolio, while when it sells securities, it reduces its holdings. When OMO is used to increase the money supply, it is referred to as "expansionary open market operations" (EOMOs). This involves the central bank purchasing government securities on the open market. This causes the money supply to increase, resulting in lower interest rates. On the other hand, contractionary open market operations (COMOs) reduce the money supply, leading to higher interest rates. In open market operations, the central bank usually focuses on short-term interest rates as opposed to long-term rates. This is because short-term rates tend to be more sensitive to changes in the money supply and interest rates. According to the Federal Reserve Board of Governors (2020), "the federal funds rate, which is the interest rate that banks charge each other for overnight loans, is the Federal Reserve's main tool for influencing short-term interest rates."

Nepal Rastra Bank used the open market operation (OMO) in 1988 as the key instrument of monetary control to ensure monetary stability, provide confidence in the monetary operations and control excess/under-liquidity in the financial system (Nepal Rastra Bank, 2018). OMO is divided into repo, reverse repo, outright purchase, and outright sales (Open Market Operation, 2018). Short-term borrowing, also known as "repos," is the purchase of securities in the money markets with the intent of reselling them at a later date, usually at a higher price. Reverse Repo refers to an act of buying securities by the monetary authority in order to absorb liquidity (Lioudis, 2020). Reverse repo and outright sales are used to absorb liquidity whereas repo and outright purchase are used to inject liquidity. In addition, central banks use tools such as repo and reverse repo to maintain interbank rates within the interest rate corridor.

The Nepalese banking industry underwent financial sector reform from 1999–2004, allowing banks to determine interbank interest rates on their own. As a result, the interbank rate became highly volatile and has been fluctuating for the past few years. The interbank rate is the interest rate at which banks borrow and lend their funds in the money market for the short term. The highest interbank rate recorded to date is 12.83% in 2010 (Neupane, 2019). The sky-high interbank rate raised the cost of funds for banks, resulting in an increase in the cost of loans for customers. This brought about reduced borrowing and economic activities, thereby adversely impacting the nation's productivity. The dwindling economic activities caused the real GDP to decrease, leading to slowed economic growth and an influx of liquidity.

Rastra Bank (NRB) oversees the interbank rate through its open market operation

(OMO) program by injecting liquidity. To help incentivize interbank transactions, NRB issued a directive allowing Banks and Financial Institutions (BFIs) to use interbank windows as deposits to meet their CCD ratio (Sharma, 2019). Rising liquidity concerns, combined with a low deposit ratio in comparison to borrowing, leading to a higher interbank rate. This is affecting the behavior of borrowers and the overall economy. To address this issue, NRB injected Rs 45 billion into the sector via seven repo auctions since January 20, 2019 (Sharma, 2019). The current trend of economic growth, commercial activities, technological shift, consumption expenditure, borrowing, and lending implies a low and stable interbank rate to meet the macroeconomic goals of the nation (Nepal Rastra Bank, 2019).

During the period of 2007–2008, a considerable number of banks struggled to obtain liquidity under reasonable market conditions in the US and Europe. The interbank rate in Nepal also became volatile after 2009, which mainly arose from supply and demand for liquidity in the money market. During the last decade, frequent fluctuations in the rate have been observed. The interbank rate fell from 12 percent in 2010 to 0.15 percent in 2015. The volatile interbank rate caused the weighted average lending rate (WALR) to increase to 16% and above. As a result, the monetary authority introduced an interest rate corridor in July 2016. Later, because of the low deposit collection rate and low cost of funds for banks, WAIR fell to 8.61% (Nepal Rastra Bank, 2021).

In the global context, various studies are undertaken to identify the impact of repo, reverse repo, and liquidity on interbank lending. Most of the studies are from developed economies. Bech & Monnet (2013) found that liquidity and availability of loanable funds were the major determinants of the interbank rate. Studies such as Peterson's (1996) and Clifton's (1985) claim that forex exchange intervention and exchange rate are the main factors affecting the interbank rate. A recent study by Fraser (2020) regarded the global pandemic of COVID-19 (coronavirus) as a major disturbance to smooth open market operations. However, a study conducted by Risal and Karki (2018) found repo and reverse repo to be major determinants of the interbank rate. Since the interbank rate influences the overall interest rate in the economy, keeping it within a reasonable range is one of the most difficult tasks for any country's monetary authority.

Financial and economic policies always attract financial scholars and motivate them to understand their different dimensions and their impact on different aspects of the economy. Issues like lending rates, the interbank market, the interbank rate, the interest rate corridor, etc. were hot topics after the devastating earthquake of 2015 in Nepal. The Nepal Rastra Bank's (NRB) policy of intervening in the interbank rate was a common monetary policy. NRB changed the interest rate corridor three times in the last five years, from 2016 to 2020 (Dhakal & Timsina, 2020). It is not hard to understand the desperateness of the monetary authority to check the interbank rate within the range. The continued appearance of interbank-related issues in the news, as well as the NRB's concerns, prompted me to delve deeper into this topic.

II. LITERATURE REVIEW

Under Open Market Operations (OMO), the Central Bank purchases or sells government securities from its member banks in order to change the supply of money in the economy (Amadeo, 2020). Alterations in the money supply affect the supply of loans and change interest rates, which ultimately affect the number of loans demanded. Repo and RevRepo are being used for the short-term purposes of OMO as a tool. Repo was first introduced in 1917 by the Federal Reserve due to less attractive lending forms. Initially, repos were only used by the US Federal Reserve in the early 1900s as an open market operation (OMO) instrument for lending to existing banks (Rajaram & Ghose, 2013), but soon after the 1920s, the use of repos expanded widely when the Great Depression and World War II took place (Kennedy, n.d.). Previously, repo served a dual purpose: it drained liquidity from the banking system in the form of surplus cash in the market and, on the other hand, assisted in injecting liquidity into the system when needed.

Although there are several studies on "the impact of OMO on interbank rate," the findings of the studies are not conclusive. Findings are different across different regions and time periods. Studies like Yellen and Janet's (2011) found a negative impact of repo on the interbank rate and a positive impact of reverse repo on the interbank rate. However, studies like Gyntelberg & Wooldridge (2008) found a positive impact of repo on the interbank rate but a negative impact of the reverse repo on the interbank rate. Similarly, the study by Furfine (2000) depicted a positive relationship between payment volume and the federal funds rate in equilibrium, while researchers like Boorman and Icard (2011) argued that interbank amount has always had an inverse relationship with the interbank rate. Furthermore, Risal and Karki (2018) and Brooks and Yan (1999) found positive and significant effects of Treasury bills on the interbank rate. In contrast, Johnson (2001) claimed that increases in short-term bills always lower the interbank rate. Various studies have concluded that the findings of the study of OMO's impact on the interbank rate are accurate. There are no exact findings about the impact of OMO on the interbank rate.

Similarly, transaction amounts and treasury bills are used to maintain market liquidity for short-term inflation control. Studies like Furfine (2000), Risal and Karki (2018), Brooks and Yan (1999), and Johnson (2001) incorporated these as an independent variables in their study and found a positive and significant relationship between RevRepo and the interbank rate, as well as between treasury bills and the interbank rate, while interbank transaction amounts and repo have found a negative relationship with the interbank rate. So, these four variables are taken as independent variables for the purpose of this study.

Moreover, control variables like credit deposit ratio (CDC), net liquidity, and exchange rate are taken into consideration to figure out the impact on liquidity availability. When there is enough liquidity with commercial banks or a shortage of liquid amounts, these variables are being used to maintain liquidity but also as a control variable that contributes to economic growth. Robertson (1995) and Christiano (1991) investigated the

liquidity effect and its relationship with the interbank rate and found it negative. The study conducted by Clifton (1985) found a negative impact of exchange rates on the interbank rate due to higher demand that exceeds supply. But the study by Demiralp, Preslopsky, and Whitesell (2006) found a positive and pressing effect of loanable fund non-availability on the interbank rate.

Furfine (2000) pointed out that uncertainty in bank reserve balances was an increasing function of payment volume. Considering the possible penalties for overnight overdrafts, banks, and financial institutions tend to hold significant amounts in reserves, mainly on busier and higher transaction days. By doing this, the fed funds rate goes lower with an excess of supply over demand, resulting in the federal funds rate being close to its target. Changes in the interbank rate are intended to favorably affect other short-term interest rates (Federal Reserve Bank of San Francisco, 2012). The study depicts that, in equilibrium, the aforementioned phenomenon created a positive relationship between payment volume and the federal funds rate. As pointed out by Allen & Carletti (2008) and Brunnermeier (2009), the inability of the interbank market to re-distribute liquidity was a prime issue of the 2007–09 crisis. Certainly, the financial turmoil in the global interbank market during the second half of 2007 puts a question mark on whether the interbank rate fixings were profoundly robust or not. Gyntelberg & Wooldridge (2008) performed a comparison of alternative fixings for similar interest rates and empirically confirmed that they diverged to an unusual extent.

Looking back over the last decade in Nepal, repos and reverse repos have shown significant performance in terms of their role in injecting and driving out liquidity during credit crunches and gluts, respectively. Historical contexts reveal the usage of repos during 2009–10 and the usage of reverse repos during 2014 (Karki & Risal, 2018). However, the use of reverse repos has shown signs of reduction due to the introduction of deposit collection facilities. These facts are observed in the statistics of the Central Bank, which show that in 2014/15, NPR 315.80 billion was mopped up through reverse repo auctions and NPR 6.0 billion was absorbed respectively through deposit auctions and outright sale auctions on a cumulative basis ("NRB issuing NPR 30 billion repo", 2021). A similar auction has been done recently where the NRB issued three repurchase agreements to minimize the shortfall of liquidity (Shrestha, 2022).

Developing countries like Nepal are susceptible to liquidity crises, so it is logical to study the actual effect of repo and reverse repo on the interbank rate. Moreover, the social cost of the financial crisis is greater in developing countries (Van, 2013). In the Nepalese context, a few studies have been conducted to examine the interbank rate. Neupane (2011) conducted a study on the volatility of interbank rates in the interbank market that considered constructs like repo and standing liquidity facilities (SLF) and their effects. The empirical result of the study indicated strong evidence of time-varying volatility, a tendency for periods of high and low volatility to cluster, and high persistence of shocks on interbank lending market volatility. The study lucidly indicated that repo helps reduce the persistence shock in interbank rates. Further, the study suggested that there is room for further analysis to measure the impact of the reserve calculation period, day-wise

effect, government spending, taxes, and external sector on market volatility. Meanwhile, Risal and Karki (2018) researched the influence of repo and reverse repo on the interbank rate using time series data from 2007 until 2017. The empirical evidence revealed that the maturity period of repos in the money market is more influential in reducing interest rates during a liquidity crunch than the volume of repos issued. Moreover, the research also found that reverse repos are not significant enough to mop up excess liquidity in the market.

However, neither the study (Neupane, 2011; Risal & Karki, 2018) consider important control variables such as liquidity ratio, credit to core capital plus deposit (CCD) ratio, credit to deposit (CDS) ratio exchange rate, and the global pandemic. Therefore, a clear lacuna exists in identifying the precise efficacy of monetary policy tools to mitigate such crises. Despite a bewildering array of models and empirical research, relatively little is known about how monetary interventions like repo and reverse repo affect the short-term interest rate. To fill these gaps, this paper uses a simple econometric model to assess the effect of monetary policy on the short-term interest rate measured by the interbank rate. To be more precise, interbank transaction amount and Treasury bill rate are used as independent variables. Whereas, net liquidity, credit to core capital plus deposit (CCD) ratio, and exchange rate are used as the control variables.

III. METHODOLOGY

The study has adopted a descriptive and causal-comparative research design. A descriptive research design has been applied to obtain a complete and accurate description of interbank rate, interbank transaction amount, liquidity, credit to core capital plus deposit ratio, and exchange rates. Descriptive statistical tools like mean, standard deviation, minimum, maximum, skewness, and kurtosis have been used to represent dependent and independent variables. Similarly, the study has also adopted causal-comparative research design to measure the effect of repo and reverse repo on the interbank rate. This study is based on secondary data. Studies like Bech and Monnet (2013) advocate for the use of monthly data for the purpose of this kind of study. Therefore, the study also uses monthly data from August 2002 to August 2021 for this very purpose. The study period has been decided on the basis of the availability of data. Even after visiting the Nepal Rastra Bank in person, data prior to 2002 were unavailable. Moreover, none of the Nepalese studies cover this period (Neupane, 2011; Risal & Karki, 2018). The required data, such as repo, reverse repo, interbank rate, etc., have been collected from reports of the public debt management department of the Nepal Rastra Bank. Moreover, the following hypothesis was formulated and tested for empirical verification of theoretical predictions.

H_1: *Repo negatively affects the interbank rate.*

Repo is one of the important instruments of Nepalese monetary policy that helps to stabilize the interbank rate. The availability of liquidity in the market for short-term purposes determines the issuance of repo. Earlier studies such as Yellen and Janet

(2011) incorporated repos as an independent variable for their study and found a negative and significant relationship between repo and the interbank rate.

H_2: *Reverse repo positively affects the interbank rate.*

A reverse repo is being issued to maintain the cash surplus in the market. Comparatively, it is cheaper than repo and helps the central bank mop up excess liquidity from the market. A higher reverse repo rate tends to increase the interbank rate by limiting the liquid surplus. Some representative studies such as Yellen and Janet (2011) found a positive relationship between reverse repo and the interbank rate in their study.

H_3: *Interbank transaction amount negatively affects the interbank rate*.

Interbank transactions refer to the demand and supply of interbank lending. The higher the demand for interbank lending, the higher the short-term interest rate, resulting in a negative relationship between the interbank rate and the amount of interbank lending. Previous studies such as Boorman and Icard (2011) incorporated these variables into their study and found a negative relationship between interbank transaction amount with the interbank rate.

H_4: *Treasury bill rate positively affects the interbank rate*.

Prior Studies like Risal and Karki's (2018) and Brooks and Yan's (1999) considered the Treasury bill rate as an independent variable for examining the relationship with the interbank rate and found a positive association between the Treasury bill and the interbank rate. Therefore, acceptance of the alternative hypothesis indicates the presence of a significant relationship between Treasury bills and the interbank rate.

On the basis of an overview of the available literature (Joseph, 2012; Risal & Karki, 2018; Brooks & Yan, 1999; Boorman & Icard, 2011; Bech & Monnet, 2013; Demiralp, Preslopsky & Whitesell, 2006 & Clifton, 1985), the expected sign is negative for repo, positive for reverse repo, negative for interbank amount, positive for treasury bill rate, negative for credit deposit ratio (CDC), and negative for exchange with the interbank rate. The dependent variable for the first regression model is the weighted average interbank rate. The core model specification is:

WAIR = f (REPO, RREPO, IBA, NL, TB, CCD & ER)

A single model may not accurately capture the complexities of the relationships between variables, resulting in incorrect predictions and a lack of understanding of the underlying correlations (Liang and Xie, 2020). To better understand these correlations and achieve more accurate estimates, this study uses three different models. The expanded models are:

$$WAIR_t = \beta_1+\beta_2*REPO_t + \beta_3*IBA_t + \beta_4*NL_t + \beta_5*TB_t + \beta_6 CCD\ (\%) + \beta_7*ER_t + e..... \quad (i)$$

$$WAIR_t = \beta_1+\beta_2*RREPO_t + \beta_3*IBA_t + \beta_4*NL_t + \beta_5*TB_t + \beta_6 CCD\ (\%) + \beta_7*ER_t + e..... \quad (ii)$$

$$WAIR_t = \beta_1+\beta_2* REPO_t + \beta_3* RREPO_t + \beta_4*IBA_t + \beta_5*NL_t + \beta_6*TB_t + \beta_7 CCD\ (\%) + \beta_8*ER_t + e..... \quad (iii)$$

The variables and measures have been presented in the Table 1.

Table 1
Variables and Measure

Variable name	Unit	Short form	Description
Weighted average interbank rate	Percentage (%)	WAIR	Monthly weighted average interbank rate in interbank market at time "t"
Repurchase agreement	NRs billion	REPO	Repurchase agreement issued by of Nepal Rastra Bank at time "t"
Reverse Repurchase agreement	NRs billon	RREPO	Reverse Repurchase agreement issued by of Nepal Rastra Bank at time "t"
Interbank transaction amount	NRs million	IBA	Monthly Interbank transaction amount in interbank market at time "t"
Net Liquidity	Percentage (%)	NL	Net Liquidity of commercial banks at time "t"
Treasury bill rate	Percentage (%)	TB	91 days Treasury bill rate of Nepal Rastra bank at time "t"
Credit cum deposit ratio	Percentage (%)	CCD	Credit to core capital plus deposit ratio of commercial banks at time "t"
Exchange rate (NRs/USD)	NRs	ER	Exchange rate between USD and NRs at time "t"

IV. ANALYSIS

Descriptive Statistics

The descriptive statistics of the different variables used in the model have been presented in table 2. The table includes the mean, max value, min value, and standard deviation of the variables.

Table 2
Summary Statics

Particulars	WAIR	REPO	RREPO	IBA	NL	TB	CCD	ER
		(NRs Billion)	(NRs Billion)	(NRs Billion)				(NRs/USD)
Min value	2%	0.01	0.1	2.8	8.3%	0.0%	62.2%	63.6
Max value	12.8%	44.05	99.5	150.727	49.9%	9.1%	86.2%	116.9
Mean	3%	7.61	18.06	36.847	2.6%	2.9%	74.8%	84.7
Stdev	0.03%	8.56	25.31	37.095	7.0%	2.3%	4.45%	14.7

The three-percent mean of the weighted average interbank rate depicted in Table 2 demonstrates the effect of NRB's target policy, which is in the 3–5 percentage range. This means that NRB policy appears to be effective in stabilizing the interbank rate in the long run. Although, the policy appears to be less effective in the short run. There is a lower maximum issuance for reverse repo, i.e., Rs 99.5 billion, as compared to repo. Similarly, the mean of Rs 18.06 billion indicates the above-average issuance of reverse repo, which means there is always high liquidity in the Nepalese market. In general, the NRB issues reverse repos most of the time to absorb the excess amount of liquidity. From this, it can be concluded that the issuance of reverse repo happens most often due to

excess liquidity, implying the higher size of the reverse repo as compared to the repo.

Similarly, the average interbank transaction amount was 36.847 trillion during the period of the study. Between 2002 and 2019, the interbank transaction amount varied greatly, with an average monthly deviation of NRs 37.095 billion. The availability of loanable funds in the banking sector is represented by 4.45 percent of the average standard deviation of the CCD ratio. In addition, the net average liquidity has been observed at 2.6%, which is less as compared to the regulatory requirement. Generally, interbank transactions are performed to solve short-term liquidity issues; the lower the liquidity, the higher the demand for interbank transactions, and vice versa. The 2.9% mean of T-bills indicates a very limited effect on future income streams. The exchange rate has a higher deviation, with an average deviation of NRs 14.7 per month.

Relationship between Variables

As expected, net liquidity has been found negatively (-0.04) correlated with the weighted average interbank rate (WAIR) with a moderate degree of negative correlation indicating that an increase in liquidity leads to a decrease in WAIR. Only the RREPO, Treasury bill, and CCD ratio has been found highly correlated with interbank rate and significant at the 10% level with a high degree of positive correlation of 0.36, 0.03, and 0.34 respectively. Similarly, apart from the reverse repo and Treasury bills, all other independent and control variables have a moderate degree of correlation with WAIR.

Furthermore, moderate degrees of association between variables were found except for net liquidity and Interbank amount, CCD ratio and IBA, Exchange rate and IBA, and Net liquidity and Exchange rate. Moreover, the high correlation between the CCD ratio and exchange rate indicates the chances of multicollinearity. Therefore, in the later section, a multicollinearity test has been conducted. The summary of the correlation is presented in table 3.

Table 3
Correlation Matrix

VARIABLE	WAIR	IBA	TB	NL	CCD	ER	REPO	RREPO
WAIR	1.00							
IBA	-0.046	1.00						
	(0.51)							
TB	0.03	-0.35*	1.00					
	(0.66)	(0.00)						
NL	-0.04	0.05	-0.04	1.00				
	(0.53)	(0.46)	(0.48)					
CCD	0.34*	0.42*	0.16*	-0.03	1.00			
	(0.00)	(0.00)	(0.01)	(0.7)				
ER	-0.36*	0.73*	0.21*	0.25*	0.33*	1.00		
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)			
REPO	-0.49*	0.36*	-0.02	0.03	0.31*	0.14*	1.00	
	(0.00)	(0.00)	(0.74)	(0.68)	(0.00)	(0.03)		
RREPO	0.36*	-0.09	-0.07	0.26*	-0.12	0.30*	-0.13	1.00
	(0.00)	(0.17)	(0.31)	(0.00)	(0.07)	(0.00)	(0.07)	

*Significant at 10% **Significant at 5% and ***Significant at 1%

Normality Test

The normality test result has been presented in table 4.

Table 4
Normality Test

Models	Variable	Pr(Skewness)	Pr(Kurtosis)	adj chi2(2)	Prob>chi2
1	resid1	0.36	0.19	5.83	0.145
2	resid2	0.62	0.26	4.05	0.141
3	resid3	0.25	0.16	3.56	0.120

table 4 depicts that the Probability of skewness is between 0.25 to 0.62 implying that skewness is asymptotically normally distributed (p-value of skewness > 0.05). Similarly, Pr (Kurtosis) for residuals of all models are above 0.05 which indicates that kurtosis is also asymptotically distributed (p-value of kurtosis > 0.05). Finally, chi (2) is also above 0.05 implying its significance at 5% level. Consequently, the null hypothesis cannot be rejected. Therefore, according to the skewness test for normality, residuals show normal distribution (Marrero et al, 2019).

Regression Diagnostic Test

Multicollinearity Test

The assumption for OLS regression analysis on the time series data says that there should be no multicollinearity among the independent variables. To test this assumption, the study has employed the Variance Inflation Factor (VIF) command. The rule of thumb for checking for multicollinearity using the VIF is that VIF values should be less than 10, with values between 5-10 indicating moderate multicollinearity, and values above 10 indicating severe multicollinearity (Clapp, 1992). Table 5 contains the variance inflation factor (VIF) for all independent variables.

Table 5
Variance Inflationary factor: For all model

	Model 1		Model 2		Model 3	
Variables	VIF	1/VIF	VIF	1/VIF	VIF	1/VIF
REPO	1.63	0.61			1.64	0.61
RREPO			1.51	0.66	1.52	0.65
IBA	2.45	0.41	2.76	0.36	2.76	0.36
NL	1.15	0.86	1.17	0.85	1.17	0.85
TB	2.71	0.36	2.01	0.49	2.75	0.36
CCD	1.43	0.70	1.41	0.70	1.43	0.69
ER	3.78	0.26	4.22	0.23	4.32	0.23

The table 5 depicted all the variables from model 1 to 3 have VIF less than 10 except reverse repo and repo in model 1 and 2 respectively. This indicated no multicollinearity in these three models and has been accepted the null hypothesis of no multicollinearity.

Autocorrelation Test

Table 6 represents the result summary of Autocorrelation test for all the models.

Table 6
Result of Autocorrelation

Particulars	Model 1	Model 2	Model 3
Lags (p)	1	1	1
F	61.691	66.186	61.267
Df	(1, 190)	(1, 190)	(1, 189)
Prob> F	0	0	0

Since for all the model's probability F is equal to 0%, it can be inferred that there is no autocorrelation (Chen & Greene, 2020).

Heteroscedasticity Test

Table 7 contains the result summary of the Heteroscedasticity test for all the models.

Table 7
Summary of Heteroscedasticity Test

Particulars	Model 1	Model 2	Model 3
Chi (2)	59.10	52.23	58.44
Prob > Chi square	0	0	0

Table 7 indicated that the probability chi-square for all the models is equal to 0% below the standard 0.05 level. Therefore, there is clear evidence to reject the null hypothesis of homoscedasticity at a 5% level of significance and accept the alternative hypothesis i. e. residuals of all the models are free from heteroscedasticity error (Steiger & Lind, 1980).

Effects of OMO on Interbank Rate

Table 8 represents the regression result of the dependent and independent variables incorporated in this study. Altogether, three models have been built for measuring the effect of independent variables on dependent variables. The F-value of all the regression models shows that the data fits the model. The adjusted R square of all models is greater than 85%, indicating that at least 85% of the variation in the weighted average interbank rate (WAIR) can be explained by variation in repo (REPO) and reverse repo (RREPO) and other control variables at a 1% level of significance. The coefficient of REPO has

been found significant in models 1 and 3 at the 1% level, indicating that the issuance of 1 billion NRs of repo leads to a decrease in the WAIR of 0.01% and 0.06%, respectively. Since the REPO is significant in all models except model 2, which shows that the issue of repo helps to stabilize the increasing interbank rate by offering REPO at a rate lower than the prevailing WAIR.

Similarly, the coefficient of RREPO has been found significant in model 2 at the one and five percent in model 3, indicating that for every 1 billion issues of RREPO, there is a 0.01% to 0.05% increase in the WAIR simultaneously. Similarly, Interbank transaction amount (IBA) has on average a significantly positive coefficient of 0.02. The coefficient indicates that 1 million IBA will lead to 0.02% in WAIR. The result of IBA is not consistent. There was an insignificant negative correlation between IBA and WAIR (Table 3), but the regression coefficient is positive. This may be due to the fact that the data points for the two variables have a scattered pattern that shows a general negative relationship but has some exceptions where the values of one variable increase as the other variable decreases (Osofsky & Siegel-Jacobs, 1980). In addition, Net Liquidity (NL) has a negative and significant coefficient above 0.047 for all three models. This means that a 1% increase in NL results in a decrease in WAIR of more than 0.047%.

Table 8
Regression Result

Variables	Model 1	Model 2	Model 3
Constant	-0.306**	-0.04***	-0.029**
	(0.013)	(0.013)	(0.013)
REPO	-0.01***		-0.06***
	(-0.005)		(-0.01)
RREPO		0.04***	0.01**
		(0.01)	(0.005)
IBA	0.01***	0.03***	0.02**
	0.00	(0.00)	(0.00)
NL	-0.049***	-0.047***	-0.047***
	(-0.010)	(-0.010)	(-0.010)
TB	0.832***	0.920***	0.836***
	(0.047)	(0.042)	(0.047)
CCD	-0.072***	-0.081***	-0.073***
	(-0.017)	(-0.018)	(-0.017)
ER	-0.002***	-0.001***	-0.003***
	(0.00)	(0.00)	(0.00)
Adj-R sqr	0.875	0.868	0.875
P > F	0.00	0.00	0.00
F	232.26	217.93	198.74

*Significant at 10% **Significant at 5% and ***Significant at 1%.

Treasury bills (TB) rates are significant in all three models at the 1% level of significance with a relatively strong positive coefficient. The approximate 0.9 coefficients of TB indicated that a 1% increase in the TB rate leads to a 0.9% increase in the WAIR. The credit to core capital plus deposit ratio (CCD), as expected, is significant and negative in all three models, indicating that a decrease in loanable funds availability leads to an increase in WAIR. The coefficients of the CCD ratio are -0.072, -0081, and -0.073 from models 1 to 3, which indicates that a 1% decrease in the CCD ratio leads to an increase in the WAIR by 0.072%, 0.081%, and 0.073%, respectively.

Furthermore, the exchange rate (ER) is negative and significant in all models, as expected; however, the coefficient is very small, indicating an almost negligible effect on the interbank rate. In all three models, the coefficient of ER is -0.001, indicating that a 1% decrease in exchange rate leads to an increase in the interbank rate of 0.001%. When the exchange rate rises, payment in foreign currency is postponed, which causes liquidity to rise in the banking sector, causing interbank rates to fall. Negative relationships have been seen in all models. Table 8 displays the regression results for all variables.

Hypothesis Testing

Table 9 presents the result of the hypothesis testing result. The table depicted that two hypotheses are rejected and two hypotheses are accepted. The hypothesis test result showed a negative relationship between repo and the weighted average interbank rate, while reverse repo and the interbank rate had a positive relationship. Similarly, the result shows that the transaction amount has a negative impact while the Treasury bill rate has a positive impact on the interbank rate. Moreover, the findings met the prior expectation and are consistent with earlier studies such as Yellen and Janet's (2011), Boorman and Icard's (2011), Risal and Karki's (2018), and Brooks and Yan's (1999), among others.

Table 9
Hypothesis Testing Results in Summary

Hypothesis	Null
Repo positively affects interbank rate	Rejected
Reverse repo negatively affects interbank rate	Rejected
Interbank amount negatively affects interbank rate	Accepted
Treasury bills rate positively affects interbank rate	Accepted

V. DISCUSSION AND CONCLUSION

The paper studied the effect of open market operations on the interbank rate while considering different control variables. The empirical results revealed the negative effects of repurchase agreements (Repos) and the positive effect of reverse repo agreements (R-Repos) on the interbank rate. This finding is consistent with Joseph (2012), Yellen and Janet (2011), Furfine (2000), Risal and Karki (2018), Brooks and Yan (1999), and

Johnson (2001), and contrasts with Gyntelberg and Wooldridge (2008). In addition, the study showed a negative effect of liquidity on the interbank rate, which is in line with earlier studies such as Reichenstein (1987), Robertson (1995), Christiano (1991), Leeper and Gordon (1992), Strongin (1995), Boorman and Icard (2011), Bech and Monnet (2013), and Küçük, Talasl, Ünalmş, and Yüksel (2016), but the result contradicts the finding of Furfine (2000). Similarly, the study depicted no significant effect of the CCD ratio on the interbank rate, indicating that loanable fund availability does not affect the interbank rate in the interbank market. This result is consistent with the findings of Demiralp, Preslopsky, and Whitesell (2006). In addition, the Treasury Bill rate was also found to have a positive effect on the interbank rate, indicating that an increase in the Treasury Bill rate leads to an increase in the interbank rate and vice versa. This finding is in line with Risal and Karki (2018) and Brooks and Yan (1999) but contrasts with Johnson (2001). Moreover, the study showed the negative effect of exchange rates on the interbank rate (Clifton, 1985). Finally, the study concluded that variables like repo and reverse repo, liquidity, Treasury bills, and exchange rate are important determinants of the weighted average interbank rate (WAIR).

In a nutshell, the study found a significant and inverse relationship between repo and interbank rate, whereas reverse repo is a marginally important determinant of interbank rate with an inverse relationship. Similarly, the study indicated the positive effect of the Treasury bill rate on the interbank rate. But the interbank transaction amount was not revealed as a significant variable. In addition, the CCD ratio seems to affect the interbank rate whenever other control variables remain unchanged. Furthermore, the exchange rate has been found to be negative and significant, as expected. The last but not least, the liquidity variable, as expected, was negative and significant.

Regarding future research, the study has added avenues for future research. It can be used as a guideline for conducting research on the issue not covered by this study. Since the interbank rate changes multiple times a day, segmenting the data from a monthly to a daily basis will provide precise results. Hence, future research can be conducted using daily data. Other variables like government expenditure and revenue and international trade could be added because government expenditure, revenue, and international trade are the major variables that affect the flow of money in the banking channel. Last but not least, the empirical findings of the study may be useful regarding short-term interest rates and associated topics in regard to monetary policy in Nepal. The research results may be of great benefit to central banks and those involved with repo and reverse repo markets. Furthermore, the findings of the research can be relevant to other nations that partake in practices similar to Nepal's or have comparable levels of financial growth and development.

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