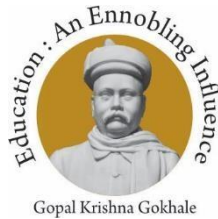


**THE IMPACT OF THE SPILLOVER OF US
QUANTITATIVE EASING ON INDIAN FINANCIAL
MARKETS: AN EMPIRICAL ANALYSIS**

A THESIS SUBMITTED IN FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE
OF
DOCTOR OF PHILOSOPHY IN
ECONOMICS AT



GOKHALE INSTITUTE OF POLITICS AND ECONOMICS

By

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(Deemed to be University u/s 3 of the UGC Act, 1956)

May 2022

*I dedicate this dissertation work to my mother, Anita Paul for encouraging me
and my spouse, Riju Samanta for being a constant support.
Both of you have been my best cheerleaders.*

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This is to certify that the thesis entitled **THE IMPACT OF THE SPILLOVER OF US QUANTITATIVE EASING ON INDIAN FINANCIAL MARKETS: AN EMPIRICAL ANALYSIS** is an authentic record of research done by MOUMITA PAUL, and submitted for the award of the degree of Doctor of Philosophy in Economics to the Gokhale Institute of Politics and Economics, Pune 411004. The thesis is her original work and has not previously formed the basis for the award of any Degree, Diploma, Associateship, Fellowship, or any other similar title of this or any other university.

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DECLARATION BY THE CANDIDATE

I, MOUMITA PAUL, hereby declare that the thesis entitled **THE IMPACT OF THE SPILLOVER OF US QUANTITATIVE EASING ON INDIAN FINANCIAL MARKETS: AN EMPIRICAL ANALYSIS** is submitted for the award of Degree of Doctor of Philosophy in Economics to the Gokhale Institute of Politics and Economics, Pune 411004. It is an authentic record of my own work completed during my tenure as a research scholar at Gokhale Institute of Politics & Economics, Pune 411004. This thesis has not been submitted anywhere for any award. Where other sources of information have been used, they have been duly acknowledged. I hereby request, to consider the thesis for the degree of ‘Doctor of Philosophy.’

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LIST OF ACRONYMS

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
APF	Asset Purchase Facility
ARDL	Auto Regressive Distributed Lag
ARMA	Auto Regressive Moving Average
BoE	Bank of England
BOJ	Bank of Japan
CAGR	Compound Annual Growth Rate
CBLO	Collateralized Borrowing and Lending Obligation
CBPP	Covered Bond Purchase Program
CD	Certificate of Deposit
CGA	Controller General of Accounts
CP	Commercial Paper
CPI	Consumer Price Index
CRR	Cash Reserve Ratio
CV	Control Variables
CSO	Central Statistical Organization
CUSUM	Cumulative Sum
DFM	Dynamic Factor Modes
DW	Durbin Watson
ECB	European Central Bank
ECM	Error Correction Mechanism
ECT	Error Correction Term
EME	Emerging-Market Economy
FED	Federal Reserve
FII	Foreign Institutional Investors
FOMC	Federal Open Market Committee
FRED	Federal Reserve Economic Data
FRFA	Fixed-Rate tender Full-Allotment
GD	Great Depression

GDP	Gross Domestic Product
GoI	Government of India
GFC	Global Financial Crisis
G-secs	Government securities
GSE	Government-Sponsored Enterprise
GVAR	Global Vector Auto Regression
GVECM	Global Vector Error Correction Model
HQLA	High-Quality Liquid Assets
IGB	Indian Government Bond
IIP	Index of industrial production
ITB	India Treasury Bill
JGB	Japanese Government Bond
LAF	Liquidity Adjustment Facility
LCR	Liquidity Coverage Ratio
LIBOR	London Interbank Offer Rate
LM	Lagrange Multiplier
LTRO	Longer-Term Refinancing Operation
LSAP	Large Scale Asset Purchase
MBS	Mortgage-Backed Securities
MSF	Marginal Standing Facility
MRO	Main Refinancing Operation
NIRP	Negative Interest-Rate Policy
NSE	National Stock Exchange
NSDL	National Securities Depository Limited
OIS	Overnight Index Swap
OMO	Open Market Operations
OLS	Ordinary Least Square
PP	Phillips-Perron
QE	Quantitative Easing
QQE	Quantitative and Qualitative Easing
RBI	Reserve Bank of India
REIT	Real Estate Investment Trust

SCB	Scheduled Commercial Banks
SDL	State Development Loan
SFSO	Special-Funds-Supplying Operation
SIC	Schwarz information criterion
SLR	Statutory Liquidity Ratio
SMP	Securities Markets Programme
SVAR	Structural Vector Auto Regressive
T-Bills	Treasury Bills
UMP	Unconventional Monetary Policy
VAR	Vector Auto Regression
VIX	Volatility Index
WACR	Weighted Average Call Rate
WITS	World Integrated Trade Solution
WPI	Wholesale Price Index
ZIRP	Zero interest-rate policy

CHAPTER I

INTRODUCTION

“There are limits to monetary policy” ~ Ben Bernanke

Monetary policy is one of the two economic policies adopted by countries to help their economies develop; the other policy tool is the fiscal policy. Monetary policy is shaped by the central bank of the country. The role of monetary policy has increased manifold in the past few decades. By managing the interest rate and total supply of money in circulation, monetary policy can stimulate an economy. Helping growth, keeping the inflation level low and stable, and ensuring higher employment can all be the objectives of a central bank. Few central banks have adopted more than one of these objectives.

In an accommodative monetary policy, interest rates in the economy are kept low. This increases money supply in the economy. Greater money supply in the hands of people increases demand for goods and services. Greater demand helps the economy grow. Low and stable inflation increases the disposable money in the hands of the people. This should lead to more savings and investments. All these are a recipe for higher growth and development. Holding interest rates low, however, is a challenge when inflation runs high in the economy. Central banks often have to raise policy rates to reduce the money supply and, thus, demand for goods and services. This in turn can bring down the inflation rate.

It is well established that in a financially integrated global economy, there is likely to be spillovers of the global monetary policy on the domestic economy. These spillovers could impact the domestic economy in multiple ways, by impacting the flows and the financial asset prices, it can impact the real economy. Based on the Mundell Fleming model trilemma, it is concluded that if there are no restriction on capital flows, then a flexible exchange rate will ensure an independent monetary policy. The corollary is that if the exchange rate is floating, along with free capital flows then the economy can have independent monetary policy (Obstfeld, Shambaugh & Taylor 2005).

However, when there is abundance of global liquidity it creates a number of risks to the domestic economy. Calvo & Reinhart (2002) discuss the ‘fear of floating’ in which the

central banks are cornered to reduce the interest rate differential to restrict large inflows. If the central bank does nothing on the face of high liquidity, then the financial conditions are impacted via the impact of the dollar as the international currency (Passari & Rey, 2015; Rey, 2015). In addition, high influx of liquidity leads to competitive easing in both advanced economies and emerging market economies (EMEs) (Rajan, 2015). Liquidity abundance has been a characteristic feature after a financial crisis. To identify the linkage between the financial crisis and liquidity, it is important to study the impact of financial crisis and the linkages between the two.

1.1 Financial crises

In the last 100 years, the world has been beset with many economic and financial crises. An economic crisis is almost always evident in falling Gross Domestic Product (GDP) growth. The crisis could also be visible in a stock-market crash, a spike in inflation or unemployment, or a series of bank failures. In a financial crisis the value of financial institutes or assets drops rapidly. Besides, investors rush to sell off assets or withdraw money from savings accounts. But economic and financial crises are not isolated events. In most instances, they overlap.

Perusing timelines of the various global crises, it is observed that the 20th century was far more tumultuous than previous centuries. Prior to the 20th century, the credit crisis of 1772 originated in London and engulfed the rest of Europe (Sheridan, 1960). The 17th century Dutch tulip mania (Veen, 2012) and the 18th century South Sea Bubble crisis (Temin & Voth, 2004) also stands out as significant episodes. At the beginning of the 20th century, after World War I, hyper-inflation in Germany was devastating (Lopez & Mitchener, 2018). This was followed by The Great Depression (GD). Romer (2003) quotes this as the “longest and most severe depression” the world had seen, lasting from 1929 to the start of World War II.

Although there was no crisis of the magnitude of the GD for the rest of the century, other crises across different regions caused significant dips. The Banker’s Panic of 1907 (Bruner & Carr, 2007); the oil crisis of 1973 (Issawi, 1979); the Latin America debt crisis in the 1980s were the major events in the first 90 years of the century (Ocampo, 2014). In the 1990s there was the Asian financial crisis; the Japanese asset price bubble; economic crises in Mexico and Argentina; and the Russian financial crisis.

The start to the 21st century has also been tumultuous with the Global Financial Crisis (GFC) which began in 2007. This was a period of extreme stress for global financial markets. In this GFC a downturn in the US housing market led to a financial crisis that spread from the US to the rest of the world. Many financial institutions suffered huge losses. Growth shrank, unemployment increased. The crisis was due to global imbalances, loose monetary policies in developed economies, financial innovation without regulation, improper credit standards, and poor corporate governance (Mohanty, 2009).

Rajan (2015) writes “The question is are we now moving into the territory in trying to produce growth out of nowhere we are in fact shifting growth from each other, rather than creating growth. Of course, there is past history of this during the GD we got into competitive devaluation ...We have to become more aware of the spill-over effects of our actions and the rules of the game that we have – of what is allowed and what is not allowed – needs to be revisited.”

1.2 Conventional policy measures

Prior to the GD, most economic theories revolved around classical economics. Regulations under the classical school centred on the belief in laissez-faire. This meant that any discrepancy would be adjusted by market movements, returning the market to a degree of equilibrium. But after the financial crash of 1929, the economy plunged and did not revive by itself. Keynesians and the monetarists explained the causes of the GD in their own ways. Keynes stated that the lower level of aggregate expenditure led to the massive decline in income and employment. On the other hand, monetarists opined that the crisis was driven by the banking crisis, which engulfed one-third of the sector and led to reduction in wealth.

From the GD till the end of 1960s, regulatory policies centered on Keynesian economics and focussed on the active intervention of the state to stimulate growth. Fiscal policy was tried in many countries from the 1960s to the end of the 1970s. A critique of the Keynesian policies was rising unemployment. The influence of Keynesian policies waned in the 1970s.

Opposition to Keynesian policies along with persistent stagflation gave way to the mounting importance of monetary policy. An accommodative monetary policy could keep

unemployment low, though at the risk of higher inflation. Since the 1980s it was believed that fiscal stimulus would be inadequate to restore an economy from recession and was only occasionally used. Romer (1992) also finds that the way out of the GD was monetary expansion: huge gold inflows and lower interest rates revived spending.

The subprime-mortgage crisis, which erupted in the U.S. in 2007, led to a full-blown international banking crisis. It may well be the worst financial crisis since the 1930s the world has seen. Nations used various combinations of government spending and tax cuts to revive economies. Central banks resorted to conventional monetary policy measures. In a conventional monetary policy, the central bank acts by setting a target for the overnight interest rate in the interbank money market and adjusting the supply of central-bank money to that target through open-market operations. Apart from altering the discount rate, other conventional monetary-policy measures include open-market operations and altering the reserve requirements.

The US Federal Reserve (Fed) reduced its benchmark policy rate to zero, popularly known as the zero interest-rate policy (ZIRP), maintaining the *nominal* interest rate at around zero from 2008 to 2015. The rationale for cutting nominal interest rates is that this can alter *real* interest rates. Since inflation expectations do not react immediately to changes in nominal rates, central banks can control real interest rates for a small period of time. When the real interest rate changes, the preference for different asset classes changes. This, in turn, impacts different asset prices; the willingness of individuals or firms to consume and invest also changes. Therefore, by altering nominal interest rates, the central bank can tweak output and employment in an economy.

The objective of the central bank is to manage liquidity in the money market in day-to-day operations while pursuing the primary objective of price stability in the medium term. At these times, all liquidity-providing operations normally take place in the form of reverse transactions against a menu of eligible collateral.

1.3 Unconventional monetary policy (UMP) measures

The problem with conventional monetary policy measures is that nominal interest rates cannot be pushed below zero. This is because people can always hold currency instead of depositing it in a bank if the short-term nominal interest rate goes below zero. This limits the effectiveness of conventional monetary policy. Central bankers are helpless when nominal interest rates near zero. This is known as the liquidity trap. As zero interest rates failed to alleviate the financial distress, central bankers resorted to policies beyond the conventional one. These were popularly termed Unconventional Monetary Policies (UMPs). It takes many forms; they are defined more by what they are not rather than what they are (Joyce, Lasaoa, Stevens & Tong, 2011).

In conventional monetary policies, the central bank is neither involved in direct lending to the private sector nor to the government, nor in outright purchases of government bonds, corporate debt or other types of debt instruments. In some cases, an UMP involves the use of negative interest rates¹. Broadly, such policies include direct lending to specific credit markets or purchases of long-term assets so as to reduce long-term interest rates. The most common form of credit easing is expansion of the central bank's balance sheet. While credit easing is intended to target specific interest rates or restore market functionality, there are policies that increase the magnitude of central bank liabilities. Such policies include Large-Scale Asset-Purchase (LSAP); commonly termed Quantitative Easing (QE). When the central bank purchases securities from the market, money supply increases and the interest rate goes down. QE increases money supply by infusing financial institutions with capital to promote increased lending and equity (Gagnon, Raskin, Remache & Sack, 2011; Krishnamurthy & Vissing-Jorgensen, 2011).

1.4 Recurrence of QE measures

The origin of QE can be traced back to Japan in the 1990s. Japan was then dealing with the bursting of a real-estate bubble and the deflationary pressure which followed. Since the policy rate was already zero, the Bank of Japan (BoJ) aimed to increase cash levels held by

¹ The Eurozone, Denmark, Sweden and Switzerland introduced a negative interest-rate policy (NIRP), where the nominal interest rate is set below zero.

banks by purchasing government securities. The BoJ was targeting a high level of reserves, which would eventually lead to more lending in the economy. This was the first time any bank had targeted the reserves, which was a major shift from policies then (Fawley & Neely, 2013; Bhattarai & Neely, 2016).

Hence, in 2001, the BoJ announced an increase in the target of bank reserves to lower the overnight call rate. By 2004, the BoJ increased the target of bank reserves, purchasing both public and private debt to increase reserves. It ended the program in 2006, when it went back to targeting the uncollateralized overnight call rate. In December 2008 the BoJ announced the special-funds-supplying operations (SFSOs), where it could lend unlimited amounts to banks at rates near zero. The BoJ supplemented this program by announcing the purchase of Japanese government bonds (JGBs), commercial paper and corporate bonds. Besides, it kept offering three- and six-month loans to banks. Toward the end of 2010, it started purchasing public and private assets.

The housing bubble collapse in 2006 followed by the bankruptcy of the Lehman Brothers in 2008 left financial markets in turmoil. The Fed initially reduced policy rates between 2007 and early 2009 from 5.25% to near zero. In November 2008, it initiated QE1, where it announced plans to purchase government-sponsored-enterprise (GSE) debt and mortgage-backed securities (MBS). First it announced purchase of \$100 billion in GSE debt and \$500 billion in MBS issued by GSEs. After four months, in March 2009, it announced purchase of \$300 billion in Treasuries, an additional \$100 billion in GSE debt and \$750 billion in MBS. This program was popularly known as the Fed's QE1 program. By the end of 2010, in November the Fed launched a second round of QE (QE2), purchasing an additional \$600 billion in Treasuries. Ten months after that, it announced QE3, which involved purchase of \$40 billion MBS a month. This was followed by QE4 in 2020 (Fawley & Neely, 2013; Bhattarai & Neely, 2016).

Even the European Central Bank (ECB) announced Longer-Term Refinancing Operations (LTRO) at the beginning of 2008 to improve liquidity in the system. In October 2008 the ECB announced fixed-rate tender, full-allotment (FRFA) operations, where it would lend to banks as much as they wanted at a fixed rate against collateral. Here, the funds were given at the ECB's policy rate, the main refinancing rate. Previously, the ECB would also lend through Main Refinancing Operations (MROs) and LTROs, where rates were determined in

the market through bidding. Toward the middle of 2009, the ECB announced the Covered Bond Purchase Program (CBPP) and 12-month LTROs. In this program the bond holder would have recourse to the issuers of the bond and the collateral; it was also necessary for the banks to hold the underlying collateral on its balance sheet. Later, in mid-2010, the ECB announced the purchase of sovereign debt from secondary markets.

The Bank of England (BoE) initiated a QE program by establishing its Asset Purchase Facility (APF) at the beginning of 2009. Through the APF, the BoE could purchase *private* assets. As this purchase was against the sale of short-term gilts, it did not increase the BoE's liabilities and was technically not QE. After three months, in March 2009, the BoE intended to increase the monetary base by £75 billion – and kept increasing the target to £200 billion in the next six months. It financed the APF purchases by issuing money, not gilts, increasing the monetary base (Fawley & Neely, 2013).

1.5 Spillover to emerging market economies (EMEs)

“Unconventional monetary policy has truly been a step in the dark” ~ Raghuram Rajan

Monetary policies of major central banks have spillover effects on EMEs (Sobrun & Turner, 2015; Gilchrist, Yue & Zakrajšek, 2019; Borio & Zabai, 2018; Dell’Ariccia, Rabanal & Sandri, 2018). This also held for UMPs. While QE was adopted by developed economies to boost asset prices, transmission channels were not always limited to only the country implementing a QE. There were spillover effects on other economies as well, especially on EMEs.

Transmission of QE to asset prices may take place through several channels. The first is the **portfolio-balancing channel** (Gagnon et al., 2011; Vayanos & Vila, 2009; Bauer & Rudebusch, 2014; Hamilton & Wu, 2012; Neely, 2010; D’Amico, English, David & Nelson 2012). QE involves purchases of longer-duration assets. This reduces the availability of these long duration assets to private investors and leads to an overall increase in demand for all substitute assets, including EME assets. In portfolio rebalancing, EME should benefit from higher asset prices and lower yields.

The second is the **signaling channel** (Bauer & Rudebusch, 2014; Krishnamurthy & Vissing-Jorgensen, 2011; Woodford, 2012; Campbell, Evans, Fisher, & Justiniano, 2012; Christensen & Rudebusch, 2012). Other markets interpret this as a signal for changes in future policy rates, or changes in the macroeconomic outlook. If the QE commitments are believed to keep future policy rates low, expectations of future short-term rates would be low. This is called the risk-neutral component (Lavigne, Sarker, & Vasishtha 2014). Huge interest-rate differences with EME are likely to increase capital flows into EMEs.

The third impact is through the **liquidity channel**. LSAP are credited as increased reserves on the balance sheets of private banks, which can be more easily traded in secondary markets than long-term assets. This reduces borrowing costs and boosts overall lending.

Most studies on EMEs have clustered economies together and commented on the entire basket of economies. Clustering economies which have fundamental differences do not allow us to incorporate political and monetary-policy backgrounds of individual economies.

While many studies (Gagnon et al., 2011; Krishnamurthy & Vissing-Jorgensen, 2011; Wright, 2011; Neely, 2010; Meier, 2009) have employed an event-study methodology, however this methodology fails to eliminate the impact of other potential significant events, announcements outside the QE event dates, contagion that runs across EMEs. While adopting the Auto Regressive Distributed Lag (ARDL) model, this study looks at cumulative data. Few studies have adopted the vector auto regression (VAR) model; however, VAR is based on many assumptions. Also the two-country VAR models cannot account for the multilateral nature of global inter-linkages – spillovers from US monetary policy may affect all economies.

Very few studies (Banerjee & Basu, 2015; Dilip, 2019; Lakdawala, 2018; Patra, Pattanaik, John, & Behera 2016a; Patra, Khundrakpam, Gangadaran, Kavediya, & Anthony, 2016c; Sahoo, Shankar & Anthony, 2020) have analyzed the spillover of the US QE on the Indian market. None of these papers, however, have included an exhaustive list of determinants of the financial variables to separate the impact of QE and other variables. Focussing only on the Indian financial market gives the study the scope to incorporate the structure of the domestic economy, and the importance of domestic variables in determining prices of Indian assets. Instead of using the event study or VAR methodology where all the variables are

endogenous, this study employs the ARDL model, which is more suitable in capturing the relation between US QE and Indian financial variables as all the variables are not hypothesized to be endogenous.

This study has incorporated an exhaustive list of domestic and global macro and financial variables to identify the spillover impact. The choice of control variables (CVs) differentiates this work from others. To proxy the US QE variables, many studies have either used the term spread or the shadow-policy rate for their analyses. Here, the asset-purchase data of the Fed has been used. The rationale for using the asset-purchase data is unlike the term spread which can be influenced by events other than QE, asset-purchase data will not.

This study makes an attempt to explore the nexus between US QE and India's financial markets. There are three main reasons for looking at QE in the US: First, it is the largest economy in the world². Second, the US is the largest trading partner of India and is the biggest market for its exports³. Third, the greatest Foreign Institutional Investors (FII) flows to India come from the US⁴. Thus, monetary policy events in the US are likely to have a huge effect on India.

1.6 Indian financial markets

The Indian financial market is one of the fastest-growing markets in the world. A number of new instruments such as market repo, Collateralized Borrowing and Lending Obligation (CBLO), Commercial Paper (CP) and Certificate of Deposit (CD) have become part of the money market, and corporate bond volumes as percent of GDP are rising. On the other hand, secondary market transactions have also been increasing; in the past twenty years the equity market has grown at a phenomenal rate. Financial sector reforms have led to the development of various segments of all financial markets,⁵

² The size of US was \$21 trillion in 2020 as per the data of the World Bank.

³ US and India did trade of \$54 billion in 2019 as per data of the World Integrated Trade Solution (WITS)

⁴ India received ₹19 trillion FII flows from US in March 2022, as per data from the National Securities Depository Limited (NSDL).

⁵ For more details on trends and developments in India's financial markets, see the respective chapters.

I. Money market

The money market is a critical segment in the financial system. It facilitates short-term demand for funds to meet short-term supply. This serves two major objectives: ensuring stability in short-term interest rates and facilitate the central bank in conducting its monetary policy. Maintaining stability in short-term rates allows the central bank to intervene to influence the level of liquidity in the system and the interest level in the economy. The money market allows the transmission of monetary policy impulses. By ensuring stability in the system, the money market helps minimize the liquidity risk of banks and achieves a balance among the various segments. Since the money market provides the first leg of any monetary policy transmission, the first impact is on the uncollateralised Weighted Average Call Rate (WACR), which is the operating target of the Reserve Bank of India (RBI) (Patra et al., 2016a). All the other markets in turn revolve around the money market.

II. Debt market

For an EME like India, a well-developed debt market is necessary. The debt market bridges the gap between lenders and borrowers. While the Indian bond market is still developing, it has grown rapidly in the last ten years. The regulatory authorities have taken an active stance in widening and deepening the scope of the debt market. Government securities (G-secs), State Development Loans (SDLs) and corporate bonds are the major types of bonds in the Indian debt market, of which the G-Sec bond market is three times the corporate bond mark. So the yield of the 10-year Indian Government Bond (IGB) is most suited to proxy the dynamics of the debt market.

III. Equity market

From a company perspective, the initial purpose of the equity market is to provide it with means of raising capital; from an investor perspective, the market provides liquidity by allowing the sale of shares to other investors at a transparent price. In the late twentieth century, financial liberalization of equity markets across the world has given foreign investors the opportunity to invest in domestic equity markets, and domestic investors the opportunity to transact in foreign equity markets. This has resulted in FII flows to the Indian stock market gradually increasing over the years. Given the dependence of the market on FII

flows, the global economic and political situation has considerable influence on Indian equities. Of the two benchmark headline indices of the Indian equity market – the Sensex and the Nifty (which share a high degree of correlation) –Nifty returns are used to capture the impact on the equity market.

1.7 Objectives of the Study

With the above-mentioned understanding, the main objectives of the present study are:

- (1) To identify the spillover channels of US QE in each of the financial markets – the money market, the debt market and the equity market
- (2) To empirically examine the impact of US QE on each financial market
- (3) To explore other factors that impact each financial market
- (4) To identify the trend of the financial market if there was no QE by the US

1.8. Methodology

To empirically estimate the short-run and long-run relationship between US QE and the chosen three segments of India’s financial markets, the ARDL model developed by Pesaran & Shin (1997) is employed.

The generalized version of the ARDL model can be written as follows:

$$\alpha(L, p)y_t = \mu_0 + \sum_{i=1}^k \beta_i (L, q)x_{it} + \mu_t \quad (1)$$

Where μ_0 is a constant; y_t is the dependent variable; x_{it} is the vector of explanatory variables and $\alpha(L, p)$ and $\beta(L, q)$ are polynomials of order p and q of the lag operator L .

Here, in addition to the QE variable, other macro and financial variables (or other factors) have been added, which have a significant bearing on the dependent financial variables chosen in this work. These CVs have been included to ascertain the impact of the changes in a dependent variable other than QE, similar to Patra et al. (2016a). However, in this study an exhaustive list of all the macro and financial variables are tested to determine its impact on the dependent variable. The selection of the CVs has been a three-step process. First, from

existing literature an exhaustive list of all variables was selected. In the second step, the correlation coefficient of the variables was calculated. In the case of two variables which were found to have a high correlation, the significance of the variable with the dependent variable was calculated using Ordinary Least Square (OLS) regression. The more relevant variable was kept. In the third step, the OLS regression was employed using all the variables. Variables which were found to be insignificant were evaluated theoretically and a final list of variables were included in the ARDL model. While a large set of variables were found to be relevant and/or empirically significant, it was necessary to keep the final model parsimonious to keep the findings relevant. This process was repeated for all the three markets.

The Weighted Average Call Rate (WACR) has been taken as a proxy variable for the money market. Apart from QE, other variables found to be important for the money market are Brent crude oil prices, the exchange rate, industrial production growth, liquidity under the Liquidity Adjustment Facility (LAF) and the repo rate. For the debt market, the 10-year IGB yield is the proxy variable. The three-month Indian Treasury Bill (ITB) yield, Brent crude oil prices, industrial production growth, net purchases under Open Market Operations (OMO), and the Wholesale Price Index (WPI) are the other independent variables. In the equity market, returns from the benchmark index, the Nifty, is considered the proxy variable of the equity market. The 10-year IGB yield, Brent crude oil prices, the Cash Reserve Ratio (CRR), the Fed policy rate, net OMO purchases, the repo rate and the reverse repo rate are the control variables⁶.

1.9. Data Source

The time period considered in the study is September 2008 to June 2019. This time period has been chosen as it marks the beginning of QE policies by the US Fed. The study analyses the impact of only one central bank – the US Fed. The exercise could be repeated for other central banks or a cumulative analysis could also be conducted. The reason for taking only US Fed for analysis is because, as mentioned before, the dominance of US economy in the world and the strong linkages it has with Indian economy. It may also be true that the impact of QE policies of other central banks on the Indian economy are likely to be similar.

⁶ For more details on the methodology adopted for the study, see Chapter 3

To identify the QE episode, US Fed balance sheet data has been taken. Weekly data for MBS, Treasuries and Federal agency debt securities have been summed (Bhattarai, Chatterjee, & Park, 2021). This data is taken from the Federal Reserve Archives, under the dataset ‘Factors affecting reserve balances...’. Since the data is reported in trillions of dollars, to make it compatible with the rest of the variables in the model, the data has been normalized. The total outstanding bonds of the US has been used as a divisor to normalize the QE variable.

Most of the data for the Indian economy has been taken from the Central Statistical Organization (CSO) – industrial production growth, wholesale price inflation. The data of the financial variables is from the RBI – liquidity under the LAF, the repo rate, the reverse repo rate, the 10-year IGB yield, the three-month ITB yield, net OMO purchases, the CRR, the WACR. The Nifty data are from the National Stock Exchange (NSE). The US Fed Funds rate and Brent crude oil prices are taken from the FRED and Bloomberg, respectively.

1.10. Scheme of the Study

The present study consists of seven chapters as presented below.

Chapter I: Introduction

This chapter identifies the history of financial crises around the world and policy measures used to rescue economies from them. The chapter talks about the evolution of UMPs since 2000 and the different UMP tools adopted by major central banks. By doing so, it introduces the objective of the study which is to empirically estimated the spillover impact of the QE measures adopted by the US on each of the financial market of India.

Chapter II: Review of literature

The first part of this chapter discusses the different policy measures adopted by the various central banks as tools of UMP. At the same time highlighting the different spillover channels via which the UMP can impact the Indian financial markets. In the later part of the same chapter, a brief discussion on the existing literature on QE is discussed. Especially, the work done in EMEs and India is identified and how this research work adds to the space is discussed.

Chapter III: Modelling methodology

The focus of this chapter is to identify the merits of using an ARDL model and compare it with the other existing methodologies used – namely the event based methods and empirical methods where VAR has been employed by many. After discussing the flow of the ARDL model, the benefits and limitations are pointed out. The chapter ends with identifying the variables and the time period used in the model.

Chapter IV: Impact on the money market

In this chapter the impact of the US QE on the money market is empirically established. To proxy the money market, the Weighted Average Call Rate (WACR) is used. After establishing all the domestic and global variables likely to have an impact on the call money market rate, it is found that the policy rate, liquidity, and exchange rate are important determinants. The empirical model shows the long-term relationship between these variables, WACR and QE. The counterfactual analysis helps in identifying the impact due to QE.

Chapter V: Impact on the debt market

In this chapter the impact of US QE on the debt market is analyzed. The benchmark 10-year Indian Government Bond (IGB) yield is chosen as the proxy variable for the debt market. The CVs for the debt market were the 3-month Indian Treasury Bill (ITB) yield, industrial production growth, Brent crude oil, inflation, and liquidity under OMO. The study finds that there exists a relationship between India's debt market and US QE.

Chapter VI: Impact on the equity market

This chapter studies the impact of US QE on the equity market. The Nifty returns are identified as the proxy variable for the equity market. The CVs in the equity market are the policy rates (The RBI's repo and reverse repo, the US policy rate), reserve requirements (the CRR), Brent crude oil prices, liquidity under OMO, the 10-year IGB yield and its own lagged values. QE had been a positive factor in increasing Nifty returns during that period, which is re-affirmed in the counterfactual analysis.

Chapter VII: Conclusion

The chapter summarises the entire work along with the key takeaways from the study. The usefulness of the study in policy formulation is discussed. Finally, the limitations and scope of further work is noted.

CHAPTER II

THEORETICAL BACKGROUND AND LITERATURE REVIEW

This chapter identifies the role of monetary policy and the evolution of unconventional monetary policies (UMPs). It critically reviews the impact of UMPs on advanced economies and the spillover to Emerging Market Economies (EMEs), focusing on the Indian market. The magnitude, methodology and scope of the existing literature are reviewed to highlight the novelty of this work. This study also broadly discusses the impact of policies on the real economy of advanced economies to infer some implications for the Indian economy.

2.1 Role of monetary policy

The role of a monetary policy is to manage interest rates and the supply of money in circulation, and is carried out by central banks. Monetary policy adopts tools to support and stimulate the economy. The objective of a central bank can differ in each country. Each central bank has its own set of goals and objectives. While the objective of the US Federal Reserve (Fed) is to ensure maximum employment and low and stable inflation, the objective of the Reserve Bank of India (RBI) is to maintain price stability while keeping in mind the objective of growth according to the RBI Act amended in May 2016. Monetary policy can be classified as conventional monetary policies which have been employed extensively in the last few decades and the relatively newer UMP which has been adopted since the beginning of this decade.

In conventional monetary policies the central bank sets a target for the overnight interest rate in the interbank money market and adjusts the supply of central bank money to that target. The chief objective is to manage liquidity in money markets and maintain price stability in the economy. The major instruments used in conventional monetary policy are open-market operations, changing the discount rate and reserve requirement. In this system, the central bank is neither involved in direct lending to the private sector or the government, nor in outright purchases of government bonds, corporate debt or other types of debt instruments. What happens when conventional monetary policy is insufficient to revive economic growth?

Bernanke (2010) notes that, for an added policy impact, once short-term rates have reached zero, the Fed must aim at pushing down longer-term interest rates. Bernanke, Reinhart & Sack (2004) write about the three policy alternatives when central banks face the zero lower bound on nominal interest rates: first, shape public expectations about the future path of the policy rate; second, quantitative easing; third, alter the balance sheet so that the supply of the security changes.

A UMP is defined as a policy that directly targets the cost and availability of external finance to banks, households and non-financial companies. Buiter (2014) classifies operations that expand the monetary base (beyond the quantity needed to maintain the current policy rate) as “quantitative easing” (QE); while those that change the composition of central bank assets without affecting base money could be referred to as “qualitative easing”. In a UMP the additional monetary stimulus is achieved by guiding medium to long-term interest-rate expectations, or by increasing the size of the balance sheet, or altering the components of the balance sheet. The sources of finance are central bank liquidity, loans, fixed-income securities or equity. Some of the major tools used are direct quantitative and credit easing, indirect quantitative and credit easing.

2.2 Stylized facts about QE

After the Great Depression (GD) growth in the 1950’s and 1960’s was due to reconstructing wartime destruction; adoption of new technologies; improvement of trade after the removal of the protectionist policies of the 1930’s. Once the easy growth came to a standstill, the Governments wanting to ensure a high level of growth resorted to higher Government spending.

The problem with higher Government spending was higher inflation, which led the Central bankers to focus the monetary policies on taming inflation. During this time the 1970’s, saw US liberalizing the industrial and financial sectors. While the liberalization brought about growth by improved competition which involved among others innovation and automation; it also led to rise in inequality. In the new economy the rich were more able to take advantage of the liberalized policies.

Europe on the other hand other kept the economy regulated, faced slower growth and higher unemployment. The establishment of euro allowed the economies to borrow cheap; this helped create jobs. But the rise in jobs led to a rise in wages, which was not tenable without a commensurate rise in productivity. Growth fell and there were large trade deficits. Debt fuelled economic growth came to an end with the Global Financial Crisis (GFC).

The GFC brought a slump in the economic activity and rising unemployment. Before the crisis, economy growth was fuelled by the ability of economic agents to borrow. It implied that the interest rates would fall so as to revive the borrowing and lending activity. However this did not happen. Because the nominal rates could not fall beyond a certain level, it was constrained by the ZIRP (Zero interest rate policy). This propelled central bankers to take the route of liquidity to drive down the real interest rates.

The central bankers using innovative ways ensured that easy liquidity was available. “ By lending long term without asking too many questions of the collateral they received, by buying assets beyond usual limits, and by focusing on repairing markets, they restored liquidity to a world financial system that would otherwise have been insolvent based on prevailing market asset prices.” Rajan (2013).

The major central banks which have adopted UMP since the beginning of the decade are the US Fed, the European Central Bank (ECB), The Bank of Japan (BOJ) and The Bank of England (BoE). Switzerland in 2013 and Sweden in 2015 also conducted Large-Scale Asset-Purchase (LSAP) programs.

The US Federal Reserve (Fed)

- The Fed initiated the QE1 program in 2008. In the first round of QE1, government-sponsored enterprise (GSE) and Mortgage-Backed Securities (MBS) issued by those GSEs were purchased by the Fed. The amount was \$600 billion.
- In 2009, the Fed announced additional purchases of \$100 billion GSE debt, \$750 billion of MBS, and \$300 billion long-term Treasury securities.
- In 2010, the Fed announced QE2, which involved purchase of additional \$600 billion in U.S. Treasuries

- In 2012, the Fed announced QE3 which involve a purchase of \$40 billion MBS a month. The program ended in 2014.
- The Fed reduced the balance sheet in 2017-2018
- In 2020, the Fed announced QE4.

The ECB

- The ECB started its LSAP program in 2008.
- At the start of 2008, it announced Longer-Term Refinancing Operations (LTROs) where the rate was determined in the market through a bidding process. Towards the end of 2008, it initiated a fixed-rate tender, full-allotment (FRFA), where it would lend to banks as much as they wanted at a fixed rate against collateral.
- In 2009 it announced a covered bond-purchase program,
- In 2010, it announced the purchase of sovereign debt in secondary markets and the Securities Markets Programme (SMP) to expand liquidity in the debt market

The BOJ

- The BOJ was the first central bank to adopt QE, which began in 2001 and ended in 2006. The program was re-started in 2010.
- The BOJ adopted the special-funds-supplying operations (SFSOs), where it would lend unlimited amounts to banks at near zero rates. The only limit on the size of loans from the BOJ to banks was the amount of available collateral (commercial paper and corporate debt)
- The BOJ also purchased Japanese Government Bond (JGB), commercial paper, CPs, corporate bonds, Real Estate Investment Trusts (REITs)
- It undertook three- and six-month loans.

The BoE

- Beginning in 2009, the BoE announced that it would start a QE program aimed at increasing the monetary base and it has continued the program.
- To increase the monetary base, the BoE financed an all new Asset Purchase Facility (APF) by issuing money (central bank reserves) rather than gilts.
- The BoE also engaged in buying private sector assets and government bonds

Source: Bhattarai & Neely (2016), Fawley & Neely (2013)

2.3 Channels of transmission

The objective of conducting a QE is to lower the term interest rate in the economy. By doing QE, the central bank wants to increase liquidity in the economy. It does so by either purchasing government securities or other securities. QE increases the money supply by flooding financial institutions with capital in an effort to promote increased lending and liquidity. With the rise in the money supply, the prevailing interest rate in the economy is reduced. There are four broad channels via which this can happen.

Portfolio-rebalancing channel

Many studies (Gagnon et al., 2011; D'Amico & King, 2013; Hamilton & Wu, 2012) have noted that this is the most significant channel through which QE affects cross-border capital flows. By reducing yields on safe long-term securities, asset-purchase programmes induce investors to shift their investments toward assets with higher expected returns, thus taking on more risk. This reduces the supply of such assets to private investors and affects the term premium in long-term interest rates due to imperfect substitutability between securities of different maturities or asset classes. This, in turn, increases demand for all substitute assets, including EME assets, as investors turn to riskier assets for higher risk-adjusted returns. This implies that the monetary stimulus is passed-through to sectors which do not hold nor issue eligible securities and therefore do not directly benefit from the programme.

Indeed, portfolio rebalancing is deemed to be able to benefit sectors, by stimulating banks' supply of loans to the sector. This is likely to boost economic activity by spreading the yields on other assets. This tends to spread the shock along the yield curve through an increase in the price of long-term assets and bonds held by financial intermediaries, which also generates a wealth effect. However, the Modigliani Miller Theorem or Ricardian Equivalence highlight that the portfolio balance channel is only likely to work when the market is segmented (Rajan, 2013).

Signalling channel

When the central bank purchases a large quantity of long-term assets, the central bank raises the interest rates it will negatively affect its portfolio of long-term assets. So when the central bank engages in QE it is implicitly signalling that interest rates would be maintained at low levels. This is likely to keep long-term bond yields low (Eggertsson & Woodford, 2003). The signalling channel affects all bond-market interest rates (with effects depending on maturities), since lower future Fed funds rates, via the expectations hypothesis, can be expected to affect all interest rates. Large interest rate differences with respect to EMEs will be expected to persist, which, in turn, trigger carry trades and capital flows into EMEs. This channel has also been an important way of transmission like the portfolio-balance channel (Bauer & Rudebusch, 2014). Christensen & Rudebusch (2012) point out that the relative contribution of the portfolio balance and signaling channels seems to depend on the guidance communication strategy pursued by the central bank.

Liquidity channel

When the central bank purchases long-term securities it increases its reserve balances. LSAPs are credited as increased reserves on the balance sheets of private banks. Reserve balances are a more liquid asset than long-term securities. Thus, QE increases liquidity with investors and decreases the liquidity premium on the most liquid bonds. This enables banks to extend credit to investors and lowers overall borrowing costs in the economy. An expansion in liquidity can be expected to reduce such a liquidity premium and increase yields. Thus QE is likely to increase the yields on the short end of the curve. LSAP can affect portfolio decisions and asset prices by raising the yield of the most liquid assets, relative to the other, less liquid assets (Gagnon et al., 2011).

Duration – risk channel

Spillover can also happen via the duration-risk channel (Vayanos & Vila, 2009). Based on the assumption of a preferred habitat model⁷, by purchasing long-term securities the central bank can reduce the duration risk and subsequently the bond yield of such securities.

⁷ The preferred habitat theory says that investors would prefer bonds which have shorter maturity and investors would buy securities with longer maturities only if they are compensated in terms of risk premium/ higher yield (Modigliani & Sutch, 1966)

Confidence channel

Neely (2010) notes that Fed announcements may provide new information about the current state of the economy. He calls this the confidence channel, which can affect portfolio decisions and asset prices by altering the risk appetite of investors. Meyer & Bomfim (2010) also talk about this channel – how LSAPs heighten confidence and risk appetite. However, this is likely to increase Treasury yields (as happened from late March through mid-June 2009).

2.4 Empirical literature on asset prices for advanced countries

As per Fama's (1970) efficient markets hypothesis, markets are likely to react to any available public information. Based on this, many studies have identified events surrounding QE to which markets are likely to react. The events would include suggestions of future QE purchases, firm statements of planned purchases, announcements of purchase slowdowns and a cutback by a central bank.

If a financial market is efficient, it is likely to react immediately to any news/announcements. If the news was anticipated or the announcement a scheduled one, the reaction is likely to be fast. However, for surprise announcements, and based on the complexity of the news, financial markets may take longer to react. Given the complex nature of a UMP, researchers have studied the impact of announcements on financial markets from a few hours to even a few days after an announcement. To identify the importance of QE and quantify its impact on asset prices, a significant amount of literature has arisen. This study discusses this in brief to identify the methods used, the conclusions reached and the scope of further related work.

Gagnon et al. (2011), in a seminal paper, find that the US QE led to a 30bp to 100bp reduction in the 10-year term premium of U.S. Treasuries. The authors used an event study (intra-day bond prices) and a time-series econometric model using the face value of privately-held debt of more than one-year maturity as percent of Gross Domestic Product (GDP) as an explanatory variable, and the 10-year yield or 10-year term premium as the dependent variable. However, the impact was more pronounced on the yields of agency debt and agency MBS, which contracted 90bps and 110bps respectively. The fall in yields was due to reduced-duration risk. These reductions in interest rates primarily reflect lower risk

premiums, including term premiums, rather than lower expectations of future short-term interest rates.

Krishnamurthy & Vissing-Jorgensen (2011) also use the event-study methodology and find evidence of a large decline in US interest rates during QE1, but not in QE2. The authors adopt a difference-in-differences approach supplemented with information from derivatives to identify the impact via each channel. They identify a number of different channels through which QE may work, such as duration, liquidity and the long-term safety channel.

Another way employed by Wright (2011) is to look at daily data on interest-rate futures to capture the impact of a QE announcement. The shocks are constructed as the first principal component of the yield changes of two-, five-, ten-, and thirty-year U.S. bond futures from 15 minutes before a given Fed announcement until 1 hour and 45 minutes after. The underlying rationale behind the approach is that when looking at high frequency data, if there is a significant variance around an event data it is likely to be the chief reason of the variability. The authors too find that the impact of QE2 was less than that of QE1.

Neely (2010) adopts the event-study methodology and finds that Treasury bond yields and corporate bond yields fell by 100bps and 80bps respectively. By using an event-study approach to assess the impact of QE announcements, Meier (2009) finds that long-term government bond yields declined by between 40bps and 100bps in the UK following the initial QE announcement by the BoE in March 2009. Even Joyce et al. (2011) finds that the asset purchases financed by the BoE depressed medium- to long-term government-bond yields by about 100bps.

The disadvantage of using an event-study methodology is that when looking at cumulative data, this method fails to eliminate the impact of other potential significant events (Kothari & Warner, 2006). It also fails to account for announcements outside QE event dates. This method does not take into account contagion that runs through EMEs.

Many authors reach a similar conclusion using an econometric model. D'Amico & King (2013) employ cross-sectional instrumental variables on the panel data. The differential effects of purchases across security characteristics such as maturity and liquidity were studied. The authors find that QE1 reduced the US long-term (5-15 year) Treasury yields by

30bps. The 10-year Treasury yield fell by 50bps. The authors also estimate cross-elasticities of their prices by estimating the substitution effects across securities. Christensen & Rudebusch (2012) use dynamic term structure models and find that while the fall in US long-term yields was due to lower policy expectations, the fall in UK long-term yields was due to reduced term premiums. Glick & Leduc (2013) found no significant effect of QE in lowering 10-year bond yields. The authors estimate the effect of a monetary policy surprise is roughly similar to that of conventional and UMPs.

The LSAP impacted asset prices in other developed countries as, globally, liquidity was impacted by QE. International (Australia, Canada, Germany, Japan, the UK) bond yields fell by around 20-80bps (Neely, 2010). His results suggest that the portfolio-rebalancing effect was more significant than the signaling effect; and efforts for more international policy coordination could be helpful. Arai (2013) and Rosa (2012) also find that QE policies in the UK and Japan had a significant effect on fixed-income markets of other developed economies, but the impact was smaller on equity markets. Darius (2010) analyzed the impact of global liquidity on asset prices, claiming that global liquidity had a significant impact on housing prices and only a limited impact on stock prices. On the other hand Forbes & Warnock (2012) find no significant role of changes in global interest rates or in global liquidity on foreign inflows and subsequent asset prices.

2.5 Empirical literature on asset prices for EMEs

With the rise in globalization of the world economy, the dependence of EMEs on the world economy has increased (Calvo, 2007). A major episode which has highlighted this dependence is the spillover impact of UMPs of major central banks. The abundance of liquidity in developed economies due to UMPs led to capital flows to EMEs. This was followed by exchange-rate and asset-price appreciations in such economies.

This unintended flow of liquidity into EMEs creates a set of problems for the central bank. At this point what would be the desirable policy of a central bank? If the central bank were to adopt a tight monetary policy and attract more capital inflows, it would lead to further appreciation in the exchange rate and asset prices. This would then push up inflation. On the other hand, a loose monetary policy pursued by a central bank would improve credit growth. This makes the role of the Government quite challenging. While a tight fiscal policy may be

appropriate in restricting aggregate demand in the economy, such measures may not be accepted well by the public. The Government would be keener to adopt policies that are pro public opinion.

External factors including excess global liquidity were among the major determinants of stock prices in EMEs (Calvo, 2007; Calvo & Reinhart, 2002; Psalida & Sun, 2009; Anaya, Hachula & Offermanns, 2017). Expansionary U.S. monetary policy plays a role in driving capital flows to EMEs. Cerutti, Claessens & Puy (2019) while looking at 34 EMEs find that the investor base, the flexibility of the exchange rate play an important role in determining the impact on capital flows.

US macro-economic news led to exchange-rate depreciation of EMEs (Özatay, Özmen, & Şahinbeyoğlu, 2009; Aizenman, Binici & Hutchinson, 2016; Alper & Forni, 2011; Fender & Hördahl, 2007; Dedola, Rivolta & Stracca, 2017). During the same time the monetary policy authorities have lowered the exchange rate to arrest the depreciation of the exchange rate (Anaya et al., 2017). Dedola et al. (2017) also find that a contractionary US monetary policy led to a depreciation of the exchange rate of EMEs.

The reaction of EME financial markets to the Fed's LSAPs announcements in 2013 and 2014 is analysed by Mishra, Moriyama, N'Diaye & Nguyen (2014). The authors identify 17 event dates when there were Federal Open Market Committee (FOMC) announcements or FOMC minutes were released. They studied changes, after these events, in exchange rates, bond yields and equity prices of 21 EMEs and find that the reaction of the financial markets depended on macroeconomic fundamentals of those economies. Economies with deeper and more stable financial markets reacted less to the events.

Even Rai & Suchanek (2014) study the impact on the financial variables (exchange rates, stock market and bond yields) of 19 EMEs. Using an event-study approach, the authors estimate the movement of the EME financial variables within two and four days from when the Fed started talking about tapering. The authors find that EMEs with strong fundamentals were more stable with less disruptions to capital flows and currency depreciation following the Fed's communications.

Aizenman et al. (2016) apply a panel framework using daily financial data of EMEs and find that the EMEs' asset prices and exchange rate were most reactive to statements made by then Fed Chairman Bernanke, not so much to other Fed officials. The authors classify the 26 EMEs into two groups – robust and fragile. Countries with current-account surpluses, high international reserves and low external debt comprised the former; the rest, the latter. In the very short term, the impact was more severe in the robust economies, but after a month the impacts were similar for both the robust and fragile economies.

Eichengreen & Gupta (2014) examine movements in exchange rates, equity prices and foreign reserves, and bond yields to identify capital-market pressures for 53 EMEs. The EMEs were grouped into strong and weak macroeconomic fundamentals. A country with a low budget deficit, low public debt, high level of reserves and high GDP growth was classified as one with strong fundamentals. The authors calculate the percentage change in these variables between April and July 2013 since this was when Fed officials began to talk of the possibility of reducing security purchases. The authors find that the strong fundamentals of a country did not soften the impact on its financial variables. Rather, the impact was correlated with the size, depth and liquidity of a country's financial market.

An event analysis of U.S. monetary policy announcements from January 2000 to March 2014 by Chen, Griffoli & Sahay (2014) have three major findings: capital flows and asset prices of EMEs are affected by U.S. monetary policy events; the spillover impact was higher in QE1 than in QE2 and the impact was especially huge following tapering announcements. The authors also note that high real GDP growth, low inflation, low debt, and strong current accounts insulate a country, and the impact of U.S. monetary policy announcements are lower.

Using an event window analysis, Morgan (2011) examines the impact of U.S. QE on inflows to Asian markets and on exchange rates there. The period from November 2009 to October 2010 is used as a baseline of no QE to study the impact of QE1 and QE2 periods. The authors find that during both QE1 and QE2 there were capital inflows to EMEs; but being small they had no significant impact on the financial markets, economic activity or inflation.

Fukuda (2018) used regression analysis to study the effect of Japan's Quantitative and Qualitative Easing (QQE) on eight East Asian economies: China, South Korea, Indonesia,

Malaysia, Singapore, Thailand, Taipei and Philippines. The author finds that, while the stock markets of the East Asian economies initially reacted negatively to the yen's depreciation, they responded positively as QQE progressed.

With the aid of a panel regression in the beginning and an event study and Global Vector Auto Regression (GVAR) then as a robustness check, Moore, Nam, Suh & Tepper (2013) study the impact of U.S. LSAP on 10 EMEs between 2004 and 2010. The authors find that a 10bp reduction in U.S. Treasury yield leads to a 40bp rise in the foreign ownership share of EME debt, which reduces government bond yields by 1.7 bps. During LSAP1 and LSAP2, U.S. Treasury yields fell by an estimated 100bps and 13bps, respectively. This lowered government bond yields by 17bps and 2bps, respectively. Even Georgiadis (2016) using a GVAR find the importance of the macro economic fundamentals inter alia exchange rate regime and financial market development in determining the impact of US monetary policy on EME.

Fratzsher, Duca & Straub (2013) analyse the impact of U.S. QE on 42 EMEs using daily data of portfolio flows into investment funds between 2007 and 2011. In the regression analysis, apart from using portfolio inflows, the other dependent variables are equity price returns, the first difference of long-term bond yields and the exchange rate. The independent variables included dummies for QE announcements, Fed Treasury purchases, Fed liquidity operations and variables for macro surprises. The major findings were the following: while in QE1 money flowed out of the EMEs, in QE2 money flowed into the EMEs; the actual LSAP programs had a larger impact than the announcements; the magnitude of the impact on flows was not huge; EMEs with better institutions and active monetary policies were less impacted than the others. The authors conclude that lower macro uncertainty during the later QE programs aided greater flows to EMEs.

Lim, Mohapatra & Stocker (2014) use panel regression to analyse the impact of QEs by the Fed, the ECB, the BOJ and the BoE on quarterly gross capital inflows across 60 EMEs between 2000 and 2013. The authors identify the transmission impact across all the three channels: portfolio balancing, liquidity and confidence. For the liquidity channel, the primary indicator is the three-month Treasury Bill (T Bill) yield; for the portfolio balancing channel it is the yield curve and the interest rate difference between the EM and the U.S.; for the confidence channel it is the Volatility Index (VIX). The authors find that QE effects account

for five percent of gross inflows for an EME, which implies that, of the 62 percent increase in inflows during 2009 to 2013, 13 percent was due to QE. From their simulation results, the authors estimate the impact on the capital flows to EME due to monetary policy normalization. While quantitatively small, these changes were likely to cause financial turmoil in EMEs.

Ahmed & Zlate (2014) examine the impact of UMP on net private capital flows to EMEs using regression analysis and find no statistically significant positive effects of UMP on the total inflows to EMEs. The authors, however, find that the composition of inflows changes: portfolio inflows rise.

After identifying the impact of US QE on U.S. macroeconomic and financial variables, Bhattarai et al. (2021), use a Bayesian Vector Auto Regression (VAR) to analyse the impact of the estimated U.S. QE on EME variables. The study is done for the period 2008 to 2014. The authors find that a two percent increase in Fed securities purchases pushes up the nominal exchange rate by 25bps, increases equity prices by 100bps, reduces long-term yields by three bps, and increases capital flows by two percent for the EMEs. The authors also find no significant impact on growth or inflation of the EMEs. The impact on the “Fragile Five” countries, Brazil, India, Indonesia, South Africa and Turkey, were more pronounced than on the other eight EMEs included in the study.

Chen, Filardo, He & Zhu (2015) employ a Global Vector Error Correction Model (GVECM) and counterfactual analysis using monthly data for 2007 to 2013. The authors compare the effect of U.S. QE on both advanced and EMEs and conclude that the impact on EMEs was larger. A cut in the U.S. corporate spread led to higher growth and inflation and exchange rate appreciation among the EMEs. U.S. QE also led to overheating of certain economies such as Brazil and China.

Dahlhaus & Vasishtha (2014) use a VAR model with monthly data for 2004 to 2014, to estimate the impact of the normalization of U.S. monetary policy on portfolio flows on 23 EMEs. The endogenous variables used in the analysis are the Fed funds rate, the spread between the U.S. 10-year Treasury yield and the Fed funds rate, the Fed funds futures contracts at the 36-month horizon, U.S. inflation, U.S. industrial production growth, and the VIX. The variable of net portfolio flows to EMEs was to capture the spillover impact. The

authors conclude that the impact on portfolio flows is small but nevertheless can be linked to huge financial volatility in the EMEs.

Bowman, Londono & Saprizza (2015) uses the VAR methodology to identify the impact of U.S. UMP on 17 EMEs, using daily data from 2006 to 2013. The financial variables included in the study are sovereign bond yields, exchange rates and stock prices. The authors find that U.S. UMP lowered the sovereign yields of the U.S. and the EMEs. Within the group of EMEs, countries with weak macroeconomic fundamentals were more perturbed by the UMPs. However, the authors note that U.S. UMP might not have outsized effects on asset prices in EMEs if a country's time-varying vulnerability is taken into account or strong fundamentals in an EME can reduce any spillover impact.

With a VAR model, where the dependent variables were long-term sovereign bond yields, nominal effective exchange rates, and industrial production, IMF (2014) and IMF (2015) analysed the impact of QE by the U.S., the UK, the Euro area and Japan on EMEs. To identify QE in the advanced economies, the study use daily data of long-term bond yields and stock prices. The authors find that a positive money shock (defined as a day on which U.S. yields rise, stock prices fall, and the exchange rate appreciates) led to capital outflows, currency depreciation, fall in stock prices and in industrial production in EMEs.

The VAR model does not need to specify the variables as endogenous or exogeneous – all are considered to be endogenous. However, the problem with using the VAR model is that it is based on many assumptions. Besides, the VAR model allows inferences about the importance of only one country factor at a time. Static models are unable to capture dynamic relations between variables. Also the two-country VAR models cannot account for the multilateral nature of global inter-linkages – spillovers from U.S. monetary policy may affect all economies

By employing a structural vector auto-regressive (SVAR) analysis, Murray (2017) investigates the impact of the U.S. on the monetary policy of Jamaica between 1992 and 2014. The author uses the shadow policy interest rates for the U.S. and Jamaica to study the spillover impact. The author finds evidence of direct policy spillover since the monetary policy of Jamaica co-moved with changes in the U.S. monetary policy.

These papers have looked exclusively at the spillover impact of UMP on the Indian financial market. Patra et al. (2016a) study the impact of global spillovers on Indian financial variables. The authors find that there was no spillover on Indian government bond yields and no significant impact on the equity market. However FPI debt flows were impacted by the UMPs and the global spillovers do affect the transmission of monetary policy. Dilip (2019) uses VAR to study the spillover impact on daily zero-coupon yields from 2009 to 2019. The study finds that there was a significant impact on the yield and that the spillover impact has increased over the years and the spillover has been more transmitted through the term premium channel than through the risk neutral rate channel.

Lakdawala (2018) uses daily stock return data and a time varying approach to estimate the impact of US monetary policies on the Indian stock market. The authors find that there was strong transmission, and the channel of transmission was the uncertainty channel. FII flows and exchange rate are sensitive to the monetary policy decisions and were impacted during QE. Patra et al. (2016c) use a combination of event study and VAR to find that there was significant impact of US QE on the monetary conditions in India via the portfolio rebalancing and liquidity channel. The largest impact was during QE1 and taper announcement.

Sahoo et al. (2020) study the volatility spillover from the U.S. UMP on the five EMEs (including the Indian bond market). The authors use the same variables as Patra et al. (2016a); employ the AR(k)-GARCH model to estimate the impact. There was a significant impact of QE1 and the taper tantrum on volatility of Indian bond markets, and the effect was persistent.

By employing a dynamic stochastic general equilibrium (DGSE) model, Banerjee & Basu (2015) estimate the impact of QE on the India economy via the terms of trade⁸. The authors take QE as a shock to the foreign interest rate and they analyze the impact of any news related to tapering on the variable. The authors find that while the terms of trade declined initially, the effect was transient.

Many authors have cautioned about the vulnerability of EMEs to the UMP of the developed economies. Rajan (2015) argued that the tapering actions of the Fed may give rise to

⁸ Terms of trade is taken as the ratio of import to export prices (Banerjee & Basu 2015)

unnecessary volatility in global financial markets and could lead to harmful spillover effects. Rajan (2011) and Mishra et al. (2014) note that such events have led to mispricing of domestic assets in the EMEs. Aizenman et al. (2016) raise the question whether the heterogeneous response across EMEs was a function of the capital inflows received by the economies. The authors IMF (2014) and IMF (2015) conclude that money shock had adverse spillovers on EMEs. MacDonald (2017) identify that the degree of economic integration between the US and the EME; the types of assets purchased by Fed are important determinants of the impact of US UMP on EME asset prices.

2.6 Empirical literature on the effect of economic variables

The impact of QE was not limited to only the financial variables. The LSAP program by the Fed is likely to increase GDP and inflation in the US (Chen, Curdia & Ferrero, 2012; Chung, Laforde, Reifschneider & Williams, 2011; Bauer & Rudebusch, 2014). Joyce et al. (2011) and Weale & Wieladek (2016) find that the QE programme of the BoE, which involved the purchase of £200 billion of UK gilts, led to an increase in GDP and increase in inflation. Bridges & Thomas (2012) find that the BoE's QE measure would lead to a similar impact.

Lenza, Pill & Reichlin (2010) study the effect of QE conducted by the Fed, the ECB and the BoE employing counterfactual analysis using the large Bayesian VAR framework developed by Giannone, Lenza & Reichlin (2019). The authors find that the UMP had lowered the unemployment rate in the countries by 0.5 percentage points and helped in the flow of bank loans, which increased GDP growth.

Auerbach & Obstfeld (2004) and Bernanke (2017) finds that the impact of QE on the real economy is via the fiscal channel. This channel relies on the observation that sufficiently large monetary injections will allow higher government spending. For the policy to have an impact, however, it has to be tied to the forward guidance that the injection will not be withdrawn.

On the other hand Curdia & Woodford (2011) find that if households perceived the assets purchased (such as short-term government bonds) as equivalent to reserves, the LSAP programs have no effect on the macro economy. Even Harrison (2012) finds that while asset purchases can improve aggregate welfare, their quantitative relevance appears to be limited.

Eggertsson & Woodford (2003) find in their New Keynesian model that LSAP programs are unlikely to have any impact on the macro economy as market participants will benefit from arbitrage opportunities. The authors also note that reduction in the private sector portfolio risks will be offset by a corresponding increase in the riskiness of the public sector portfolio due to the inherent uncertainty of future taxes and spending. Lam (2011) while studying the financial indicators of Japan in the 2000s found that the policies had no impact on inflation or the exchange rate.

On the other hand, Fujiwara (2005), while examining the effect of QE on inflation in Japan found inflation expectations raised slightly, post-QE. Auerbach & Obstfeld (2004) find that monetary expansion during a liquidity trap in Japan led to inflation, and output rose as well when prices were not fully flexible. Bridges & Thomas (2012) find in their study of the UK that QE had a positive impact on GDP and inflation. Chen et al. (2012) come to the same conclusion for the U.S. economy.

Very few studies exist on the spill over impact of US QE on the economic variables of EMEs. Dedola et al. (2017) while analyzing 36 countries (advanced and EMEs), find that a contractionary US monetary policy led to a fall in GDP and industrial production; a rise in the unemployment. On the other hand, Anaya et al. 2017 find that the loose US monetary policy led to real GDP growth of 0.3 percentage points. The authors note that the QE measures led to a response of the EME central banks by lowering the interest rate. Economic uncertainty has an impact on the inflation expectation in India (Ghosh, Sahu & Chattopadhyay, 2017).

2.7 Future of the QE program

The problem of an easy monetary policy stance is the lower real interest rate it brings about and triggers an increase in commodity prices such that investors expect commodity prices to decline in future (Frankel 2006). In equilibrium, the low real interest rate merely suffices to compensate investors for the expected depreciation (assuming other costs of carrying inventories, such as storage costs and any risk premium, are either constant or also low).

Tobin & Brainard (1968) note that as money and other financial assets are imperfect substitutes, an increase in the money supply induces households and firms to try to rebalance

their portfolios by trading money for non-money assets. But because the private sector collectively cannot change its asset holdings, attempts to rebalance portfolios will tend to raise the prices and lower the yields of non-money assets. This will lead to higher asset values and lower yields.

What happens when the QE has to be withdrawn? Meier (2009) notes that the challenges ahead, notably related to the appropriate timing, scale, and fine-tuning of the BoE's unconventional operation. The credit provision to private nonbanks stretches the BoE's operations well beyond standard monetary policy. If the central bank raises rates, it suffers a loss on these assets (Clouse, Henderson, Orphanides, Small & Tinsley, 2000). So the central bank may want to continue to purchase long-term assets or maintain the balance for a long time. Eggertsson & Woodford (2003) also note that an optimal policy would be to keep the nominal interest rate lower for a longer period than would be implied by a discretionary policy. The QE policy raises pertinent questions regarding the timing and the nature of the exit strategy (Williams, 2011).

Eggertsson (2013) talks about the deflation bias. While the public understands the benefits today of committing to lower future real interest rates, it also understands the government's incentive in the future to renege on these promises once the economy has recovered.

The problem is not only limited to inflows of capital into EMEs. What happens when the UMPs are reversed? Since the objective of QE was to impact asset prices, the reversal will lead to volatility in asset prices. Rajan (2015) notes what happens to those assets where prices have gone up due to leverage. Sudden outflows of capital from these sectors would lead to a large-scale economic loss. All this makes it imperative to study the impact of UMP on each financial market and the spillover channels. There are three primary channels identified in the existing literature via which the impact of QE is likely to spill over to the EMEs. The objective of the work is to identify the spillover impact of the US QE on the Indian financial market and suggest suitable policy prescription to reduce the volatility of the impact.

While there is extensive literature on the impact of the U.S. QE on advanced economies, there are fewer studies on the impact on EMEs. For India the work is limited⁹. Focusing only

⁹ Seminal work done by Lakdawala (2018), Patra et al. (2016a), Patra et al. (2016c), Prabu et al. (2016)

on the Indian financial market gives the thesis the scope to incorporate the structure of the domestic economy, and emphasises the importance of domestic variables in determining Indian asset prices. Instead of using the event study or VAR methodology where all the variables are endogenous, this study employs the Auto Regressive Distributed Lag (ARDL) model, which is more suitable in capturing the relation between the U.S. QE and the Indian financial variables.

2.8 Conclusion

The study of the literature of the QE shows that the LSAP was successful in lowering long-term interest rates, which was aimed at improving growth. The LSAP program also led to higher inflation rates in developed economies. The spillover of QE on EMEs is also proven. The impact on EMEs have varied based on their macro-economic fundamentals, and restrictions on capital flows imposed by those countries. The impact was more severe during the Fed tapering, which resulted in the fall in equity markets in the EMEs.

CHAPTER III

METHODOLOGY

In this chapter the study critically evaluates the different types of methodology used in the existing literature. The advantages of using the Autoregressive Distributed Lag (ARDL) model vis-à-vis the other models and the methodology of the ARDL model is discussed in detail. The workflow of the ARDL model and the diagnostic tests are also touched upon.

3.1 Comparison of the methodologies

The event-study methodology employed by many authors¹⁰ has the disadvantage of using a methodology that, when looking at cumulative data, fails to eliminate the impact of other potentially significant events and announcements outside the Quantitative Easing (QE) event dates. This method does not take into account contagion that runs across Emerging Market Economies (EMEs). So if the impact was not QE, but an external factor, then this methodology fails to differentiate the impact of QE and the external factor.

Within the empirical methods adopted for analysing the impact of QE, the Vector Autoregression (VAR) method is popular. The VAR methodology¹¹ or the Global Vector Autor Regression (GVAR) methodology (Pesaran, Schuermann, & Weiner, 2004), involves setting up country-specific individual VARs, then linking them through including foreign variables. While extensively employed, this methodology is applicable when all the variables are endogenous. The study hypothesizes that the QE program is not an endogenous variable. However the proxy variables for the Indian financial market are. In other words, the proxy variables of the Indian financial market cannot determine the US QE, but the reverse is true. The VAR model is also based on many assumptions and is the other disadvantage. The two-country VAR models do not account for the multilateral nature of global inter-linkages and spillovers from the US monetary policy that may affect all economies.

Chen et al. (2012) use the Global Vector Error Correction Model (GVECM) to assess the longer term effect of the US balance sheet on EMs. The GVECM framework is similar to that

¹⁰ Gagnon et al. (2011); Krishnamurthy & Vissing-Jorgensen (2011); Wright (2011); Neely (2010); Meier (2009) and others have used the event study methodology.

¹¹ Employed by Moore et al. 2013; Bhattarai et al. 2021; Dahlhaus & Vasishtha 2014; Bowman et al. 2015; Murray 2017; Dilip 2019 and others.

of the GVAR methodology. The GVECM uses the error correction term since the variables in the model have a long-term relationship.

However, in the present study the hypothesis is that there is a one-way causality between and Indian financial variables. The econometric framework which is more suitable to the analysis is the ARDL model. There is the co-integration technique (Granger, 1981 and Engle & Granger, 1987) of ARDL and there is The Johansen & Juselius (1990) co-integration techniques, also used to identify the long-run relationship between series when the variables are non-stationary.

In this study the bounds test developed by Pesaran, Shin & Smith (2001) is employed. The advantage of using the bounds test ARDL model is that, unlike traditional co-integration models, which require all the variables to be integrated into the same order, the bounds test ARDL model requires the variables to be integrated of order I(0) or I(1) or a combination (Nkoro & Uko, 2016). The bounds test is based on standard F- and t-statistics to test the significance of the variables.

3.2 Generalized version of ARDL

The generalized version of the ARDL model (Pesaran et al., 2001) can be written as follows:

$$\alpha(L, p)y_t = \mu_0 + \sum_{i=1}^k \beta_i(L, q)x_{it} + \mu_t \quad (2)$$

Where μ_0 is a constant; y_t is the dependent variable; x_{it} , is the vector of explanatory variables and $\alpha(L, p)$ and $\beta(L, q)$ are polynomials of order p and q of the lag operator L.

$$\alpha(L, p) = \alpha_0 + \alpha_1 L + \alpha_2 L^2 + \dots + \alpha_p L^p \quad (3)$$

and

$$\beta_i(L, q_i) = \beta_{i0} + \beta_{i1} L + \beta_{i2} L^2 + \dots + \beta_{iq} L^{q_i} \quad (4)$$

Where

$i = 1, 2, \dots, k$

In the long-run equilibrium $y_t = y_{t-1} = y_{t-2} = \dots = y_0$ and $x_{it} = x_{it-1} = x_{it-2} = \dots = x_0$

Using these equilibrium conditions and solving for y , we get the following long-run relation:

$$y = a + \sum_{i=1}^k b_i x_{it} + \gamma_t \quad (5)$$

Lastly, the error-correction framework of the ARDL is written as:

$$\Delta y_t = \Delta \alpha_0 + \sum_{j=1}^p \alpha_j \Delta y_{t-j} + \sum_{i=1}^k \sum_{j=1}^q \beta_{ij} \Delta x_{i,t-j} - \gamma EC_{t-1} + \mu_t \quad (6)$$

Where

$$EC_t = y_t - \hat{\alpha} - \sum_{i=1}^k \hat{b}_i x_{it} \quad (7)$$

where Δ is the first difference operator; α_j , and β_{ij} are the short-run dynamic coefficients and γ is the speed of adjustment to equilibrium. The error-correction term (ECT) determines the speed of adjustment to equilibrium.¹²

3.3 Workflow of the model

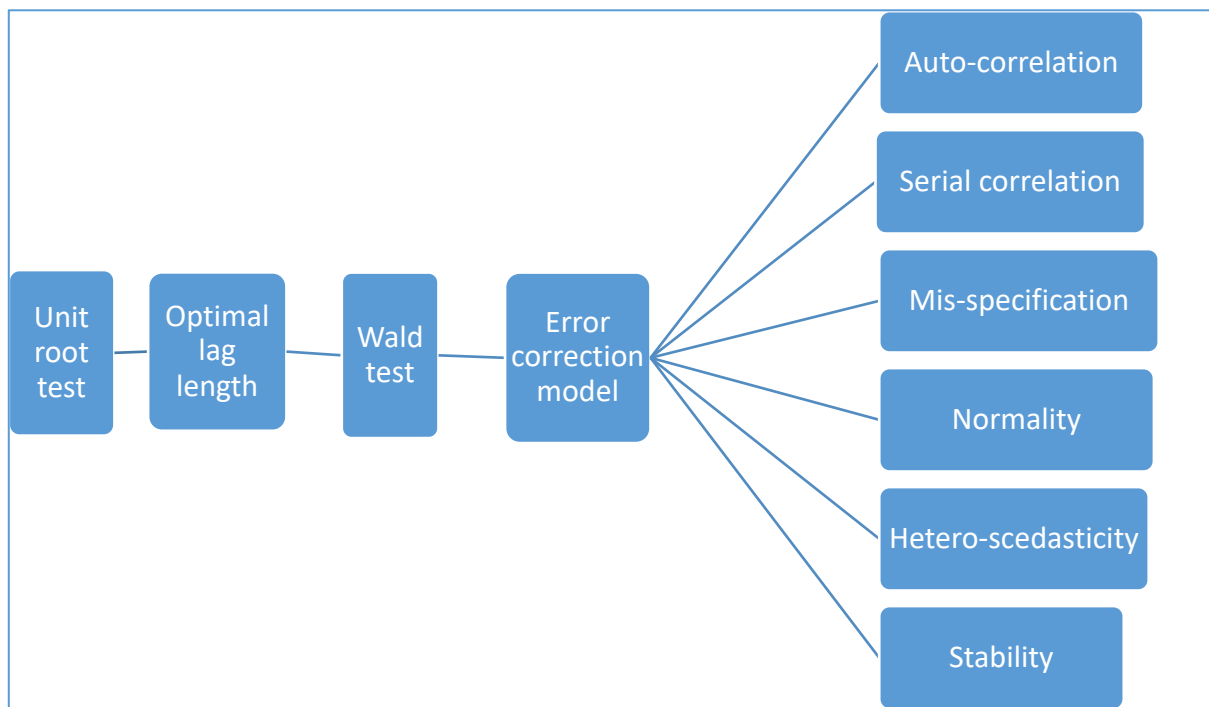
In the first step, the tentative variables are identified from the existing literature. By employing the correlation coefficient and regression using Ordinary Least Square (OLS), few of the variables are eliminated. The objective is to have an exhaustive, yet a parsimonious model. Before estimating the coefficients with the ARDL model, the order of integration of each of the variables is estimated using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root test. This is done to ensure that the variables are of order $I(0)$ or $I(1)$ or a combination of both.

The first step of estimating the ARDL model, is identifying the optimal lag length of the variables. This is done by using the Akaike information criterion (AIC) and the Schwarz

¹² The final form of the ARDL equation for a particular market is given in the related chapter.

information criterion (SIC)¹³. The following step is to ascertain if the variables are cointegrated using the Wald test. On instances when there is a long term cointegrating relation between the variables, the error correction model (ECM) is employed. To check the robustness of the variables, the following diagnostic tests are conducted on the residuals for auto-correlation; serial correlation; model mis-specification, normality test; heteroscedasticity test and stability test. The work flow of the model is displayed in Fig 3.1.

Fig 3.1: Flow of the model



Unit root test

Most economic models are based on the fundamental assumption that the time series is stationary or is a linear combination of stationary variables in the case of multi-equation models. So it is necessary to identify the order of integration of the variable. The null hypothesis of the test is that the process contains a unit root and therefore is non-stationary; the alternative hypothesis is that the process does not contain a unit root. To calculate the stationarity of the variables the ADF test (Said & Dickey, 1984) and the PP test (Phillips & Perron, 1988) are employed.

¹³ Based on Akaike (1969) and Schwarz (1978)

Wald Test (F-test)

The existence of long-run relationships is confirmed with the help of the Wald test (F statistic) by imposing restrictions on the long-run estimated coefficients. The null hypothesis is that there are no level relationships, irrespective of whether the regressors are $I(0)$ or $I(1)$. Two sets of asymptotic critical values are given (Pesaran et al., 2001). These two sets of critical values provide a band covering all possible classifications of the regressors into purely $I(0)$, purely $I(1)$ or mutually co-integrated.

The calculated F-statistic is compared to the tabulated critical value (Pesaran et al., 2001). The explanatory variables are assumed to be integrated of order zero, or $I(0)$ for values of the lower bound, while the upper bound values assume that they are integrated of $I(0)$, or $I(1)$. Therefore, the decision rule is that if the computed F-statistic falls below the lower bound value, $I(0)$, the null hypothesis (no co-integration) cannot be rejected. Contrarily, if the computed F-statistic exceeds the upper bound value, $I(1)$, it can be concluded that the variables are co-integrated.

Diagnostic tests

For the purpose of checking the stability of the ARDL model, the following diagnostic tests are conducted on the residuals for auto-correlation; serial correlation; model misspecification, normality test; heteroscedasticity test and stability test.

(i) The Durbin Watson (DW) test for auto-correlation

The DW test is used to understand if there is a first-order auto-correlation in the residual term. The null hypothesis is that there is no first-order auto-correlation. The test statistic is d . When d is around 2 there is zero auto-correlation (Harvey, 1980). When d is greater than 2 there is negative auto-correlation; when it is less than 2 there is positive auto-correlation.

(ii) The Lagrange Multiplier (LM) test of residual serial correlation

The LM test is employed in the ARDL model and is used to test for higher order Auto Regressive Moving Average (ARMA) errors (Breusch, 1978 and Godfrey, 1978). The Breusch-Godfrey LM test statistic is calculated. The null hypothesis of the test is no serial

correlation up to a certain integer, where the integer is pre-specified. Accordingly, the alternative hypothesis is serial correlation.

(iii) The Ramsay RESET specification test of functional form

This test is used to identify if there are any omitted variables or incorrect functional form in the model (Ramsey, 1969). The test uses artificial regression, which includes the predicted value of the dependent variable and tests the statistical significance of these terms. The null hypothesis is that the model is correctly specified.

(iv) The Jarque-Bera normality test

This is a test to check whether the residual series is normally distributed. The test statistic measures the difference of the skewness and kurtosis of the series with those from the normal distribution (Jarque & Bera 1980, 1987).

(v) The Breusch-Pagan-Godfrey heteroscedasticity test

The Breusch-Pagan-Godfrey test is a Lagrange multiplier test of errors in regression (Godfrey 1978; Breusch & Pagan 1979). The null hypothesis of the test is of no heteroscedasticity (or homoscedasticity) against heteroscedasticity. The test statistic approximately follows a chi-square distribution, where the null hypothesis is that the error variances are equal.

(vi) The CUSUM (cumulative sum) test

The stability of the regression coefficients is evaluated by stability tests; stability tests can show whether or not the regression equation is stable over time (Bahmani-Okooee, 2001). The null hypothesis is that the coefficient vector is the same in every period. The CUSUM test is based on the cumulative sum of residuals with the 5% critical lines. If the test line lies within the critical lines the model is stable (Bahmani-Oskooee & Wing, 2002).

3.4 Counterfactual analysis

The ARDL model was followed by a counterfactual analysis done for each of the 3 markets. The period between September 2008 to June 2019 have been split into four segments, based on whether the QE variable was increasing or reducing. It was noted that between September

2008 to April 2010 QE was rising, this is period 1 in the study. Period 2 is between May 2010 to September 2012, when there was a decline in the QE variables. This marks the time period when no QE was done. The third period, is between October 2012 to February 2015, when asset purchases were on the rise again. The last period, Period is between March 2015 to June 2019, when the asset purchase was on the decline. To conduct the counterfactual analysis, the QE is assumed to be zero for the pertaining time period while the other variables remain unchanged. Based on zero QE for that particular period, the exercise is done for each of the proxy variable. The new series shows the possible behaviour of the proxy variable if there was no QE done.

3.5 Data

The time period for the study covers September 2008 to June 2019. This period is taken for analysis since the US had conducted its first Large-Scale Asset Purchase (LSAP) program at that point of time. This long period covers the recurring episodes of QE, the taper episode, the balance sheet normalization. Time period prior to September 2008 is avoided, since the objective of the study is to empirically analyze the spillover impact of US QE. Since monthly data is employed, a large number of data points can be include in the study.

The critical variable for the study is QE. QE is proxied by the movement of the variable, Mortgage Backed Securities (MBS), Federal Agency debt securities and US Treasuries. Since the study examines the impact of QE on the three segments of India's financial market. The following variables are selected¹⁴. From the existing literature, variables which are found relevant are selected for each model. Then, based on the correlation coefficient among the variables and the OLS regression, significant variables are selected for the ARDL model.

Money market

The Weighted Average Call Rate (WACR) is chosen as the proxy variable for the money market. Apart from the US QE, the other variables are industrial production, liquidity under the Liquidity Adjustment Facility (LAF), the repo rate, the exchange rate and Brent crude oil prices.

¹⁴ The details of variables and their expected relationship are given in the related chapter.

Debt market

The 10-year benchmark Indian Government Bond (IGB) yield is the proxy variable for the debt market. Apart from the US QE, the other variables found significant from the OLS regressions in determining the 10-year IGB yield are wholesale price inflation, the three-month Treasury bond yield, industrial production, net Open Market Operation (OMO) purchases and Brent crude oil prices.

Equity market

The returns of the Nifty 50 index is the proxy variable in the equity market model. Apart from the US QE, other domestic variables included in the model are the 10-year Government yield, the cash-reserve ratio, the Reserve Bank of India (RBI) policy rate, the reverse repo rate, and net OMO purchases. The two other variables significant for Nifty returns are the US Federal Reserve (Fed) fund rate and Brent crude oil prices.

The QE variable is proxied by the weekly average data of MBS, Federal agency debt securities and US Treasuries (Bhattarai et al., 2021). The data are published under the dataset 'Factors affecting reserve balances of depository institutions and condition statement of Fed banks' in the Federal Reserve Archives. The QE data, given in dollars, is normalized by taking it as a percentage of total outstanding bonds of the US.

The macro-economic data of the Indian domestic variables are from the Central Statistical Organization (CSO): industrial production growth and wholesale price inflation. The data of the financial variables are from the RBI: liquidity under the Liquidity Adjustment Facility (LAF), the repo rate, the reverse repo rate, the 10-year IGB yield, the three-month Indian Treasury Bond (ITB) yield, net OMO purchases, the Cash Reserve Ratio (CRR), and WACR. The data of the Nifty 50 index is from the National Stock Exchange (NSE) taken from Bloomberg. The US Federal Reserve (Fed) Funds rate and Brent crude oil prices are taken from the Federal Reserve Economic Data (FRED).

3.6 Conclusion

The chapter highlights the advantage of the ARDL model vis-à-vis other methodologies employed by other authors. The process of estimating the ARDL model is discussed in detail; along with diagnostic tests. The chapter also discusses the time period and source of the different variables used in the study.

CHAPTER IV

IMPACT ON THE MONEY MARKET

4.1 Introduction

The money market is an important feature of the financial system; it facilitates short-term demand for funds to meet near-term requirements. These serve two major objectives: (1) stability in short-term interest rates and 2) facilitating the central bank's monetary policy. A change in the money-market rate is likely to have an impact on the term structure (Moschitz, 2004). Maintaining stable short-term rates allows the central bank to intervene to change interest rates in the economy by altering liquidity in the system. Any shocks to the monetary policy are transmitted via the money market. In ensuring stability in the system, the money market helps minimise the liquidity risk of banks and achieves balance among the various segments.

The features of the money market in India have been changing over the years on the inclusion of new instruments. The money market is made of instruments with maturities of less than a year. Table 4.1 shows activity in the money market, which can be divided into uncollateralized and collateralized segments. Major instruments in the former are call money, notice money and term money. Major instruments in the latter are market repo, certificates of deposits (CDs), commercial paper (CP) and Treasury Bills (T-Bills).

Of the larger, collateralized, segment, Treasury bills constitute a sizeable proportion. The major Treasury securities are the 91-day, 182-day and 364-day T-Bills. These are short-term debt instruments issued by the Government of India (GoI) and are presently issued for the three tenures, 91 days, 182 days and 364 days. Treasury securities are zero coupon and pay no interest. The CDs which were important during the 2000s, have lost significance in the past 12 years. CP continues to be an important instrument and the use of market repos has increased in the past few years.

The most important instrument of the smaller, uncollateralized, segment is the call money market. The call money and notice money markets, which formed the core of the Indian money market for many decades, have gradually given way to other instruments such as the

CP, CDs, short term T-Bills, and repos. The size of the call money market has shrunk from ₹186 billion in 2000-01 to ₹136 billion in 2019-20 and so has its share in the money market.

Since the call market permits funds to be borrowed without any collateral, it allows short-term liquidity mismatches to be bridged in day-to-day operations. The weighted average call rate (WACR) is recognized as the operating target of monetary policy (RBI, 2021). The monetary policy is implemented daily to achieve the ultimate objective of price stability and growth (Walsh, 2011); and the operating procedure for doing this is to conduct liquidity operations so that the WACR is maintained close to the policy rate. That makes liquidity operations and the policy rate important determinants of the WACR. The RBI has been successful in keeping the WACR stable by managing liquidity efficiently (Moreno & Villar, 2011).

An interest-rate corridor has been defined since May 2011, with the interest rate on the marginal standing facility (MSF) as the upper bound and the fixed overnight reverse repo rate as the lower bound and the policy rate in between (RBI, 2011), known as the Liquidity Adjustment Facility (LAF) corridor. The WACR is maintained close to the policy rate and within the LAF corridor (Fig 4.2).

Liquidity plays an important role in determining the WACR (Potter, 2016; Kumar et al., 2017; Nascimento, 2005). When scheduled commercial banks have more liquidity than the required reserves they lend in the inter-bank market to banks falling short of liquidity needed for reserves. So the equilibrium in the inter-bank market is achieved when demand for liquidity is met by supply. When the demand and supply is not met in the inter-bank market, the RBI as net supplier of reserves intervenes. This matching of demand and supply determines the WACR. So it is not surprising to find a strong correlation between liquidity under the LAF¹⁵ and the WACR (Fig 4.2).

While the main liquidity instruments used by the RBI are the fixed and variable rate repo/reverse repo auctions, outright Open Market Operations (OMO) is another method in the hands of the RBI to alter liquidity. In an outright OMO purchase the RBI will inject liquidity

¹⁵ Liquidity under the LAF is calculated by taking the difference of the repo rate (fixed & variable), the Marginal Standing Facility (MSF), the Special Liquidity Facility (SLF) with the reverse repo rate (fixed & variable).

into the banking system, while in an OMO sale the RBI will withdraw liquidity from the banking system. Like liquidity under the LAF, there is a notable correlation between OMO and the WACR, especially in cases of surplus liquidity (Fig 4.3).

A strong relationship has been identified in the US between the Federal Funds rate and the 3-month Treasury-bill rate, which has been stable across different monetary-policy regimes (Sarno & Thornton, 2002). The relation holds true in other economies as well (Patra et al., 2016a; Sarno & Thornton, 2002; Wetherilt, 2002; Wurtz, 2003). This signifies the relation between the short-term interest rate and the policy rate. As the monetary-policy objective of the RBI is to keep the WACR close to the policy rate, an increase (decrease) in the policy rate would lead to a rise (fall) in the WACR. The correlation between the two is apparent in Fig 4.4.

Reserve requirements can influence the money market (Nascimento, 2005). Banks have to maintain a specified proportion of their net demand and time liabilities (NDTL) as cash reserves with the RBI. They may borrow from the call market to meet reserve requirements. They may frontload (backload) their maintenance at the beginning (end) of the reserve-maintenance period. Hence, overnight rates are affected by demand for reserves.

Interest rates are altered to restrict fluctuations in foreign exchange of EMEs (Eichengreen, 2005; Calvo & Reinhart, 2002; Mohanty & Klau, 2004). Based on the Mundell Fleming model,¹⁶ when the exchange rate is falling, the monetary authorities are likely to raise interest rates (this will curb inflationary pressures and stabilise the currency). A higher interest differential would attract capital inflows and result in exchange-rate appreciation. Similarly when the exchange rate is appreciating, the central bank may reduce the interest rate and let the exchange rate stabilize.

There is a positive relation between inflation and interest rate (Darby, 1975; Tobin, 1965). When the level of inflation is high, the central bank is likely to pursue a restrictive monetary policy to control the supply of money in the economy. The relation between the WACR and inflation is given in Fig 4.5.

¹⁶ The Mundell Fleming model states that the economy cannot maintain a fixed exchange rate, free capital flows and an independent monetary policy (Fleming, 1962; Mundell, 1963).

Bhatt & Virmani (2005) find that the money market in India is integrated with the money market in the US. The integration was because of the covered interest parity¹⁷ (Jain & Bhanumurthy, 2005). In September 2008, when the Fed initiated QE1, the WACR was around 10.3 percent and the repo rate was 9 percent. In the next eight months, the RBI reduced policy rates by 425 bps; it also injected liquidity by conducting a continuous series of fixed reverse repo alongside OMO. During this period, the WACR reduced to 3.1% by May 2009. In 2013, when the US Fed reduced its monthly purchase of securities (popularly known as ‘tapering’), the RBI widened the LAF by increasing the MSF by 200 bps, and restricted access to easy liquidity under normal repos (Patra et al., 2016a). The WACR rose to 9.7 percent while the policy rate remained around 7-8 percent. During the episodes of QE and tapering, the WACR was volatile and money-market spreads widened. In this chapter, we hypothesize that UMP in the US led to volatility in the WACR. The objective of the chapter is to empirically identify the impact of the US QE on the WACR.

There are two channels of transmission by which the US QE could have impacted the WACR. The first is the liquidity channel (Gagnon et al., 2011; Krishnamurthy & Vissing-Jorgensen, 2011). In QE when private banks purchase long-term assets, they sit as reserves on their balance sheets. These reserves, which are more easily tradeable than long-term securities, increase the bank’s ability to lend to investors, bringing down overall borrowing costs. The second channel is the signalling channel (Bauer & Rudebusch, 2014; Krishnamurthy & Vissing-Jorgensen, 2011; Woodford, 2012; Campbell et al., 2012; Christensen & Rudebusch, 2012). When the US does QE, other markets may interpret this as a signal of changes in future policy rates, or changes in the macro-economic outlook. With more visibility regarding the future expectation of Fed policy rates, it is likely that there was an impact on WACR, which is the operating policy of the RBI¹⁸.

To summarize, the WACR is the operating target of the RBI and is the first leg of the monetary policy transmission. This makes the WACR a good proxy for the money market. The liquidity and the RBI’s policy rate are key determinants of the WACR. While the reserve requirements, the long-term interest rate, and economic growth determine the WACR, there is evidence from existing literature supporting a spillover of US monetary policy on the

¹⁷ Covered interest parity implies that the relationship between interest rate, spot and forward currency values of the two countries are in equilibrium and there is no scope for arbitrage.

¹⁸ A detailed analysis of the theory of spillover is given in Chapter 2.

Indian money market. This chapter empirically estimates the impact of US QE on the WACR. The rest of the chapter is organized as follows. Section 4.2 gives the summary and gap in earlier empirical studies related to the impact of QE on money markets of other countries. Section 4.3 presents the empirical model and the variables for the money-market. Section 4.4 highlights important findings, and the last section concludes with takeaways from this chapter.

4.2 Summary and research gap

Few papers have analyzed the impact of US QE on short-term rates. Lim, Mohapatra & Stocker (2014) use panel regression to analyse the impact on EMEs of QE by the Federal Reserve (Fed), the European Central Bank (ECB), the Bank of Japan (BOJ) and the Bank of England (BoE). Using capital inflows across 60 EMEs over 2000 and 2013, they identify transmission through the liquidity channel. The authors use the 3-month T-Bill yield as proxy for short term rates. They find that the impact of QE spilled over to EMEs through the liquidity, portfolio-balancing and confidence channels.

Patra et al. (2016a) study the impact of global spillovers on Indian financial variables. To capture the impact through the liquidity channel the authors use the London Interbank Offer Rate (LIBOR) - Overnight Index Swap (OIS) spread. They identify the impact of the spread on the money market. The proxy for the money market is taken as the spread between the WACR and the repo rate with liquidity as the control variable (CV). The authors find there was a significant impact on the call money market following the crisis; they also note, however, that the impact was transient. The authors also find a significant increase in volatility.

Breedon, Chadha & Waters (2012) and Joyce et al. (2011), on the other hand, study the impact of QE in the UK on interest rates. While they find a significant impact on long-term rates, the impact on short-term rates was trivial.

Very few studies have analyzed the spillover of US QE on short-term rates; only one paper (Patra et al, 2016a), focused on India. The current work adds to that space. While this work is on similar lines, the objective and modelling differ. The money-market model incorporates an exhaustive list of domestic and global macro and financial variables to identify the spillover

impact of US QE on the WACR. The choice of control variables differentiates the work from others. To proxy the US QE variable, many studies have either used the term spread or the shadow-policy rate for their analyses. Here, this study used the asset-purchase data of the Fed, the rationale being that unlike the term spread which can be influenced by events other than QE, asset-purchase data will not.

Most of the work of empirical modelling has been conducted using linear regression, panel data models, global vector autoregression (GVAR), and dynamic factor modes (DFM) to estimate the spillover impacts. However, the ARDL model is more suited for this analysis and is a superior model than others.¹⁹

4.3 An empirical model

The WACR is the dependent variable in the money-market model. The study uses monthly data from September 2008 to June 2019 in an Autoregressive Distributed Lag (ARDL) model to empirically estimate the impact of US QE on the WACR. Liquidity is an important determinant of the WACR (RBI, 2018). Net liquidity under LAF is a determining variable of WACR (Bhattacharyya & Sahoo, 2011; RBI, 2018; Kumar et al., 2017). When net liquidity under the LAF is negative (which implies surplus liquidity in the system), the WACR is likely to soften. Hence, the coefficient of liquidity is expected to be negative. Two separate variables – liquidity under the LAF, liquidity under OMO – were considered as CVs for the money market model. However, the liquidity under OMO was not found to be significant in the initial Ordinary Least Square (OLS) regression and hence has not been included in the final ARDL model.

The WACR is the operating target which is maintained within the LAF corridor and close to the repo rate. Therefore, the repo rate is also an important determinant of the WACR (RBI, 2019). When the central bank increases (reduces) the policy rate, it will accordingly adjust liquidity in the banking system to influence the WACR to rise (fall). The coefficient of the repo rate is likely to be positive.

India has a flexible exchange rate: a partially free capital account and a flexible inflation-rate targeting. It is hypothesized that when the exchange rate depreciates, the central bank may

increase the WACR and widen the interest rate difference to arrest the depreciation. Hence, when the exchange rate is falling, the monetary authorities are likely to increase interest rates, which would curb inflationary pressures and stabilize the currency. Thus, the coefficient of the exchange rate is likely to be positive. Since a rise in Brent crude oil prices is likely to increase inflation, the coefficient of Brent crude oil also expected to be positive (via the inflation channel). When the level of inflation is high, the central bank is likely to pursue a restrictive monetary policy to control the supply of money in the economy.

Industrial production growth has been included as a CV to proxy economic growth. Higher growth momentum in the economy is likely to increase demand for short-term funds. This is likely to increase the WACR. The coefficient of industrial production growth is likely to be positive. The final list of variables is given in Table 4.2.

The relation between US QE and Indian money market is likely to take this functional form

$$\text{WACR} = f(\text{usqe}) \quad (8)$$

The ARDL model specifies the functional relation between the variables of interest as follows:

$$\begin{aligned} \Delta wacr_t = & \alpha + \sum_{i=1}^2 \beta_1 \Delta(iip)_{t-i} + \sum_{i=1}^2 \beta_2 \Delta(lcrude)_{t-i} + \sum_{i=1}^2 \beta_3 \Delta(lliquidity)_{t-i} + \\ & \sum_{i=1}^2 \beta_4 \Delta(lusdinr)_{t-i} + \sum_{i=1}^2 \beta_5 \Delta(qe)_{t-i} + \sum_{i=1}^2 \beta_6 \Delta(repo)_{t-i} + \sum_{i=1}^2 \beta_7 \Delta(wacr)_{t-i} + \\ & \beta_8(iip)_{t-1} + \beta_9(lcrude)_{t-1} + \beta_{10}(lliquidity)_{t-1} + \beta_{11}(lusdinr)_{t-1} + \beta_{12}(qe)_{t-1} + \\ & \beta_{13}(repo)_{t-1} + \beta_{14}(wacr)_{t-1} + \varepsilon_t \end{aligned} \quad (9)$$

where,

wacr = weighted average call rate of India

iip = growth in the index of industrial production of India

lcrude = natural log of Brent crude oil prices in \$/bbl

lliquidity = natural log of liquidity under LAF in India

lusdinr = natural log of exchange rate of India with US

qe = asset purchase by US Fed as percentage of total outstanding bonds

repo = policy rate of India

and Δ is the first difference operator; α and β_1 to β_7 are short-run dynamic coefficients and β_8 to β_{14} are long-run coefficients and ε is the error term.

To analyse the short-run dynamics, the study uses a short-run error-correction mechanism (ECM). It is specified as follows:

$$\begin{aligned} \Delta wacr_t = & \alpha + \sum_{i=1}^2 \beta_1 \Delta(ip)_{t-i} + \sum_{i=1}^2 \beta_2 \Delta(lcrude)_{t-i} + \sum_{i=1}^2 \beta_3 \Delta(liquidity)_{t-i} + \\ & \sum_{i=1}^2 \beta_4 \Delta(lusdinr)_{t-i} + \sum_{i=1}^2 \beta_5 \Delta(qe)_{t-i} + \sum_{i=1}^2 \beta_6 \Delta(repo)_{t-i} + \sum_{i=1}^2 \beta_7 \Delta(wacr)_{t-i} + \\ & \gamma(ECT)_{t-1} + \varepsilon_t \end{aligned} \quad (10)$$

where Δ is the first difference operator; α and β 's are short-run dynamic coefficients, γ is the speed of adjustment to equilibrium and ε is the error term. The error-correction term (ECT) determines the speed of adjustment to equilibrium.

Monthly data for each of the variable has been employed in the model. Most of the Indian financial data (WACR, repo rate, liquidity, exchange rate) is from Central Statistical Organization (CSO); QE data is from Federal Reserve Archive and Brent crude oil price data is from FRED. The detailed list of variables with sources is given in Table 4.2. The period of study is September 2008 to June 2019.

4.4 Results and Discussion

At the outset, for the purpose of primary investigation, descriptive statistics for the selected variables for money-market analysis are given in Table 4.3. It is found that the dependent variable, the WACR fluctuated between 3% and 11% during that period. Systemic liquidity fluctuates widely and is reflected in the high standard deviation of the variable. The other variable with a high standard deviation in the model is QE. Three variables: industrial-production growth, liquidity and QE have high kurtosis, implying there may be outliers in these datasets. All the variables except industrial production and liquidity have an almost normal skewed distribution.

The lag length of the model is estimated by minimizing the information criteria. The results from AIC and SC, suggest 2 as the optimal lag length of the model (Table 4.4). In the ADF and PP test, the null hypothesis being tested has unit root. The test is carried out with intercept term for all variables. The test determines the order of integration in the individual data series. It is observed that QE and industrial production growth are $I(0)$ while Brent crude oil price, liquidity under LAF, the repo rate and WACR are $I(1)$. The estimated unit root test results are given in Table 4.5.

The F statistic of the ARDL bound test along with the critical values is given in Table 4.6. As the number is higher than the critical values noted in the Pesaran tables, it concludes the presence of a co-integrating relationship among the variables. This implies that there is a long-term relationship between the WACR, QE, domestic macro variables – industrial-production growth, liquidity under the LAF, the exchange rate, the repo rate of the RBI and global variable crude prices. Since there is a long-term relationship among the variables, the Error Correction Model (ECM) is employed.

Estimates of the long-term coefficients of the model and the results are reported in Table 4.7. It is seen that the coefficient of the US QE is positive and significant. A one percentage-point increase in QE leads to a 0.3-basis-point rise in the WACR. Yields were anticipated to soften due to US QE (the liquidity rebalancing and signalling channels). However, the results of the study show that the impact was the opposite. It is possible that the impact of the monetary-policy changes of the RBI to counter the spillover impact of QE outweighed the spillover impact of QE.

The coefficient of the repo rate is positive and significant, and in line with expectations. The rise in the repo rate has been found to translate to an increase in the WACR. Also, the other important determinant of WACR – the coefficient of liquidity under LAF is positive and is significant at the 5 percent level.

From the ECM (as the variables have a long-term relationship), the coefficients of the short-term variables are noted (Table 4.8). The short-term coefficients of the first lag of WACR are significant and positive. This implies that the high rate in any month will increase the rate of the next month. The first month lag of the QE is negative, in line with expectation. In the short run, the QE has a negative impact on WACR (liquidity and signaling channel). The

short-term coefficient (first-month lag) of the repo rate is positive and significant. There is a direct relation between the WACR and the repo, reflected in the positive coefficient of the short-term and long-term.

The findings of the diagnostic tests are reported in Table 4.9. The test statistic of the Lagrange Multiplier (LM test) is insignificant, suggesting there is no serial autocorrelation in the model. The Breusch-Pagan-Godfrey test of heteroscedasticity is employed and it is noted that there is no heteroscedasticity in the residuals. The normality distribution of the residuals is conducted using the Jarque Bera statistic. The model does not clear the normality distribution test. The Ramsey Reset Specification test is a check for model mis-specification; the model is correctly specified. For the stability of the model and the long-term parameters, the cumulative sum (CUSUM) test is conducted (Fig 4.6). The plot of CUSUM stays within the critical 5% bounds, confirming the long-term relations among the variables and thus shows the stability of the coefficient.

A series of counter-factual scenarios have been built for September 2008 to June 2019. The four periods have been built by splitting the time into segments where the QE has changed from increase to decrease, and vice versa. The four are Period 1 September 2008 to April 2010, when the Fed increased monthly asset purchases; Period 2 May 2010 to September 2012, when asset purchases were falling; Period 3 October 2012 to February 2015, when asset purchases were on the rise again and Period 4 March 2015 to June 2019, when they fell. For each of these scenarios, QE is assumed to be zero for the pertaining time period and the similar exercise is done.

In Period 1, at the onset of QE, the WACR had a V-shape fall and recovery like the actual WACR. There would be no impact on the fall in the WACR, with or without QE. However, the rise in the WACR would have been higher were there no QE. During most of Period 2, the actual WACR was much higher than it would have been were there no QE. In Period 3, it is noted that there was a sharp rise in the WACR during 2013-14. The study suggests that this may have been caused by changes in QE measures. In the absence of QE, the WACR would have fallen (not risen). In Period 4, it is observed that the impact of QE is not much and the WACR from the counter-factual analysis shows the same trend as the actual (Fig 4.7, 4.10).

The empirical exercise reaffirms the importance of the liquidity and the repo rate in determining the WACR. Also it is noted that contrary to the expectation of US QE leading to a fall in the WACR, the WACR increased. The counterfactual analysis shows how the spillover led to the volatility in the WACR. The RBI also has been reactive to the spillover of the monetary policies. When the Fed started QE, the RBI reduced policy rates drastically. It also injected liquidity by continuous fixed reverse repo and OMO. Again, during the tapering, the RBI increased the MSF rate and restricted access to easy liquidity. However, the monetary policy actions of the RBI were aimed at protecting the domestic economy, even if the monetary policy action was not suited to the current domestic situation²⁰.

4.5 Conclusion

The money market is a critical segment in the financial system. Despite the uncollateralized segment of the money market shrinking, it serves the important role of matching demand and supply of short-term funds. The WACR is the operating policy of the RBI and is chosen as a proxy for the money market. The key determinants of the WACR are liquidity and the policy rate. Alongside this, it is found that industrial-production growth, crude-oil prices, and the exchange rate determine the WACR.

The purpose of this chapter is to analyze the long-run and short-run spillover effect of US QE on the WACR. The empirical model shows that there exists a long term relation between these variables, the WACR and QE. A one-percentage-point increase in QE leads to a 0.3-basis-point rise in the WACR. This is in line with findings from other papers, which have noted a spillover impact due to the liquidity and signalling channels. However, contrary to theory and other work, this study finds that QE led to hardening of the WACR. The counterfactual analysis shows that the WACR was more volatile in the first few periods. US QE lowered the WACR at the onset of QE, and kept the WACR higher in the second period when QE was falling.

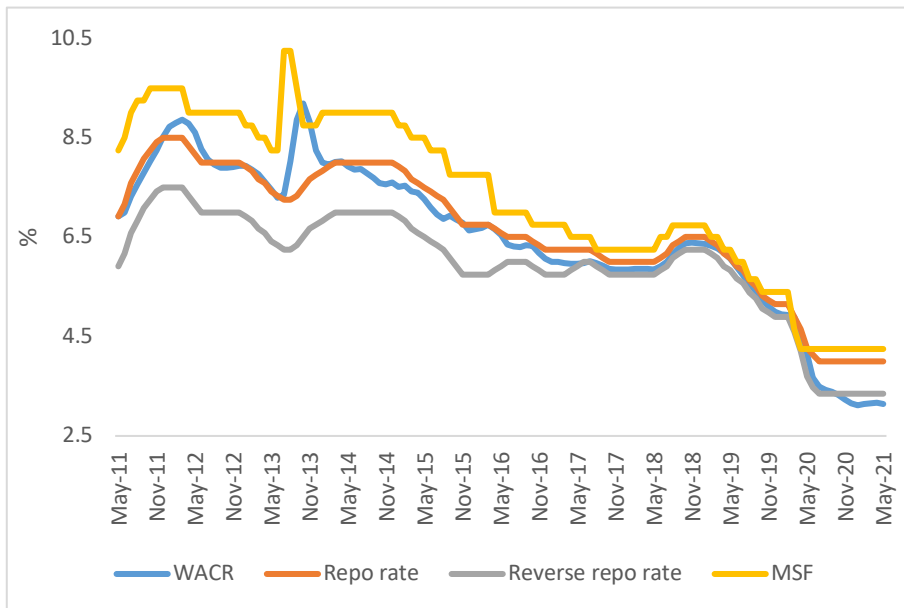
Uncoordinated international monetary policy has created a difficult situation for a central bank of an EME like India. Despite high inflation, the threat of QE forced the RBI to keep and ultra loose monetary policy. There has been a role reversal when US decided to taper the

²⁰ Before the Fed started QE1, inflation in India was ~9%. Despite such high inflation, the RBI had to reduce the policy rate substantially. India's inflation climbed up further and averaged ~ 11 percent in the next three years.

QE program. More clarity regarding the future actions of the Fed would have helped the RBI in forming its own policies.

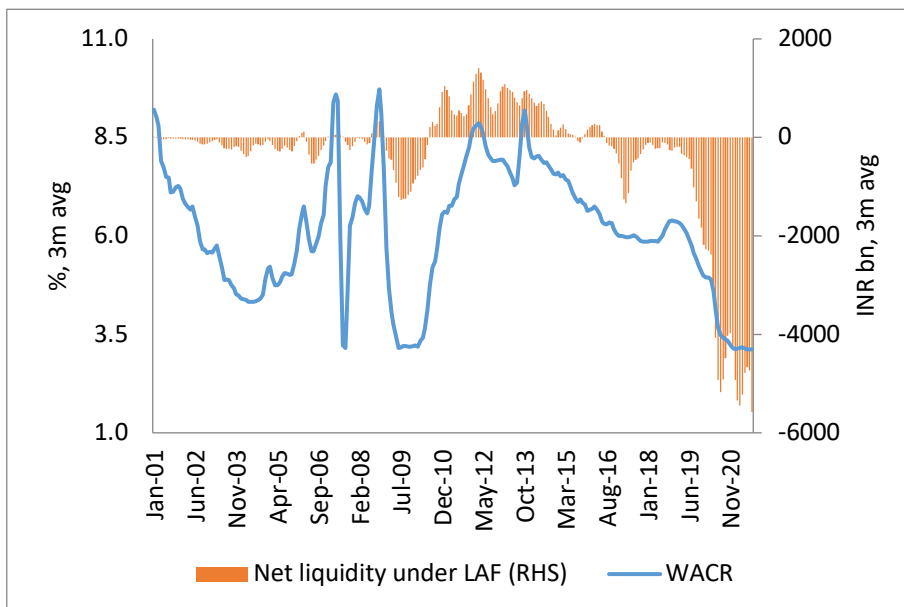
Tables and figures

Fig 4.1: Movement of the WACR, repo rate, the LAF corridor



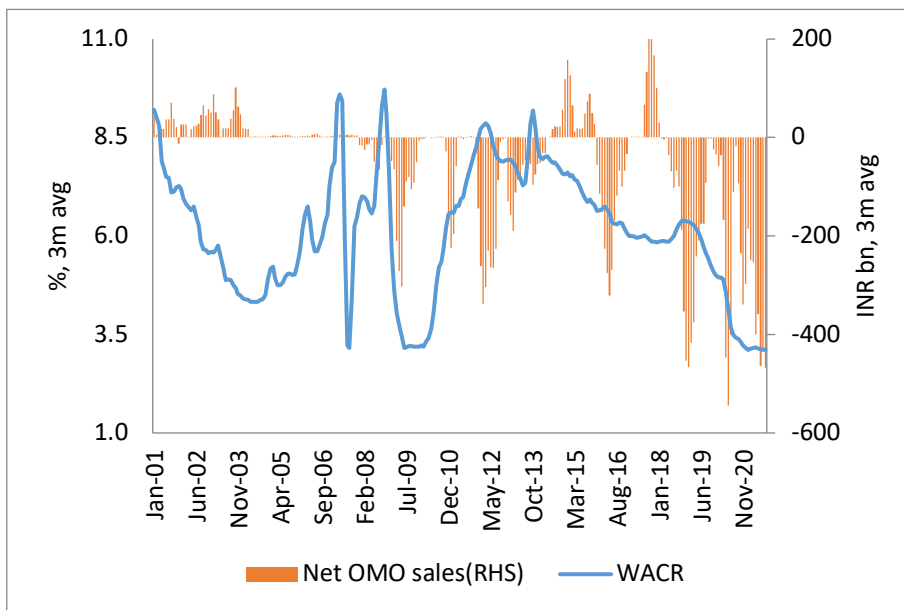
Note: In the LAF corridor, the MSF rate is the upper bound and the reverse repo rate is the lower bound
Source: RBI

Fig 4.2: Impact of net liquidity under LAF on WACR



Source: RBI

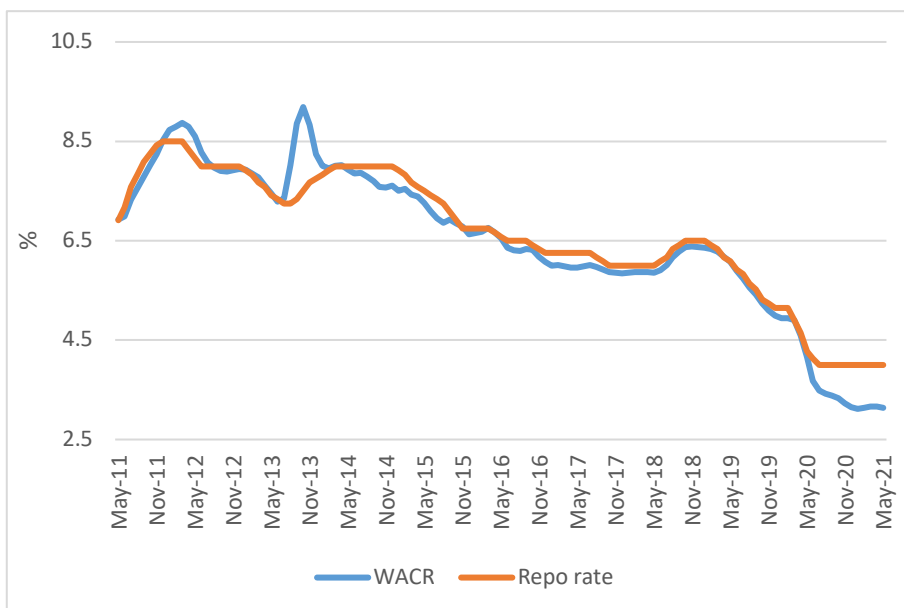
Fig 4.3: The impact of OMO on WACR



Note: Net OMO sale is the difference between purchase & sale of OMOs

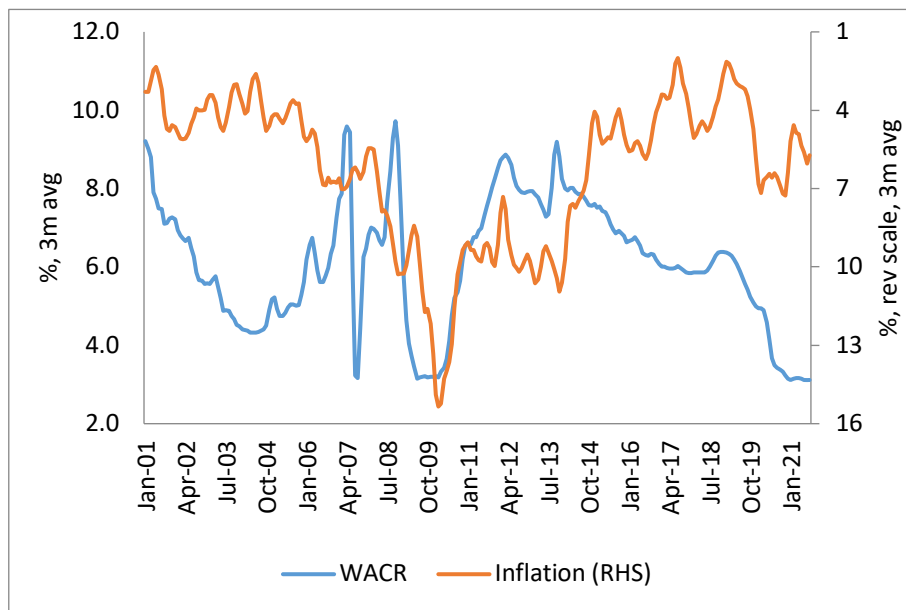
Source: RBI

Fig 4.4: Relation between WACR and the repo rate



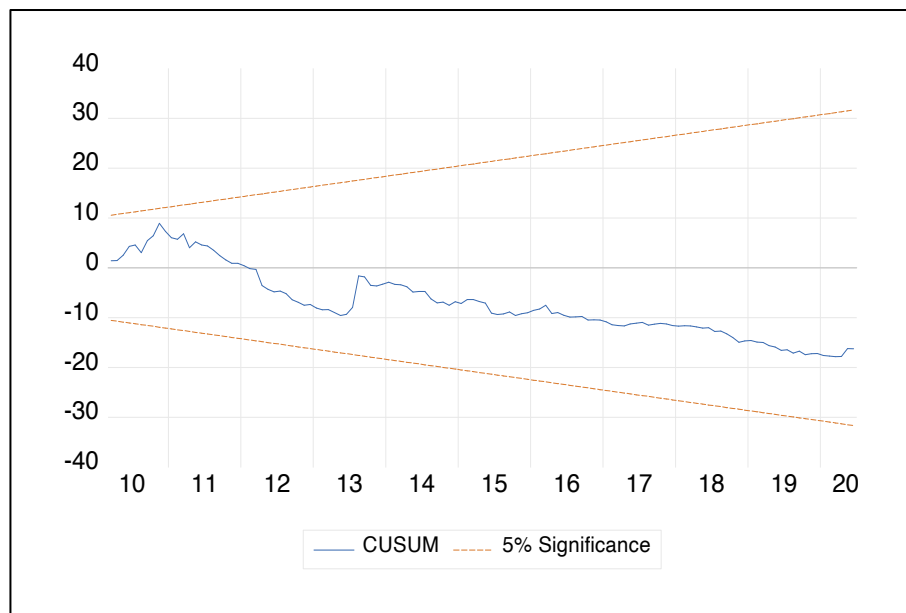
Source: RBI

Fig 4.5: Relationship between WACR and inflation



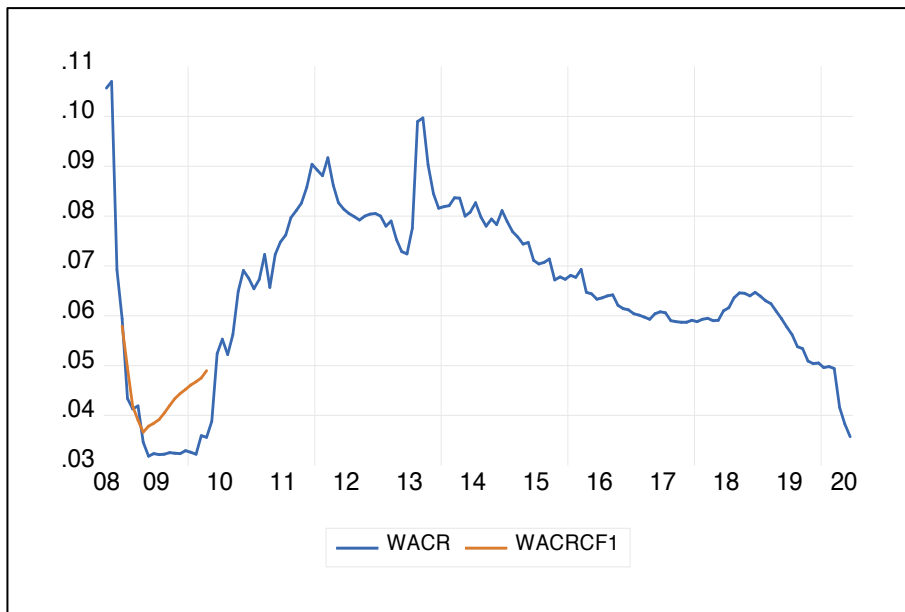
Source: RBI, CSO

Fig 4.6: Findings of the CUSUM test from the WACR model



Source: Author's estimates based on ARDL model

Fig 4.7: The movement of WACR in Period 1



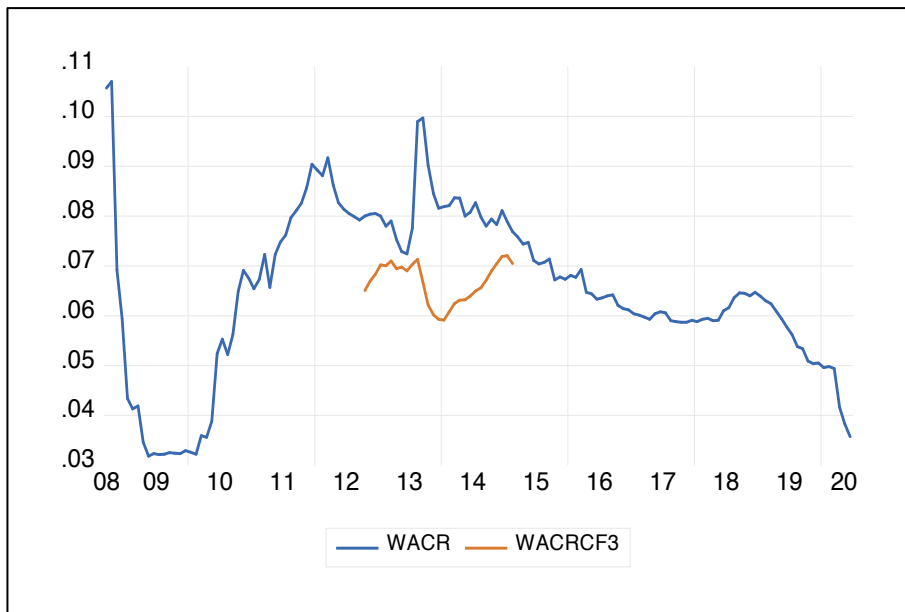
Source: Author's estimates based on ARDL model

Fig 4.8: The movement of WACR in Period 2



Source: Author's estimates based on ARDL model

Fig 4.9: The movement of WACR in Period 3



Source: Author's estimates based on ARDL model

Fig 4.10: The movement of WACR in Period 4



Source: Author's estimates based on ARDL model

Table 4.1: Activity in the money market

(INR mn)	Average daily turnover				Outstanding amount *				
	Call money	Notice money	Term money	Market repo	CP	CD	Treasury Bills		
							91 days	182 days	364 days
2000-01	186,090				58,460	7,710	19,300	-	155,000
2001-02	197,740				72,240	15,830	50,260	-	205,880
2002-03	164,030		1,590		57,490	9,080	96,520	-	261,260
2003-04	97,980		2,100		91,312	44,610	71,220	-	261,360
2004-05	73,700		1,640		134,189	120,780	283,170	-	481,330
2005-06	78,820		2,880		127,670	435,680	163,180	87,710	450,180
2006-07	97,590		3,190	72,086	173,330	932,720	452,290	172,060	538,130
2007-08	98,310		2,010	107,398	325,920	1,477,920	399,570	147,850	572,050
2008-09	100,450	27,160	2,110	107,461	441,710	1,928,670	755,500	203,750	545,500
2009-10	71,130	17,130	1,062	157,964	755,060	3,410,540	715,030	215,000	414,970
2010-11	80,695	17,893	1,251	98,858	803,050	4,247,400	703,450	220,010	424,810

2011-12	108,052	29,598	2,426	95,130	911,900	4,195,300	1,246,100	520,000	933,800
2012-13	125,510	36,657	4,764	135,789	1,092,600	3,896,100	1,050,963	641,961	1,369,460
2013-14	116,205	36,216	2,719	168,899	1,066,100	3,758,000	1,255,166	763,974	1,378,655
2014-15	95,064	32,898	2,043	191,904	1,932,700	2,809,700	1,364,166	768,250	1,482,507
2015-16	109,648	24,357	2,420	248,925	2,602,400	2,105,900	1,326,964	776,060	1,539,419
2016-17	128,355	23,207	4,221	361,027	3,979,700	1,557,400	1,056,860	871,842	1,416,782
2017-18	120,716	18,001	4,433	400,154	3,725,800	1,857,300	1,370,826	862,347	1,565,591
2018-19	154,559	24,879	3,652	420,223	4,830,800	2,722,600	911,457	1,172,925	2,042,655
2019-20	135,999	18,272	3,990	436,001	3,445,270	1,729,960	768,502	1,566,728	2,107,183

Note: * Outstanding amount is ending March

Source: RBI

Table 4.2: List of variables in the WACR model

Variable	Unit	Source	Expected signs
India weighted average call rate (wacr)	%	RBI	+
Asset purchase by US Federal Reserve as percentage of total outstanding bonds (qe)	%	Federal Reserve Archive	-
Brent crude oil (crude)	dollar/bbl	FRED	+
India industrial production index (iip)	Index	CSO	+
India liquidity under LAF (liquidity)	INR	RBI	-
India policy rate (repo)	%	RBI	+
Exchange rate of India with US (usdinr)	Ratio	RBI	+

Source: Author's estimates

Table 4.3: Descriptive statistics of the WACR model

	iip	lcrude	lliquidity	lusdinr	qe	repo	wacr
mean	0.0268	1.8200	-0.7068	1.7678	0.9468	0.0662	0.0652
median	0.0366	1.8371	-0.6721	1.7928	0.9495	0.0650	0.0646
maximum	0.1494	2.0395	0.0000	1.8822	1.6342	0.0900	0.1070
minimum	-0.5763	1.2187	-1.7187	1.6471	0.0064	0.0400	0.0318
Std Dev	0.0756	0.1525	0.2139	0.0707	0.3023	0.0117	0.0166
Skewness	-4.5925	-0.6475	-1.4015	-0.3643	0.5143	-0.1612	-0.2413
kurtosis	33.8939	3.4466	10.1567	1.7162	5.0210	2.0986	2.8153
Jarque-Bera	6146.2530	11.1037	349.5283	12.8935	30.4265	5.4225	1.5797
Probability	0.0000	0.0039	0.0000	0.0016	0.0000	0.0665	0.4539
Sum	3.0181	258.4372	-100.3604	251.0219	134.3998	9.4010	9.2716
Sum of sq deviation	0.8059	3.2794	6.4510	0.7054	10.1636	0.0193	0.0390
Observations	142	142	142	142	142.0000	142	142

Source: Author's estimates

Table 4.4: Estimated statistics of unit root test of the WACR model

	ADF		PP	
	Level	First difference	Level	First difference
iip	-3.8327 **		-5.4268 ***	
lcrude	-2.5616	-8.4592 ***	-2.1612	-8.3086 ***
lliquidity	-2.0034	-16.0930 ***	-5.5289 ***	
lusdinr	-2.3912	-11.1881 ***	-2.4018	-11.5548 ***
qe	-6.2597 ***		-3.3523 *	
repo	-2.1411	-10.7923 ***	-2.5303	-10.8059 ***
wacr	-2.9193	-9.2414 ***	-3.2913 *	

*, ** & *** indicates statistical significance at the 10%, 5% & 1% level respectively.

Source: Author's estimates

Table 4.5: Optimal lag length of the WACR model

	Lag 0	Lag 1	Lag 2	Lag 3	Lag 4	Lag 5
AIC	-8.6857	-8.7059	-8.7706*	-8.7555	-8.7429	-8.7287
SIC	-8.5336	-8.5320	-8.5750*	-8.5383	-8.5038	-8.4679

Source: Author's estimates

Table 4.6: Estimated statistics of bound test – WACR model

Significance level (in %)	Critical values		F statistics
	Lower Bound	Upper Bound	
10	2.12	3.23	4.50
5	2.45	3.61	
2.5	2.75	3.99	
1	3.14	4.43	

Source: Author's estimates

Table 4.7: Estimated long-run coefficients of WACR model

Variables	Coefficient	T-statistic	P-value
iip	-0.0110	-1.2545	0.2121
lcrude	0.0053	1.6203	0.1078
lliquidity	-0.0018	-0.6452	0.5200
lusdinr	0.0096	1.3576	0.1771
qe	0.0026 *	1.7361	0.0852
repo	0.3602 ***	4.0142	0.0001
wacr	-0.3532 ***	-4.7542	0.0000

*, ** & *** indicates statistical significance at the 10%, 5% & 1% level respectively.

Source: Author's estimates

Table 4.8: Estimated short-run coefficients of WACR model

Dependent variable	Coefficient	T-statistic	P-value
D(qe(-1))	-0.0224 *	-1.8422	0.0678
D(repo(-1))	0.3498 **	2.2198	0.0283
D(wacr(-1))	0.221 ***	2.7416	0.007
ECT(-1)	-0.2861 ***	-3.8248	0.0002

*, ** & *** indicates statistical significance at the 10%, 5% & 1% level respectively.

Source: Author's estimates

Table 4.9: Estimated values of diagnostic tests – WACR model

	L M version	p-value	F-version	p-value
Serial correlation	0.0181	0.8931	0.016	0.8996
Normality	1151.658 ***	0	NA	
Heteroscedasticity	11.1653	0.673	0.7736	0.6957

*, ** & *** indicates statistical significance at the 10%, 5% & 1% level respectively.

Source: Author's estimates

CHAPTER V

IMPACT ON THE DEBT MARKET

5.1 Introduction

A robust bond market is critical to the growth of a country. A developed bond market increases the depth of financial markets by serving the needs of the private and public spheres. It is even more relevant now as bank balance sheets are weak,²¹ impeding loan growth. Part of the funding can come from the bond market. Hence, it is no surprise that the Indian regulatory and monetary authorities recognize this and have been taking continuous steps to deepen the fixed-income market in India. Consequently, the domestic bond market has grown more than four-fold, from around ₹38 trillion in 2010-11 to ₹159 trillion in 2020-21. The types of bonds issued in the Indian domestic bond markets are (1) Government securities (G-secs), (2) State Development Loans (SDLs) and (3) corporate bonds. The activity in the bond market is given in Table 5.1

As a percent of Gross Domestic Product (GDP), government and corporate bonds have been growing. The former, which comprised 38% of India's GDP in 2010-11, has risen to 58% in 2020-21 (Fig 5.1). More significantly, during this time, corporate bonds as a percent of GDP have grown from around 12% to 18%. The major holders of government securities are Scheduled Commercial Banks (SCBs), which possessed more than one-third in 2020-21. The Reserve Bank of India (RBI) and insurance companies are other significant owners; they held respectively 27% and 11% of government bonds (Fig 5.2).

Compared to the G-sec market, the corporate bond market is still developing and is now one-third the size of the government bond market. Government and corporate bond yields are strongly correlated (0.83), visible in Fig 5.3. Within the various-tenured government bonds, the 10-year government bond has been the most traded security, with the greatest percentage of volumes being traded in the 7-year to 10-year bucket. The second-most traded security is the 5-year bond in the 5-year to 7-year bucket.²² The 10-year and 5-year bond yields also move together; there is a correlation of 0.93 (Fig 5.4). The study, therefore, identifies the benchmark 10-year Indian Government Bond (IGB) yield as the most suited variable to capture the impact on the bond market in India.

²¹ The consolidated balance sheet was ₹180 trillion in 2019-2020

²² As per data from The Clearing Corporation of India Ltd (CCIL) for 2019–20

The objective of this chapter is to identify the impact on IGB yields of the Quantitative Easing (QE) measures implemented by the US. After the Global Financial Crisis (GFC) in 2007, the Federal Reserve (Fed) initiated certain UMP measures to help the US economy to recover. QE was one of the tools adopted by the Fed in 2008. In QE, by purchasing assets of a longer-duration, the central bank reduces the yield of these securities in the US, which eventually translates to lower long-term interest rates. The Fed has undertaken QE measures since 2008, the last round being in 2020.

The Fed's purchase of long-duration assets leads to an increase in demand for all substitute assets, such as long-duration assets of Emerging Market Economies (EMEs), which affects the asset prices of EMEs. A visible co-movement between US and Indian long-term bond yields is seen; they have moved in tandem in the last 10 years, particularly after the GFC and during the taper tantrum (Fig 5.5). This throws up the question of whether there was any impact of the US QE on the long-term bond yields in India. However, while considering the impact of US QE on the Indian debt market, the study first need to establish the other determinants of 10-year IGB yields.

GDP growth is a determinant of long-term bond yields (Hilscher & Nosbusch, 2010; Afonso, 2010). The relationship between bond yields and GDP growth is not deterministic. Higher GDP growth generally entails a higher cost of funding and inflation. Consequently, the relationship is likely to be positive. That is, higher GDP growth should lead to higher yields on account of greater demand for funding and greater compensation required to cover higher inflation. In India, a discernible negative relationship between GDP growth and debt yield can be observed (Fig 5.6). That is, yields soften as growth accelerates—and vice-versa.

Higher GDP growth increases demand for gilts and reduces supply. Two main factors seem to result in the softening debt yield in India as GDP accelerates. Most government revenue in India arises from taxes. Taxation on income (both corporate and personal), in turn, comprises the greater portion of tax revenue. Progressive taxation of income leads to tax-revenue growth surpassing GDP growth when the latter accelerates. This results in a lower fiscal deficit and, thereby, the reduced need for market borrowing when GDP growth is strong. In such situations, reduced supply of sovereign bonds softens yields (Fig 5.7 and 5.8).

Higher GDP growth also generally leads to a higher savings rate. In India, households are the largest savers and a large portion of household financial savings is generally channelized to bank deposits, especially in the early phase of growth recovery. SCBs are statutorily required to invest in government securities. Higher GDP growth would lead to greater demand for such securities.

Inflation and yield are significantly correlated (Ang & Piazzesi, 2003; Hördahl & Tristani, 2014; Crump, Eusepi & Moench, 2018; Rudebusch & Wu, 2008). Unlike with GDP growth, the normative link between inflation and yield is straightforward. Higher inflation lowers real returns on government securities, leading to demand for higher nominal yields (Fig 5.9). Like most central banks, the main monetary-policy tools of the RBI are the rates at which banks can borrow from (repo) or lend to (reverse-repo) the RBI. A change in policy rates almost immediately impacts money-market rates as the former is the effective benchmark in that market. Transmission of short-term or money-market rates on long-term or debt-market rates is, however, far from certain (Fig 5.10). Consequently, tight monetary policy translating to higher debt-market yields is not axiomatic. In fact, it can be argued that, if the debt market feels that tightening by the central bank would be effective in bringing down long-term inflation, debt-market yields can soften rather than harden even when inflation is high.

Banks account for the largest holding of government securities. Over the years, they have been scaling down their holdings of excess government securities beyond that required by the statutory liquidity ratio (SLR) norms. Also, since late 2010 the RBI has reduced banks' SLR requirement. Yet, banks still have considerable excess SLR holding. In 2014, the RBI introduced the Liquidity Coverage Ratio (LCR) norms as part of the Basel III Framework on Liquidity Standards. The objective was to build up resilience to face a potentially acute liquidity-stressed situation lasting up to 30 days. Toward this end, banks need to maintain high-quality liquid assets (HQLA) so as to meet net cash outflow for 30 days under acute liquidity stress. Bank assets that qualify as part of HQLA are cash in hand, excess SLR holdings over the statutory norm and banks' borrowing limits under the Marginal Standing Facility (MSF). The movement of SLR and bond yields is given in Fig 5.11.

The sharp monetary easing following the global crisis of 2008 was accompanied by banks parking huge amounts of liquidity with the RBI under the reverse repo window, i.e., large net liquidity withdrawal by the RBI. Major rate easing, backed by the banking-system liquidity

overhang, led to a sharp softening of debt yields in this period. Thereafter, the reversal of the highly-accommodative monetary policy in 2010 coincided with a major tightening in banking-sector liquidity. From being large lenders to the RBI under the reverse-repo window, the banking system started borrowing large amounts from the RBI under the repo window. Liquidity tightening backed monetary tightening led to a major hardening of gilt yields in this period (Fig 5.12). To address the large banking-sector liquidity problem, the RBI started easing liquidity through outright government bond purchases under Open Market Operations (OMOs) by the end of 2011, well before the start of the next rate-easing cycle (Fig 5.13).

The monetary-easing cycle during 2012–2013 largely registered improvements in banking sector liquidity, and yields softened during this period. Before the policy-rate tightening started in 2013, the RBI sharply tightened banking liquidity in order to thwart a major depreciation in the rupee. The process led to the spike in debt yields. The rest of the chapter is arranged as follows: section “Summary and Gap” covers existing literature pertaining to the impact of QE on bond markets; section “Empirical Model” outlines an empirical framework for the bond market; section “Results and Discussion” delineates results and findings; section “Summary and Conclusion” concludes the chapter.

5.2 Summary and Gap

Following the GFC, the Fed initiated QE measures and the program has been recurring since. In September 2008, the Fed started the QE1 program in which the US central bank announced the purchase of \$1.25 trillion in Mortgage-Backed Securities (MBS) and \$200 billion in federal agency debt. In the second QE program (QE2), which began in November 2010, the Fed notified its commitment to buying Treasury Securities worth \$600 billion. Following this, the US conducted Operation Twist, in September 2011, where it announced it would buy short- and long-term bonds to reduce long-term rates. Then came QE3 in September 2012, where the Fed announced an open-end bond-purchase program of MBS worth \$40 billion every month. In March 2020, the Fed announced QE4 to tackle the Covid-19 pandemic.

The stated objective of conducting QE was to reduce long-term interest rates to revive economic growth. There are three major ways in which this happens. First is the signalling channel in which the UMP measures serve as a credible commitment to keep interest rates

low. (Eggertsson & Woodford, 2003). The second is the liquidity channel: when the central bank purchases long-term securities the reserve balance of the central bank increases. This leads to increased liquidity for investors and they demand a lower liquidity premium on these assets. The third is the duration-risk channel (Vayanos & Vila, 2009). Based on the assumption of a preferred habitat model, by purchasing long-term securities the central bank can reduce the duration risk and subsequently the bond yield of these securities. From existing literature, it is found that \$100 billion QE in the US leads to a 3–15 bp softening of the US 10-year bond yield (Doh, 2010; D’Amico & King, 2013; Gagnon et al., 2011; Neely, 2010; Krishnamurthy & Vissing-Jorgensen, 2011; D’Amico et al., 2012; Swanson, 2011).

However, the impact of US QE was not contained within the US economy, it spilled over to bond yields of EMEs (Sobrun & Turner, 2015; Gilchrist et al., 2019; Borio & Zabai, 2018; Dell’Ariccia et al., 2018). Bowman et al. (2015) uses the Vector Auto Regression (VAR) methodology to identify the impact of US UMP on 17 EMEs, using daily data of sovereign bond yields from 2006 to 2013. The authors find there was an impact on the EMEs (including India) and the impact was more on countries with weak macroeconomic fundamentals. In a similar study, Bhattarai et al. (2021) study the impact between 2008 and 2014 and come to the conclusion that a 2% increase in Fed security purchases reduces long-term yields in EMEs by 3 bps. However, they find that the impact on the “Fragile Five” EMEs—Brazil, India, Indonesia, South Africa and Turkey—was harder than on other EMEs. Ghosh et al. (2017) find that global uncertainty impacts monetary policy decisions in India.

Using panel regression along with an event study and Global Vector Auto Regression (GVAR) as a robustness check, Moore et al. (2013) examine the impact of the US Large Scale Asset Purchase (LSAP) on 12 EMEs. The authors find that a 10 bp reduction in long-term US Treasury yields reduced EME government yield by 1.7 bps. From the event study (impact within three days from the date of announcement), the authors find that the impact on the 10-year IGB yield was significant. In a similar study, Fratzscher et al. (2013) analyse the impact of US QE on 42 EMEs using daily data between 2007 and 2011. The authors find that in QE1 money flowed out of the EMEs; in QE2 money flowed into EMEs. Lim et al. (2014) use panel regression to analyse the impact of QE by the Fed, the European Central Bank (ECB), the Bank of Japan (BOJ) and the Bank of England (BoE) on quarterly gross capital inflows across 60 EMEs over 2000 and 2013. The authors identify there was transmission through the portfolio balancing channel on the yield curve.

Rajan (2015), the then RBI governor, had argued that the tapering actions of the Fed might give rise to unnecessary volatility in global financial markets and could lead to harmful spillover effects. Aizenman et al. (2016) apply a panel framework using daily financial data of EMEs and find that asset prices were most reactive to statements made by then-Fed Chairman Bernanke. When classifying the 26 EMEs into robust and fragile, the authors conclude that, while in the very short term the impact was more severe in robust economies, the impact after a month was similar for robust and fragile economies.

Mishra et al. (2014) studied the impact of US QE on bond yields of 21 EMEs between 2013 and 2014 and concluded that the impact on the country depended on its macroeconomic fundamentals. Countries with deeper and more stable financial markets reacted less to the tapering events. Compared with other EMEs, the impact of tapering was less in India, as the current account balance improved in 2013 compared to 2008 (during QE1) and the country imposed capital flow controls.

Few papers have looked exclusively at the spillover impact of UMP on the Indian debt market. Patra et al. (2016a) study the impact on the debt market (via the portfolio balance channel), where the authors look at the US term spread and US risk spread. The authors find that there was no spillover on Indian government bond yields. However, FPI debt flows were impacted by the UMPs and global spillovers do affect the transmission of monetary policy. Dilip (2019) uses VAR to study the spillover impact on daily zero-coupon yields from 2009 to 2019. The author finds that the impact on the yield was significant and the spillover impact has increased over the years, with the spillover coming through the term premium channel more than through the risk-neutral rate channel.⁴ Sahoo et al. (2020) study the volatility spillover from the US UMP on the five EMEs (including the Indian bond market). The authors use the same variables as Patra et al. (2016a), and employ the AR(k)-GARCH model to estimate the impact. There was a significant impact of QE1 and the taper tantrum on the volatility of Indian bond markets, and the effect persisted.

Most of the research around this come to the conclusion that there has been a spillover impact on the EME debt market. However, the few studies analysing the impact of US QE on the Indian debt market show mixed results. While some papers find that the impact was significant; others find that the impact on the Indian debt market was insignificant and

transient. The limited number of work and the ambiguity of findings make this study relevant. The choice of variable may have a bearing on the overall result. So unlike the previous studies, this work has taken the asset purchase data of the Fed as a proxy for the QE. All the work has been based on either an event study or an empirical model of VAR or AR(k)-GARCH. The methodology in this study is novel and as discussed in Chapter 3 shows the superiority over the other models.

While clustering economies as robust or fragile to find the cumulative impact on the EMEs, the authors do not have the scope to ascertain the strength of the debt market of the economy (and not the economy as a whole). The classification of the economies have been based on broad macro economic parameters, which fail to highlight the characteristics of the financial market. Most of the studies have been clustered around the tapering period or limited to the first two episodes of QE. This study runs for a period of over 10 years, which makes the model robust. All the major episodes of QE *inter alia* tapering of QE, balance sheet normalization is studied in this work.

5.3 An Empirical model

The 10-year benchmark IGB yield is the dependent variable in the study. Monthly data from September 2008 to June 2019 are used in the empirical analysis. Dua, Raje & Sahoo (2004) note that “factors which can arise from monetary-policy shifts” are important determinants of the 10-year IGB yields. One such factor is the introduction of UMP like QE. In the model, US QE is an independent variable and the chief area of interest. The data are normalized by taking them as a percent of total outstanding bond purchases in the US. There are two possible channels by which the US QE can impact the 10-year IGB yield. First is portfolio-rebalancing: with the fall in the supply of long-term US bonds, demand for substitute assets in India is likely to increase. This would lead to a rise in asset prices and a fall in bond yields in India. In the signaling channel, with low, long-term interest rates in the US, the interest rate difference between the US and India would increase. This would lead to more capital flows to India and greater demand for Indian long-term securities. The impact is likely to suppress the bond yields.

As it is argued above, the relationship between growth and bond yield is not deterministic. Higher growth generally entails a higher cost of funding and inflation. Consequently, the

relationship is likely to be positive. To proxy economic growth, industrial production growth has been taken. As industrial growth figures are printed monthly, this variable has been chosen over GDP growth, which is released every quarter but would have been the most suitable indicator to proxy economic growth.

Inflation plays an important role in determining bond yields (Dilip, 2019). Higher inflation lowers real returns on government securities, leading to demand for higher nominal yields. Another way of looking at it is when inflation increases, the central bank raises policy rates to control the rise in inflation. A successful monetary-policy transmission would therefore increase long-term rates.

For the empirical analysis, both the Consumer Price Index (CPI) and the Wholesale Price Index (WPI) inflation were considered at the outset. There was a notable degree of correlation between these two measures. The period of study is from 2008 to 2019 and, during the first four years, the WPI was considered the benchmark inflation rate. Only since 2012 has the CPI become the benchmark for inflation. Given its relevance as the benchmark inflation rate in the initial years of QE; WPI inflation has been included in the ARDL model. Besides, to capture the impact of global prices, both Brent crude oil and WTI were included in the initial set of regressions. Apart from prices, these indicators reflect market volatility and liquidity. A high degree of correlation was noted between the two. The Brent crude oil price, the more popular and common measure, has been included in the final model.

A few authors have found that monetary policy and monetary-policy shifts have an impact on long-term bond yields (Dua et al., 2004; Dilip, 2019). However, none of the policy variables—the repo rate or the reverse repo rate—had a significant impact on the 10-year IGB yields in the initial regression models. The reserve requirements—the Cash Reserve Ratio (CRR) and the SLR were found to be insignificant. Hence, none of these variables has been included in the ARDL model. The 6-month Libor rate had also been included in the initial set of regressions, but not in the final model as there was no literature that has found a significant impact of this variable.

Akram & Das (2019) find that the Keynesian conjecture of short-term interest rates being a key determinant of long-term interest rates holds for the Indian economy. This is based on the expectations theory of the term structure, where the long-term interest rate is defined as the

weighted average of present and future short-term interest rates. With the rise in the short-term interest rate, the long-term interest rate is likely to rise. The 3-month Indian Treasury Bill (ITB) yield has been taken as a proxy for the short-term rates in the ARDL model.

Goyal (2019) notes that OMOs also impact bond yields. The net open-market purchase by the RBI has been taken to proxy the OMO of the RBI. The variable has been converted into its logarithmic value to maintain consistency with the other variables in the equation. Higher net open-market purchases by the RBI would increase liquidity with investors. This would increase demand for long-term assets and compress their yields. The coefficient of net open-market purchases is expected to be negative.

Patra, Kapur, Kavediya & Lokare (2016b) find that foreign investment in debt instruments has a significant impact on long-term bond yields. Foreign portfolio investment in debt markets is regulated by restrictions of capital flows to the country. So this variable has been avoided. On the other hand, the variable of mutual-fund investment in G-secs was also compiled. However, since mutual funds are small players in the bond market, this variable also has not been included. The final list of variables is given in Table 5.2.

Many authors have used the Vector Auto Regression (VAR) model, which is more suitable when all variables are endogenous. However, in the present study, the hypothesis is that there is a one-way causality between QE and 10-year IGB yields. Using the ARDL bounds test developed by Pesaran & Smith (1998) and Pesaran et al. (2001) is novel. The other advantage of using the ARDL model is that, unlike the traditional co-integration models of Engle & Granger (1987), Johansen (1991), Johansen & Juselius (1990), which require all the variables to be integrated into the same order, the ARDL model requires the variables to be integrated of order I(0) or I(1) or a combination (Nkoro & Uko, 2016).

The relationship between US QE and Indian bond market is likely to take this functional form:

$$10\text{-year IGB yield} = f(\text{QE}) \tag{11}$$

The ARDL model specifies the functional relationship between the variables of interest as follows:

$$\Delta bond_t = \alpha + \beta_1 \Delta(bond)_{t-1} + \beta_2 \Delta(bill)_{t-1} + \beta_3 \Delta(iip)_{t-1} + \beta_4 \Delta(lcrude)_{t-1} + \beta_5 \Delta(lomo)_{t-1} + \beta_6 \Delta(qe)_{t-1} + \beta_7 \Delta(wpi)_{t-1} + \beta_8 (bond)_{t-1} + \beta_9 (bill)_{t-1} + \beta_{10} (iip)_{t-1} + \beta_{11} (lcrude)_{t-1} + \beta_{12} (lomo)_{t-1} + \beta_{13} (qe)_{t-1} + \beta_{14} (wpi)_{t-1} + \varepsilon_t \quad (12)$$

where,

bond	= 10-year Indian Government Bond (IGB) yield
bill	= three-month Indian Treasury Bill (ITB) yield
iip	= growth in the index of industrial production of India
lcrude	= natural log of Brent crude oil prices in \$/bbl
lomo	= natural log of OMO in India
qe	= asset purchase by US Fed as percentage of total outstanding bonds
wpi	= wholesale price index inflation of India

and Δ is the first difference operator; α and β_1 to β_7 are short-term dynamic coefficients, β_8 to β_{14} are long-term coefficients and ε is the error term.

The null hypothesis of no long-run relationship among the selected variables ($H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0$) has been discarded against the alternative hypothesis of the existence of a long-run relationship.

In the presence of a long-term relationship among the variables, the short-term Error Correction Model (ECM) is applied. This is specified as:

$$\Delta bond_t = \alpha + \beta_1 \Delta(bond)_{t-1} + \beta_2 \Delta(bill)_{t-1} + \beta_3 \Delta(iip)_{t-1} + \beta_4 \Delta(lcrude)_{t-1} + \beta_5 \Delta(lomo)_{t-1} + \beta_6 \Delta(qe)_{t-1} + \beta_7 \Delta(wpi)_{t-1} + \gamma (ECT)_{t-1} + \varepsilon_t \quad (13)$$

where Δ is the first difference operator; α and β_s are short-term dynamic coefficients, γ is the speed of adjustment to equilibrium and ε is the error term. The error-correction term (ECT) determines the speed of adjustment to equilibrium.

The robustness of the ARDL model on the residuals have been checked by the following tests: (a) the Lagrange multiplier test of residual serial correlation; (b) the Ramsay RESET specification test of functional form; (c) the Jarque-Berra normality test; (d) the Breusch-

Pagan-Godfrey heteroscedasticity test. Besides, the cumulative sum (CUSUM) test for stability of the model is also evaluated.

Four counterfactual scenarios are built where the QE variable is assumed to be zero and the behaviour of the 10-year IGB yield is observed. The four scenarios are built by splitting the period into segments when there has been a change in the US QE program. The four segments are Period 1: from September 2008 to March 2010 when the Fed increased monthly asset purchases; Period 2: from April 2010 to November 2012 when asset purchases fell, followed by a brief period of rise and fall again. Broadly as the number was falling, this has been taken as Period 2; Period 3: from December 2012 to June 2014 when asset purchase was on the rise again, and Period 4: from July 2014 to June 2019 when it fell. For each of these scenarios, QE is assumed to be zero for that period. Monthly data is used for the analysis. Economic and financial data for India is taken from CSO and the RBI.

5.4 Results and findings

From the descriptive statistics given in Table 5.3, we find that the 10-year IGB yield fluctuated between 5% and 9% during the period under observation. The variables showing high fluctuation are QE, OMO and Brent crude oil prices. Three variables: industrial production growth, OMO and QE have high kurtosis, implying there may be outliers in these datasets. All the variables except industrial production and OMO have an almost normal skewed distribution.

The lag length of the model is estimated by minimizing the information criteria. The results from the Akaike information criterion (AIC) and the Schwarz information criterion (SIC) suggest 1 as the optimal lag length of the model (Table 5.4). In the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, the null hypothesis is that the variable (trend and intercept) has a unit root. Industrial production growth, QE, the 10-year IGB yield, and OMO are $I(0)$ while the 3-month ITB yield, Brent crude oil prices and wholesale inflation are $I(1)$. The results of the unit root test are given in the Table 5.5.

Before estimating the ARDL model, the existence of a long-term relationship between the variables is determined. In the presence of a long-term relationship between the variables, the ECM is applied.⁸ The F statistic of the model is 3.36, which is higher than the critical value at

the 10% level of significance (Table 5.6). This shows that there exists a long-term relation between QE, the 10-year IGB yield, and the control variables: the 3-month ITB yield, WPI, OMO, Brent crude oil prices and industrial production growth.

The long-term coefficient of all the variables is given in Table 5.7. The long-term coefficient of QE is significant and positive. A one-percentage-point increase in QE leads to a 0.4 bp rise in the 10-year IGB yield. The yields were anticipated to soften due to QE (portfolio re-balancing). Two possible reasons for this are: first, the co-movement of the bond yields, which was visible in the initial years of QE, was not there in the later years. Second, policy changes by the RBI and monetary-policy transmission have impacted long-term yields.

Of the control variables (CVs), the coefficient of industrial-production growth and Brent crude oil prices are significant. The coefficient of Brent crude oil price is positive and in line with expectation. A rise in Brent crude oil prices would harden inflation and lead to a rise in the 10-year IGB yields. While the coefficient of industrial-production growth was anticipated to be positive. The rationale is that, as growth slows down, investment in a safe haven like a 10-year IGB yield would rise. However, the correlation between GDP growth and industrial-production growth is rather weak, and industrial-production growth may not reflect the actual health of the economy.

Two short-term coefficients were significant. The short-run coefficient of the past value of the 10-year IGB yield and the wholesale price inflation is significant as well. The coefficient of the ECT is negative and significant in both models. This implies that any short-term disequilibrium is corrected each month, in line with long-term equilibrium values. The coefficient of ECT is 0.4 and any dis-equilibrium in the bond market is corrected at the speed of 40% (Table 5.8).

The results of the other diagnostic tests are given in Table 5.9. There is no auto-correlation, serial correlation, heteroscedasticity or model misspecification in the models. However, the residual errors do not follow a normal distribution. The result of the CUSUM test is given in Fig 5.14. The plot of CUSUM stays within the critical 5% bounds, confirming the long-term relationships among variables and, thus, showing the stability of the coefficient.

The objective of doing a counterfactual analysis is to analyze the deviation of the 10-year IGB yield due to the QE measures. The results of the counterfactual analysis are given in Fig 5.15-5.18. In Period 1, yields dropped sharply toward the end of 2008. The ARDL model shows that were there no QE, bond yields would have been flat. In Period 2, bond yields initially hardened, then softened back to the level at the beginning of Period 2. The counterfactual analysis, on the other hand (were there no QE), shows that bond yields would have softened by ~150 bps. Even in Period 3, the counterfactual analysis points to a consistent softening of bond yields. In Period 4, there is not much difference between the actual and the constructed bond yield series in terms of volatility. The average bond yields would have been lower during that period.

The impossible trinity in economics suggests that a country with a flexible exchange rate and capital-account convertibility cannot have an autonomous monetary policy. Due to some restrictions on cross-border capital movements (especially for outflows by residents) and RBI's ability to intervene in the foreign exchange market has allowed the central bank to manoeuvre the domestic monetary-policy in the desired way. That is why it could tighten monetary policy in 2010 and 2011 and again in 2013 and 2014, while most developed countries maintained a prolonged pause.

However, despite these efforts, the spillover impacted the bond market. This has two broad implications – mispricing of debt market assets and the RBI's ability to guide the domestic monetary policy in the way most suited for the domestic economy, which would have been possible if the international monetary policies were coordinated. Failure to do has made the work of the central bank difficult by reacting to the spillover impact of US QE, while guiding the economy on a path of higher growth and keeping inflation low and stable.

5.5 Conclusion

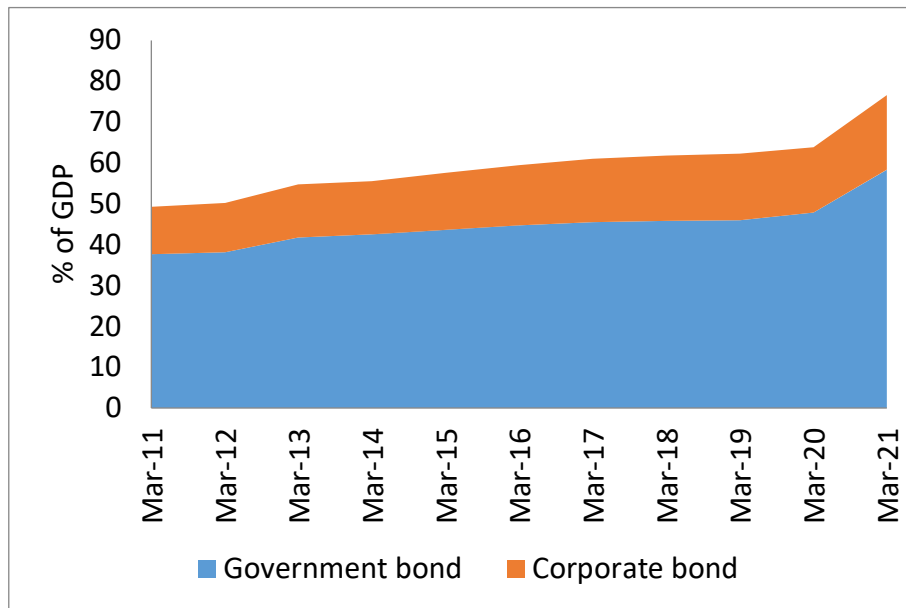
The ultimate objective of the RBI has been to ensure complete transparency and to increase liquidity across the curve, thereby helping in the better discovery of prices of government and corporate bonds. Clearly articulated steps have been taken by the RBI to ensure this is achieved. Further, to make the market more vibrant, the RBI has been introducing new products and encouraging more types of investors to actively contribute to the bond market.

The purpose of this chapter is to analyze the long-term and short-run effects of US QE on 10-year IGB yields, using the ARDL bounds testing co-integration approach. There exists a long-term relationship between QE, the 10-year IGB yield and the CVs. A 10 percent increase in QE leads to a 4-bp hardening of yields. Industrial-production growth and crude prices also have a significant effect on the yields. The conclusion from the counterfactual analysis is that the volatility in yields would have been lower were there no QE.

The UMP policies of US has made the monetary policy actions of the RBI dependent, not only on the domestic situation but also the spillover impact of the UMP policies. In a globalized economy, it is important that the central banks of the developed countries choose policies which does not have an adverse impact on EME's. As the major central banks continue to pursue UMP policies on an intermittent basis, the domestic economy has to regulated to shield from the negative impact of the spillovers.

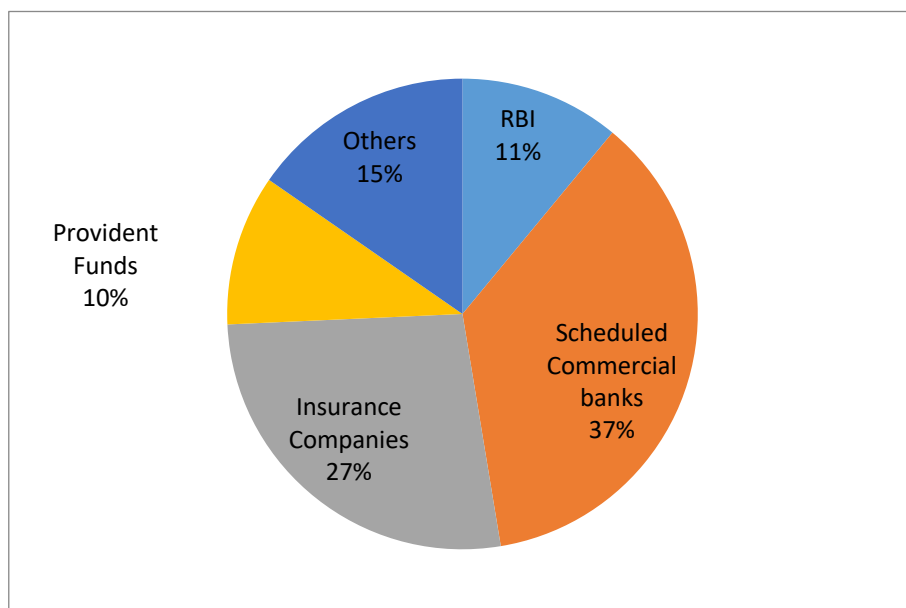
Tables and figures

Fig 5.1: Size of the bond market as a percentage of GDP



Source: RBI

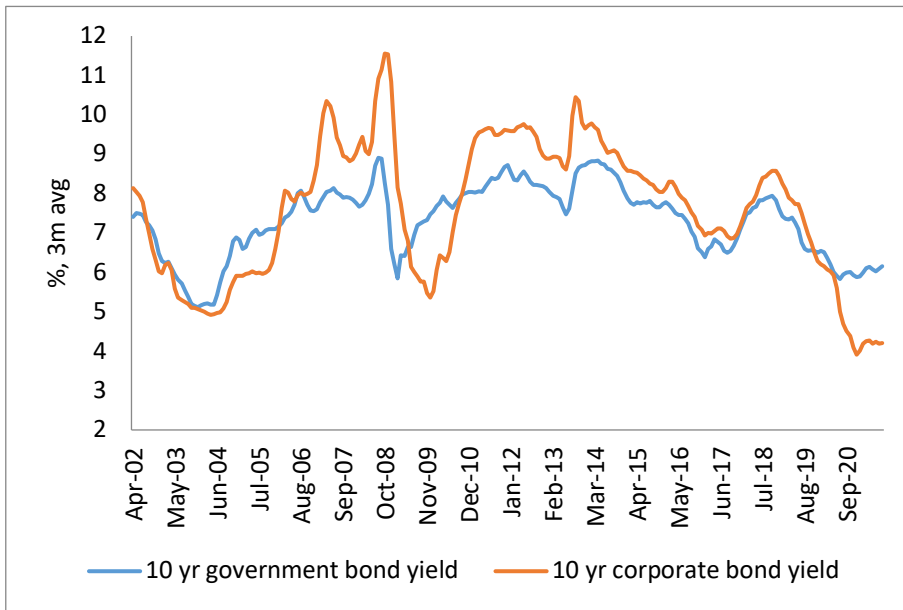
Fig 5.2: The major owners of G-Secs



Note: Data is of the fiscal year 2020-2021

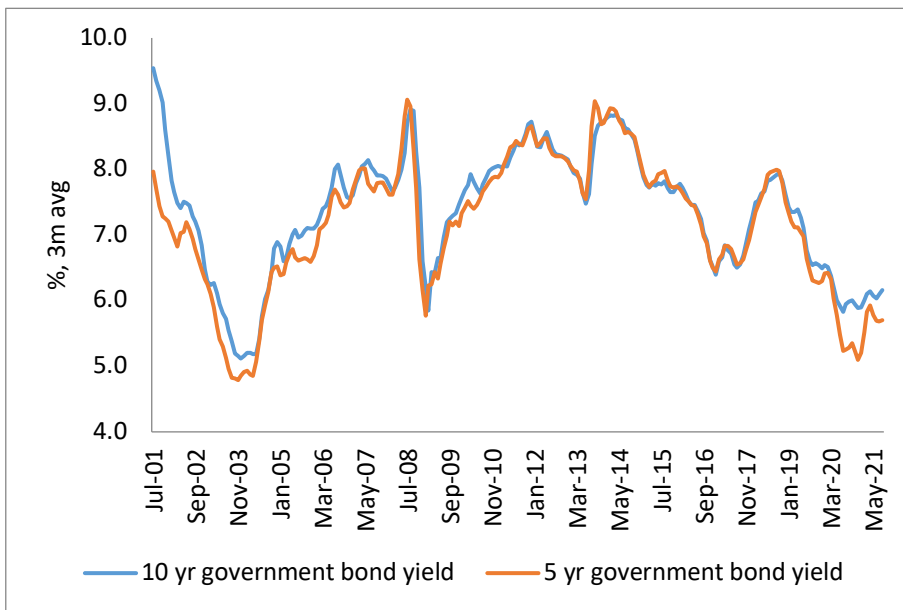
Source: RBI

Fig 5.3: Relation between government & corporate bond yield



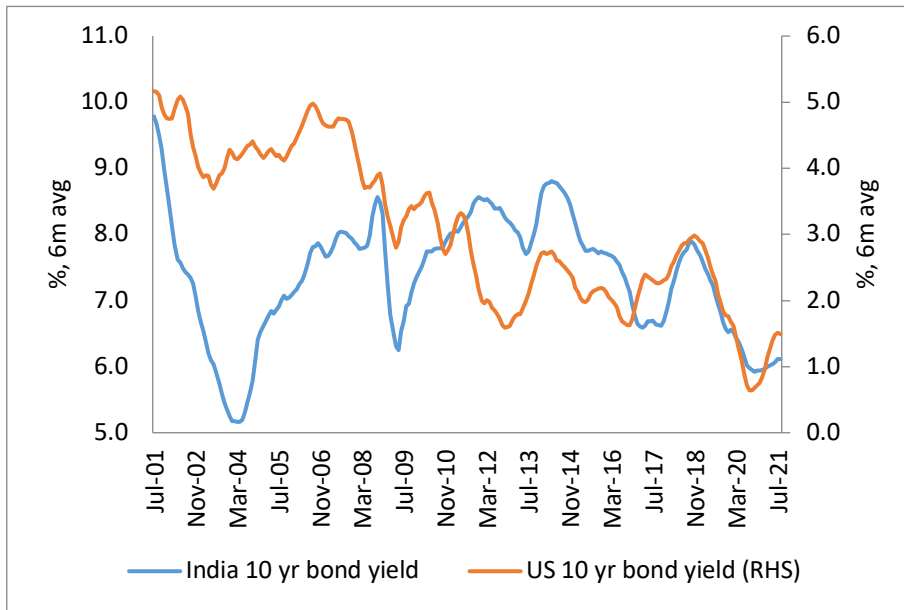
Source: RBI

Fig 5.4: Movement of different tenured bond yield



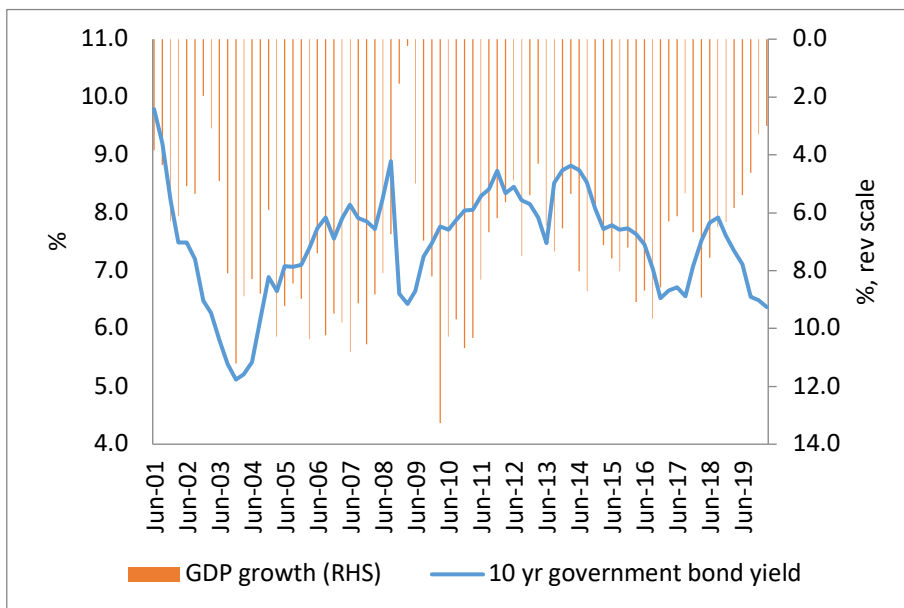
Source: RBI

Fig 5.5: Movement of US & India's long-term bond yields



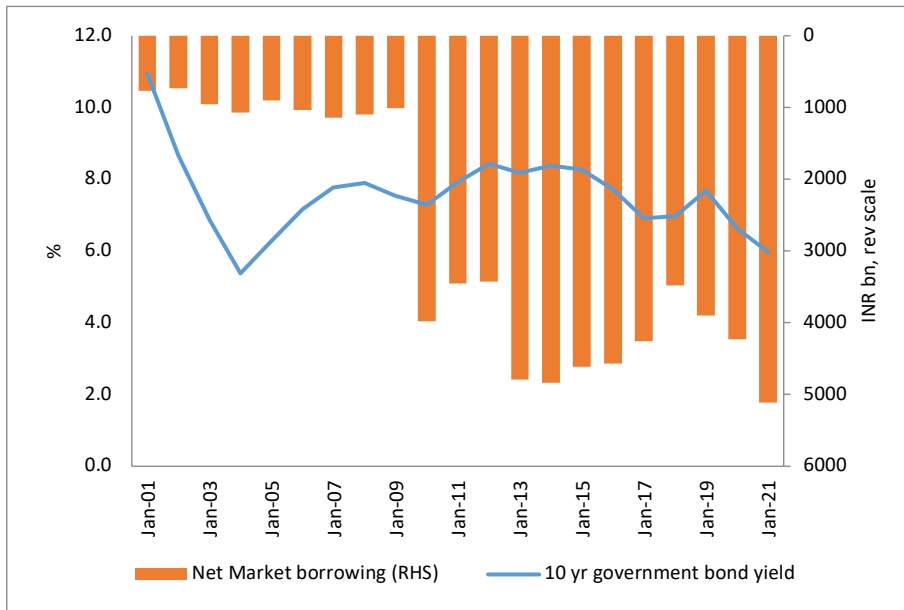
Source: RBI, FRED

Fig 5.6: Relationship between bond yield & GDP growth



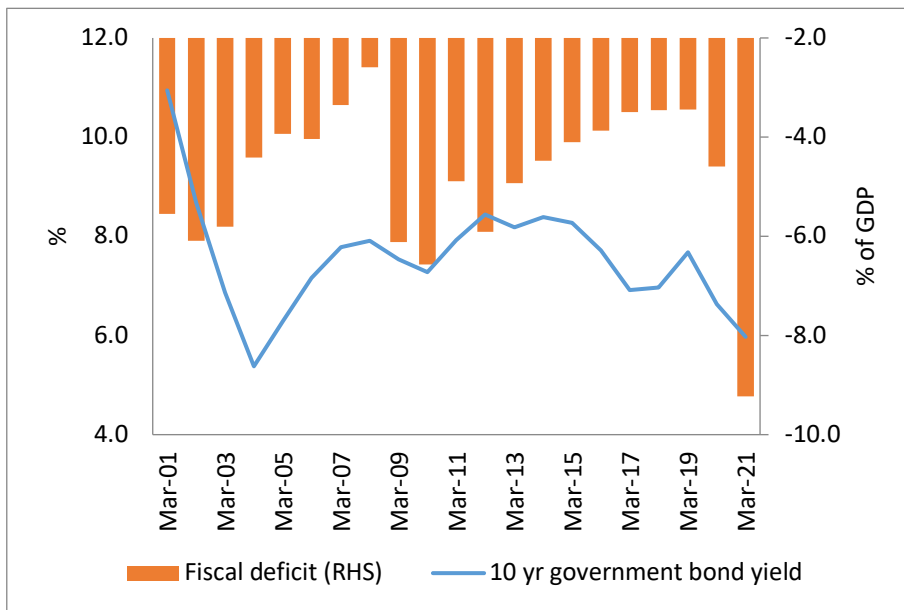
Source: RBI, MOSPI

Fig 5.7: Movement of bond yield and net market borrowing



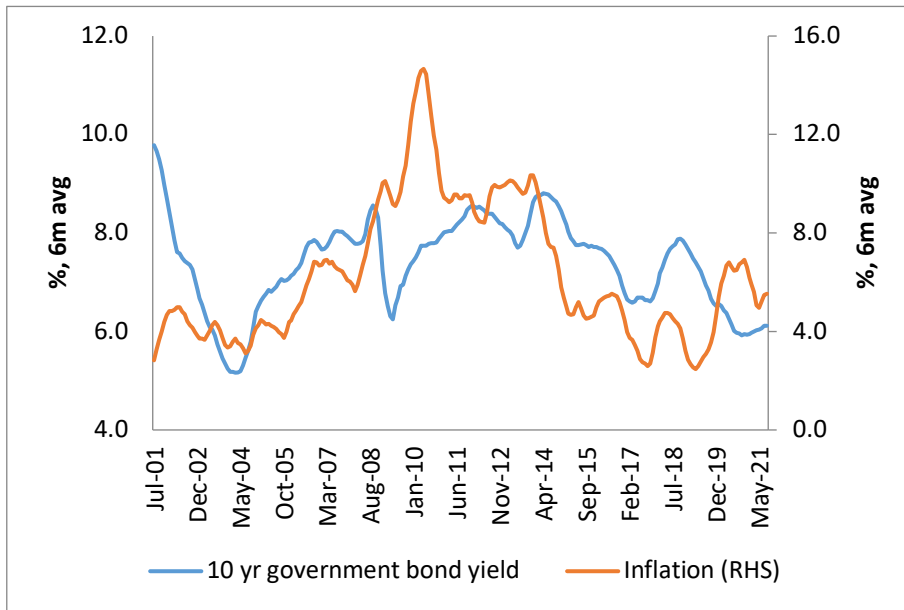
Source: RBI, Controller General of Accounts (CGA)

Fig 5.8: Relationship between bond yield & fiscal deficit



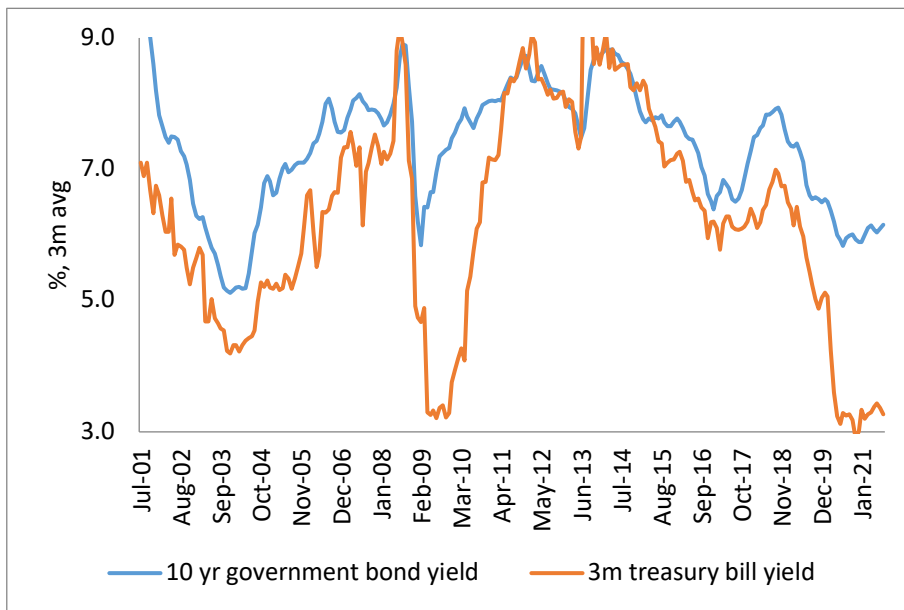
Source: RBI, CGA

Fig 5.9: Relationship between bond yield & inflation



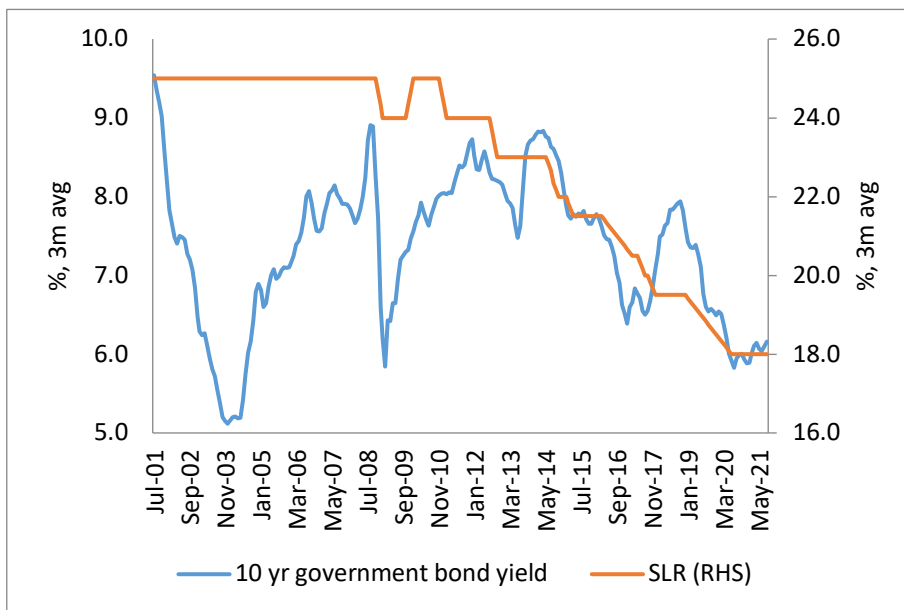
Source: RBI

Fig 5.10: Relationship between short term and long term rates



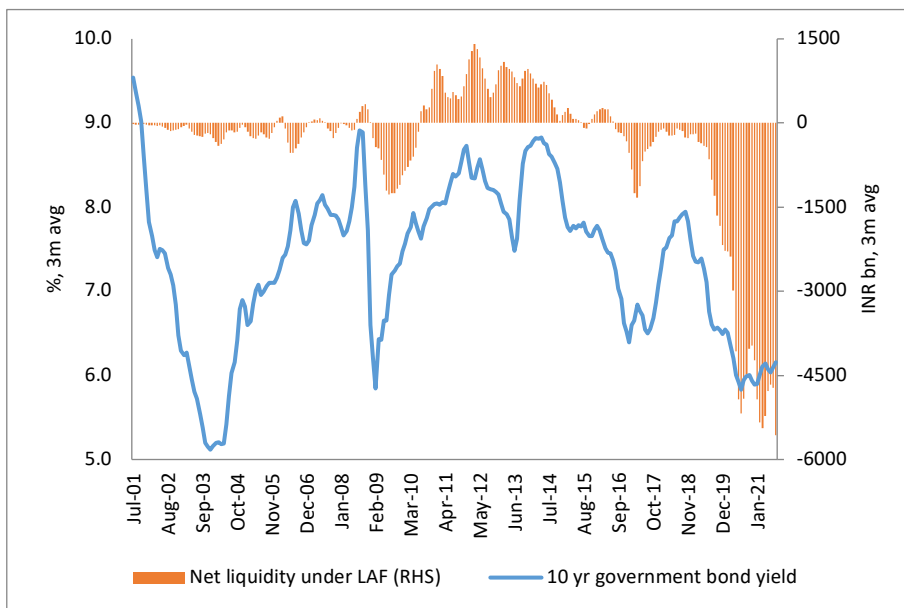
Source: RBI

Fig 5.11: Relationship between bond yield & SLR



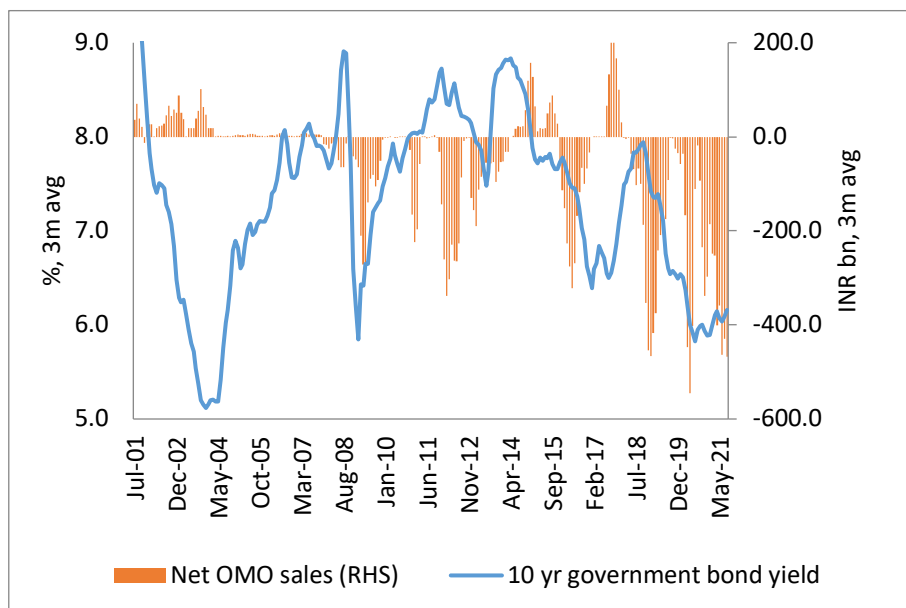
Source: RBI

Fig 5.12: Movement between bond yield & liquidity



Source: RBI

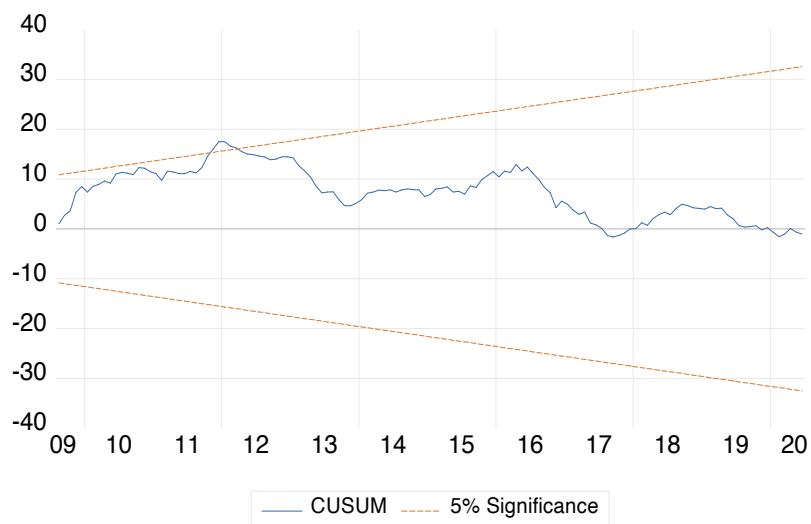
Fig 5.13: Movement of bond yield and net OMO purchase



Note: net OMO purchase is the difference between purchase and sale of OMO

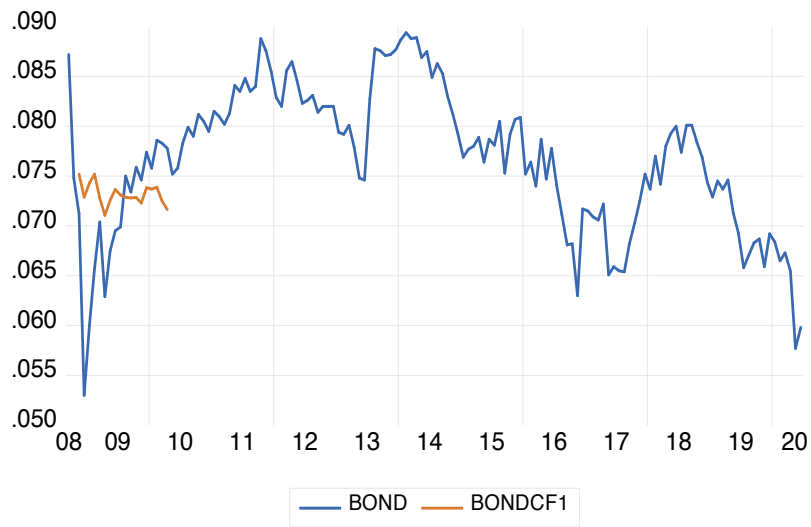
Source: RBI

Fig 5.14: Findings of the CUSUM test from the debt model



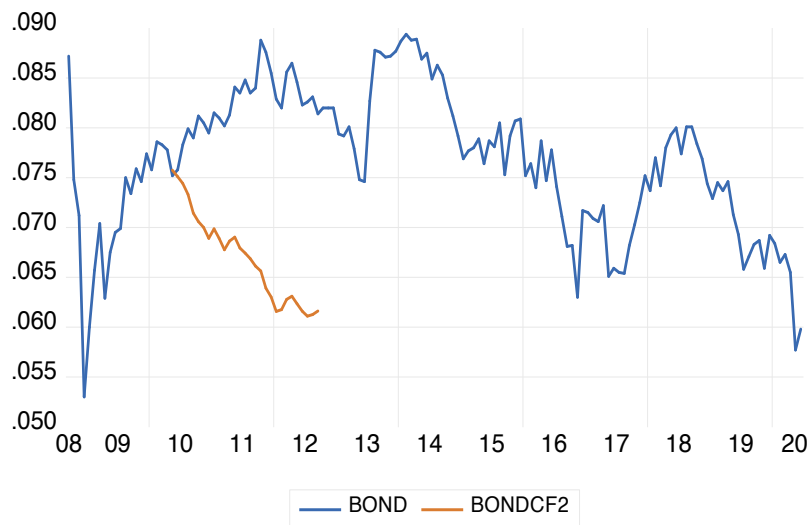
Source: Authors' estimates based on the ARDL model

Fig 5.15: Movement of bond yield in Period 1



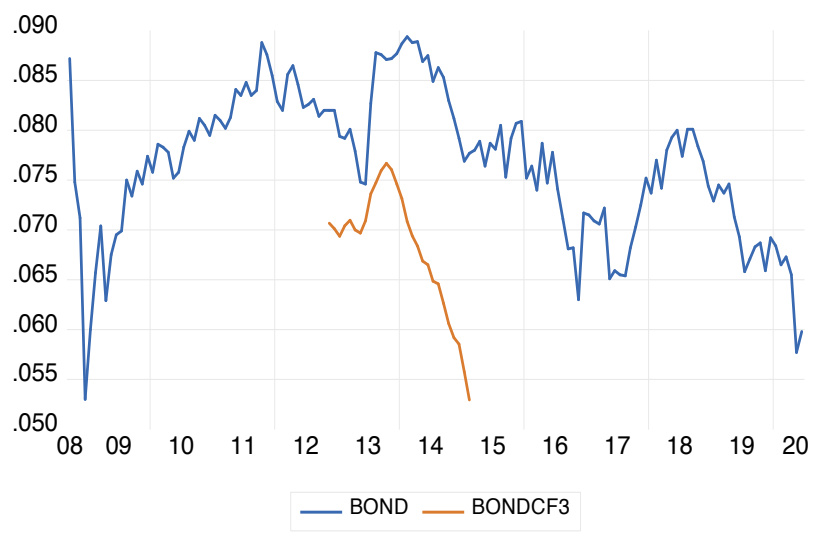
Source: Authors' estimates based on the ARDL model

Fig 5.16: Movement of bond yield in Period 2



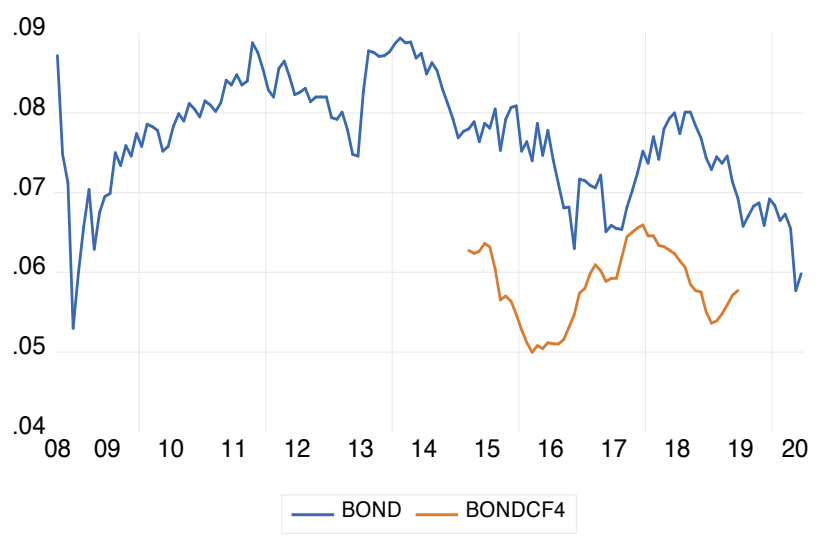
Source: Authors' estimates based on the ARDL model

Fig 5.17: Movement of bond yield in Period 3



Source: Authors' estimates based on the ARDL model

Fig 5.18: Movement of bond yield in Period 4



Source: Authors' estimates based on the ARDL model

Table 5.1: Activity in the bond market

INR billion	Government securities *		State development loans	Corporate bonds**	Total
	central government	state government			
2010-11	22,689	6,059	995	8,895	38,638
2011-12	25,933	7,425	1,599	10,516	45,473
2012-13	32,541	8,970	1,636	12,901	56,048
2013-14	37,150	10,619	2,136	14,674	64,579
2014-15	41,578	12,755	2,348	17,503	74,183
2015-16	45,325	16,314	2,844	20,193	84,676
2016-17	49,110	20,893	3,736	24,049	97,789
2017-18	53,968	24,288	4,347	27,423	110,026
2018-19	59,210	27,772	5,237	30,672	122,892
2019-20	64,866	32,660	6,564	32,539	136,629
2020-21	76,359	38,800	7,787	36,126	159,072

Note: * T Bills are not included since it has maturity of 1 year or less

** Corporate bonds include Public Sector Unit (PSU) bonds

Source: RBI

Table 5.2: List of variables in the debt model

Variable Description (referred to as)	Unit	Source	Expected signs
India 3m treasury bond yield (bill)	%	RBI	+
India 10yr government bond yield (bond)	%	RBI	+
India industrial production index (iip)	Growth, %	Central Statistical Organization (CSO)	+
Brent crude oil (lcrude)	dollar/bbl	Federal Reserve Economic Data (FRED)	+
India liquidity under OMO (lomo)	INR	RBI	-
Asset purchase by US Federal Reserve (Fed) as a percentage of total outstanding bonds (QE)	%	Federal Reserve Archive	-
India wholesale price inflation (wpi)	Inflation, %	CSO	+

Source: Author's estimates

Table 5.3: Descriptive statistics of the debt model

	bill	bond	iip	lcrude	lomo	qe	wpi
Mean	0.0667	0.0767	0.0268	1.8200	-0.6563	0.9468	0.0395
Median	0.0672	0.0778	0.0366	1.8371	-0.7391	0.9495	0.0395
maximum	0.1114	0.0894	0.1494	2.0395	0.0000	1.6342	0.1088
Minimum	0.0305	0.0530	-0.5763	1.2187	-1.9682	0.0064	-0.0614
Std Dev	0.0173	0.0073	0.0756	0.1525	0.2436	0.3023	0.0417
Skewness	-0.3491	-0.4767	-4.5925	-0.6475	-1.1084	0.5143	0.2899
Kurtosis	2.7380	2.9547	33.8939	3.4466	9.5157	5.0210	2.3095
Jarque-Bera	3.2908	5.3896	6146.2530	11.1037	272.6081	30.4265	4.8101
Probability	0.1929	0.0675	0.0000	0.0039	0.0000	0.0000	0.0903
Sum	9.4726	10.8909	3.0181	258.4372	-93.1947	134.3998	5.6045
Sum of sq deviation	0.0420	0.0076	0.8059	3.2794	12.8876	10.1636	0.2455
Observations	142	142	142	142	142	142	142

Source: Authors' estimates

Table 5.5: Estimated statistics of unit root test of the debt model

	ADF		PP	
	At level	At first difference	At level	At first difference
bill	-2.7205	-8.8743 ***	-2.7237	-14.2644 ***
bond	-3.9853 **		-4.2661 ***	
iip	-3.8327 **		-5.4268 ***	
lcrude	-2.5616	-8.4592 ***	-2.1613	-8.3086 ***
lomo	-5.5188***		-5.4644***	
qe	-5.3120***		-2.8416	-9.2924 ***
wpi	-2.3419	-7.6107 ***	-2.2221	-7.5632 ***

*, ** and *** denote the level of significance at 10%, 5% and 1% respectively

Source: Authors' estimates

Table 5.4: Optimal lag length of the debt model

	Lag 0	Lag 1	Lag 2	Lag 3
AIC	-9.1114	-9.1386 *	-9.1302	-9.1273
SIC	-8.9593	-8.9647 *	-8.9344	-8.9100

Source: Authors' estimates based on the ARDL model

Table 5.6: Estimated statistics of bound test – debt model

Significance level (in %)	Critical values		F statistics
	Lower Bound	Upper Bound	
10	2.12	3.23	3.36
5	2.45	3.61	
2.5	2.75	3.99	
1	3.14	4.43	

Source: Authors' estimates based on the ARDL model

Table 5.7: Estimated long-run coefficients of debt model

Dependent variable	Coefficient	T-statistic	P-value
bill	0.0743 **	2.4419	0.0160
bond	-0.4038 ***	-4.4924	0.0000
iip	-0.0029	-0.5756	0.5659
lcrude	0.0101***	2.674	0.0085
lomo	0.0002	0.1543	0.8776
qe	0.0037 ***	2.8537	0.0051
wpi	-0.0065	0.6616	0.5094

*, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively

Source: Authors' estimates based on the ARDL model

Table 5.8: Estimated short-run coefficients of debt model

Dependent variable	Coefficient	T-statistic	P-value
D(wpi(-1))	0.0742 ***	2.8107	0.0057
ECT(-1)	-0.4031 ***	-4.5935	0

*, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively

Source: Authors' estimates based on the ARDL model

Table 5.9: Estimated values of diagnostic tests – debt model

	L M version	p-value	F-version	p-value
Serial correlation	0.004	0.9496	0.0037	0.9515
Normality	199.1275 ***	0	NA	
Heteroscedasticity	11.123	0.1948	1.4133	0.1967

*, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively

Source: Authors' estimates based on the ARDL model

CHAPTER VI

IMPACT ON THE EQUITY MARKET

6.1 Introduction

Equity is an important part of financial markets. From a company's perspective, the purpose of the equity market is to provide it with the means to raise capital. Investors, though, are afforded liquidity and transparent trading of shares. Some perceived benefits of a well-functioning equity market are higher productivity growth, elevated real-wage growth, more employment opportunities and greater macroeconomic stability.

The equity market in India has steadily grown. In the last twenty years, trading volumes have risen 11-fold and the number of listed companies has increased 2.5 times (Table 6.1). During this time the National Stock Exchange (NSE's) market capitalization registered an 18.7% Compound Annual Growth Rate (CAGR) (Fig 6.1). A significant part of this growth arose after the financial liberalization of equity markets across the world in the late twentieth century. This offered foreign investors the opportunity to invest in domestic equity markets and domestic investors the right to transact in foreign equity markets. Nifty returns and Foreign Institutional Investors (FII) flows are directly correlated (Fig 6.2)²³. Data from The National Securities Depository Limited (NSDL) show that of FII flows to India, most come from the US: in March 2021, one-third of net FII flows to India. In 2009 and 2010, huge net FII inflows to the Indian equity market paralleled high Nifty returns.

As it was seen in the past,²⁴ major FII inflows can disrupt the domestic economy. The two major crises of the 1990s – the Mexican and Asian Financial Crises – were marked by huge inflows of foreign capital followed by sudden outflows. In the aftermath of these crises, FII flows were ascribed terms such as 'hot' and 'short-term'. FII flows to India, too, have been on the rise.

²³ Dua & Garg (2014) show the importance of FII for the Indian stock market,

²⁴ In the early 1990s significant inflows of capital to East Asian countries was seen: to Thailand, Malaysia, Indonesia, Philippines, South Korea. Towards the late 1990s, this was rapidly withdrawn, and led to a steep fall in the exchange rate of East Asian currencies.

Beginning in 2009, the US undertook Quantitative Easing (QE) programs to help its economy recover after the Global Financial Crisis (GFC). The Fed implemented QE multiple number of time starting in 2008. QE works thus: by purchasing assets of longer duration, the central bank reduces the yield on these securities in the US, which eventually translates to lower long-term interest rates. The US Federal Reserve (Fed) purchase of long-duration assets increases demand for all substitute assets such as long-duration assets of Emerging Market Economies (EMEs). This obviously results in capital inflows to EMEs and subsequent (and consequent) asset-price rises in the EMEs.

Very few studies²⁵ have estimated the impact of the US QE on the Indian stock market. Most of the literature, clustered around a group of EMEs along with India, does not allow the inclusion of other variables that affect the stock market. To analyse the spillover to EMEs, the Vector Auto Regression (VAR) methodology has been commonly used. This study argues that this is better done with the Auto-Regressive Distributed Lag (ARDL) model due to the non-endogeneity of the variables.

Alongside the US QE, it is important to consider the impact on market returns from other variables, called control variables (CV). In a seminal paper, Chen, Roll & Ross (1986) find that macroeconomic variables impact future dividends and can affect stock-market returns. Mukherjee & Naka (1995) also find a long-term correlation between Japanese equities and the variables: industrial production, inflation, money supply, call-money rates, long-term government bond yields and exchange rates. Brown & Otsuki (1990) find that industrial production, money supply and crude-oil prices impact stock markets. Hamao (1988) finds that expected inflation and the term structure are important determinants of stock-market returns. Monetary policy, too, impacts stock markets (Ioannidis & Kontonikas, 2008; Jensen & Johnson, 1995; Thorbecke, 1997). Conover, Jensen & Johnson (1999) find that the US monetary policy impacted returns in economies other than that of the USA.

Economic growth and stock returns are correlated (Atje & Javanovic, 1993; Garcia & Liu, 1999; Levine & Zervos, 1996, 1998; Singh, 1997). Economic growth, proxied by real Gross Domestic Product (GDP) growth and industrial production growth in India, has a positive relation with Nifty returns (Figs 6.3 and 6.4). Since stock prices are a function of dividends,

²⁵ Patra et al. (2016a); Rai & Suchanek (2014); Sahoo et al. (2020), Lakdawala (2018) among others.

any variable that influences dividends is likely to impact market returns. Economic growth can affect future dividends since it is a measure of the state of the economy (Chen et al., 1986). The discount rate, is the other way in which economic growth can affect market returns, can be impacted by the risk premium. As economic growth reflects consumer demand, changes in consumption are likely to impact the risk premia (Chen et al., 1986).

The relation between equity returns and inflation is negative (Fama & Schwert, 1977; Chen et al., 1986; Geske & Roll, 1983; Mukherjee & Naka, 1995). When inflation increases, the risk-free rate also rises, leading to a higher discounting rate and lower market returns. Only when cash flows increase at a similar pace, inflation may not have an adverse impact on returns. Cash flows are unlikely to increase at a similar pace to the rise in inflation since input prices increase quickly while output prices adjust with a lag (DeFina, 1991). To proxy the impact of inflation, the consumer price index and the wholesale price index are considered. The correlation of inflation with stock returns is given in Fig 6.5.

Changes in the policy rate have the same impact on the discount rate via the impact on inflation (Mukherjee & Naka, 1995). A tight monetary policy leads to higher discount rates and lower cash-flows while a loose monetary policy has the opposite impact. Thus a tight policy would lower market returns while a loose monetary policy increases them. Another way by which monetary policy exerts influence on the stock market is by influencing the market's expectations of future economic activity. An indirect way in which monetary policy influences the equity market is via economic growth (Chen et al., 1986). When the policy rate is low, the cost of borrowing would be lower and may lead to higher economic growth via greater investment growth. The relation between market returns in India and the policy rate is given in Fig 6.6.

Changes in the reverse repo rate are undertaken by the Reserve Bank of India (RBI) to alter liquidity in the system. By keeping the reverse repo rate low, the RBI allows greater liquidity in the system. Similarly, the RBI raising the reverse repo rate reduces liquidity. The greater the liquidity in the system, the higher the likelihood of the quantum of trading activities being higher. Apart from the reverse repo rate, another tool by which the RBI controls liquidity in the economy is through Open Market Operations (OMO). OMO is defined as the net open-market purchases by the RBI. Higher net open-market purchases by the RBI are likely to

increase liquidity with investors. The relation between OMO and Nifty returns is given in Fig 6.7. There is no distinguishable relationship.

For an investor, the debt market may be considered an alternative to investing in the equity market as both are popular asset classes. Generally, an investor would usually choose between the two based on past returns and his or her appetite for risk. An investor who does not want to invest in risky assets may not be keen to invest in equity. Rather s/he may want to invest in Government securities, which carry much lower risk. However, as the number of new investors rises, returns from debt and equity markets may rise. The co-movement of Nifty returns and 10-year yield for the past twenty years is given in Fig 6.8. In the next part of the chapter, gaps in existing literature are summarized. This is followed by an empirical model for the equity market and significant findings from the model. In the last section, the chapter is summarized and concludes.

6.2 Summary of existing studies and research gap

QE is likely to impact the Indian equity market in three major ways. The portfolio-rebalancing channel – by reducing yields on safe long-term securities, asset-purchase programmes induce investors to shift investments toward assets with higher expected returns, thus taking on more risk (Gagnon et al., 2011; D'Amico & King, 2013; Hamilton & Wu, 2012). QE could also impact Indian equity via the liquidity channel. The central bank purchasing long-term securities increases the reserve balances of private banks. Thus, QE increases liquidity with investors. This would imply higher flows to the equities of EMEs. The impact could also be via the confidence channel. Neely (2010) notes that Fed announcements may provide new information about the current state of the economy. This could affect portfolio decisions and asset prices by altering the risk perception (and appetite) of investors.

Quite a number of studies look at the spillover effect of QE on other stock markets.²⁶ For instance, Fratzscher et al. (2013) observed that the impact of QE on raising equity prices of EMEs was much lower in QE2 than in QE1 and the impact was stronger at the time of the

²⁶ An extensive literature review of earlier related studies is given in chapter 2.

announcements than when the policies were actually implemented. While studying the impact on EMEs of the US tapering, Mishra et al. (2014) find that equity markets on average fell in the fragile five countries. However, as India had imposed capital-flow strictures before the event, its economy proved more resilient. Aizenman et al. (2016) find that the statement of the then-Fed Chairman Bernanke regarding tapering reduced the equity market by 3.9%; the impact was greater in economies that had fragile macroeconomic fundamentals. Anaya et al. (2017) adopts a GVAR model to analyze the impact of US portfolio flows on the EME macro economic and financial variables. Alongside other variables, the authors find that between 2008 and 2014 there was a significant increase in equity returns.

On the other hand, Rai & Suchanek (2014) come to the conclusion that there was no significant relationship between the robustness of an economy and the Fed tapering; even countries with strong fundamentals were affected. There was no statistically significant impact on India. Eichengreen & Gupta (2014) examine movements in equity prices of EMEs to find that better fundamentals did not lessen the impact on equity prices. Event analysis of US monetary policy announcements by Chen et al. (2014) concludes that though stock prices of EMEs are affected by US monetary policy events, the impact was especially large during tapering announcements.

Fukuda (2018) finds that stock markets initially reacted negatively but later, positively; the authors conclude that Japan's Unconventional Monetary Policy (UMP) helped neighboring economies. Bhattarai et al. (2021) find that, while the strength of macro-economic fundamentals led to a differentiated impact on bond yields and exchange rates, this was not true for the impact on equity prices. Dahlhaus & Vasishtha (2014) find that even though the impact on portfolio flows was small, even this tiny impact can be linked to huge financial volatility in EMEs. Bowman et al. (2015) also use the VAR methodology and opine that US UMP might not have large effects on asset prices in EMEs with strong fundamentals. Lim et al. (2014) on the impact of QE by the four central banks, could predict that capital flows to EMEs would contract by 10% by the end of 2016 due to monetary-policy normalization.

Patra et al. (2016a) find that, while the Indian equity market has heightened sensitivity to global spillovers, there is no significant evidence that they have affected domestic monetary policy. Sahoo et al. (2020), while studying the impact of the spillover of US monetary policy on EMEs, find heightened volatility in the Indian stock market during the periods of QE. The

impact was less, though, during the balance-sheet normalization episode. Lakdawala (2018) uses daily stock return data and a time varying approach and conclude that the US QE did impact the stock market returns in India via the uncertainty channel. Prabu, Bhattacharyya & Ray (2016) find that there was no impact of US monetary policies on the Indian stock market except during QE1 and Operation Twist in 2011.

Almost all the literature, barring a handful come to the conclusion that the US QE impacted the stock market of the EMEs. Most of the studies focusing on India also come to a similar conclusion. This work adds to the space. The ARDL methodology and the choice of variables differentiates this study from the others.

Many studies have clustered economies as fragile or robust, however this categorization fails to incorporate the changing dynamics of the domestic economy. While the Indian economy which was classified as a fragile EME during the inception of QE, it may not be anymore. By considering all the variables which impact the stock market, this study tackles this problem.

The sensitivity of the market to news, make the event study approach hugely popular. But the lack of accurate information regarding announcements reduces the accuracy of the findings. In addition, the event-study methodology is based on the assumption that any impact on financial markets happens within 2–4 days of an announcement. The studies fail to capture the impact of events beyond the 4 days. Also, it is impossible to directly map the cause and the impact. The event study cannot distinguish between the impact on the equity market due to QE and other causes (like geopolitical or price shocks). These make the ARDL methodology superior to the event study approach.

Most of the work has revolved around specific QE episodes. This study takes QE as a continuous variable by analyzing the impact of US QE since its inception. This is necessary, since QE is not an isolated event, it is a paradigm shift. This study provides a benchmark to empirically estimate the impact of QE events in the future as well. The objective of the chapter is to evaluate the impact of US QE on the Indian equity market and determine significant CVs for the equity market.

6.3 Empirical modelling

A significant correlation exists between the two benchmark indices of the Indian equity market – the Sensex and the Nifty. Since the latter is more broad-based, it has been taken as a proxy for the Indian equity market. The Nifty's monthly returns is the dependent variable in the model. Monthly data from September 2008 to June 2019 are used in the empirical analysis.

Among the wide set of macro-economic variables that can impact the equity market; seven CVs were selected. Crude-oil prices have a significant relationship with the stock market (Aloui & Jammazi, 2009; Papapetrou, 2001; Hammoudeh & Aleisa, 2004; Zarour, 2006; Basher & Sadorsky, 2006; Arouri & Fouquau, 2009). A rise in crude-oil prices affect the stock market via the inflation channel. The coefficient of the crude-oil price is expected to be negative.

A tight monetary policy reduces stock-market returns (Conover et al., 1999; Thorbecke, 1997; Ioannidis & Kontonikas, 2008; Cassola & Morana, 2004; Jensen & Johnson, 1995). Fuhrer (1995) finds that US monetary policy affects longer-term interest rates. The discount rate is the average of rates over time. An increase in monetary policy rates by the central bank is likely to raise the interest rate and impact stock prices. The reverse is also likely to hold true. Changes in monetary policy also affect the discount rate via the expectations channel. A change in the policy rate is likely to influence market expectations of future rates and the discount rate (Waud, 1970). So, the coefficient of the monetary-policy rate of India, the repurchase rate, is expected to be negative. The same hypothesis is also likely to hold for the other monetary policy tool used in India.

A rise in the Cash Reserve Ratio (CRR) is likely to increase money supply in the economy. Money supply and inflation are positively related (Fama, 1982). The coefficient of CRR is likely to be negative. Another variable that impacts the money supply in the economy is OMO conducted by the central bank. Net open-market purchases by the RBI have been taken to estimate the impact of such operations on the market. Higher net open-market purchases by the RBI are likely to lead to greater liquidity with people. More money supply is likely to

have a negative impact on market returns via the inflation channel. The reverse repo rate is a proxy for liquidity in the system and may thus have a considerable effect on market returns.

Changes in returns on long-term government bonds are likely to impact the discount rate via the impact on the nominal risk-free rate (Chen et al., 1986; Mukherjee & Naka, 1995). The coefficient of the long-term bond is likely to be negative. In India two-thirds of the debt market comprise government bonds; so the 10-year Indian Government Bond (IGB) may have a considerable impact on the interest rate.

An increase in the interest rate by the US central bank is likely to have a negative impact on a developing economy's stock market, like India, for two reasons. With a rise in the interest rate in the US, the yield of US treasuries is likely to increase. The withdrawal of FII will depreciate the exchange rate, so outflows will rise even more. The coefficient of the Fed policy rate is likely to be negative.

Industrial production growth as a proxy of economic growth has been considered by many authors (Chen et al., 1986; Mukherjee & Naka, 1995; Brown & Otsuki, 1990; Fama, 1990; Geske & Roll, 1983). However, the initial Ordinary Least Square (OLS) estimates show that India's industrial production growth is not a significant variable for Nifty returns. The Consumer Price Index (CPI) inflation was taken as the proxy for inflation in India, similar to Chen et al. (1986); Mukherjee & Naka (1995); Hamao (1988). The Wholesale Price Index (WPI) was also considered in the initial set of OLS regression as the WPI was the benchmark inflation indicator for India for most of the time under the study. However, inflation was not found to be a significant determinant of market returns. The 3-month India Treasury Bill (ITB) yield was initially considered as a proxy for short-term rates in the market. The final list of variables and the source of the data are given in Table 6.2.

For the time-series data where the variables are $I(0)$ or $I(1)$ or a combination, using the ARDL bounds test (Pesaran & Smith, 1998; Pesaran et al., 2001) to check the short-term and long-term relationships between the variables is more appropriate. The relationship between US QE and the Indian equity market is likely to take this functional form

$$\text{Nifty returns} = f(\text{QE}) \quad (14)$$

The ARDL model is given below:

$$\begin{aligned} \Delta nifty_t = & \alpha + \sum_{i=1}^n \beta_1 \Delta(bond)_{t-i} + \sum_{i=1}^n \beta_2 \Delta(crr)_{t-i} + \sum_{i=1}^n \beta_3 \Delta(fedrate)_{t-i} + \\ & \sum_{i=1}^n \beta_4 \Delta(lcrude)_{t-i} + \sum_{i=1}^n \beta_5 \Delta(lomo)_{t-i} + \sum_{i=1}^n \beta_6 \Delta(nifty)_{t-i} + \sum_{i=1}^n \beta_7 \Delta(qe)_{t-i} + \\ & \sum_{i=1}^n \beta_8 \Delta(repo)_{t-i} + \sum_{i=1}^n \beta_9 \Delta(revrepo)_{t-i} + \beta_{10}(bond)_{t-1} + \beta_{11}(crr)_{t-1} + \\ & \beta_{12}(fedrate)_{t-1} + \beta_{13}(lcrude)_{t-1} + \beta_{14}(lomo)_{t-1} + \beta_{15}(nifty)_{t-1} + \beta_{16}(qe)_{t-1} + \\ & \beta_{17}(repo)_{t-1} + \beta_{18}(revrepo)_{t-1} + \varepsilon_t \end{aligned} \quad (15)$$

where,

nifty = returns to Nifty 50 index

bond = 10-year Indian Government Bond (IGB) yield

crr = cash reserve ratio of India

fedrate = Federal Funds rate of US

lcrude = natural log of Brent crude oil prices in \$/bbl

lomo = natural log of OMO in India

qe = asset purchase by US Fed as percentage of total outstanding bonds

repo = policy rate of India

revrepo = reverse repo rate of India

and Δ is the first difference operator, α and β_1 to β_7 are short-run dynamic coefficients; β_8 to β_{14} are long-run coefficients and ε is the error term.

The null hypothesis of no long-term relationship among the selected variables ($H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0$) has been discarded against the alternative hypothesis of the existence of a long-term relationship.

In the presence of a long-term relationship among the variables, the short-term Error Correction Model (ECM) is applied. This is specified as:

$$\begin{aligned} \Delta nifty_t = & \alpha + \sum_{i=1}^n \beta_1 \Delta(bond)_{t-i} + \sum_{i=1}^n \beta_2 \Delta(crr)_{t-i} + \sum_{i=1}^n \beta_3 \Delta(fedrate)_{t-i} + \\ & \sum_{i=1}^n \beta_4 \Delta(lcrude)_{t-i} + \sum_{i=1}^n \beta_5 \Delta(lomo)_{t-i} + \sum_{i=1}^n \beta_6 \Delta(nifty)_{t-i} + \sum_{i=1}^n \beta_7 \Delta(qe)_{t-i} + \\ & \sum_{i=1}^n \beta_8 \Delta(repo)_{t-i} + \sum_{i=1}^n \beta_9 \Delta(revrepo)_{t-i} + \chi(ECM)_{t-1} + \varepsilon_t \end{aligned} \quad (16)$$

where Δ is the first difference operator, α and β s are short-run dynamic coefficients, γ is the speed of adjustment to equilibrium and ε is the error term. The error-correction term (ECT) determines the speed of adjustment to equilibrium.

For the counter-factual analyses, the four periods are: Period 1 between September 2008 to March 2010 when the Fed increased monthly asset purchases; Period 2 between April 2010 to November 2012 when asset purchases fell, followed by a brief period of rise and fall again (broadly, as the number was falling, this has been taken as Period 2); Period 3 between December 2012 to June 2014 when asset purchase was on the rise again, and Period 4 between July 2014 to June 2019 when it fell. For each of these scenarios, QE is assumed to be zero for that period.

6.4 Empirical findings

Descriptive statistics of the variables are given in Table 6.3. As anticipated, the Nifty fluctuated widely during the period under the study observation. QE, OMO and Brent crude oil prices were the other variables with high fluctuations. While the skewness of the Nifty is within the normal range, some of the rates—CRR, Fed rate and India's reverse repo rate—deviate from the normal distribution. From the kurtosis data, it is noted that the Nifty distribution has fewer outliers than the normal distribution.

Based on the Akaike information criterion (AIC) and the Schwarz Criterion (SC), the optimal lag length of the model is estimated at 1 (Table 6.4). The Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests are employed to check for unit roots. Crude, the repo rate and reverse repo rate are found I(1), while the rest of the variables are I(0). As per the ADF test, the Nifty is I(0), but per the PP test, the Nifty is I(1). Thus, all the variables are found stationary at I(0) or I(1). The results for the unit root test are given in Table 6.5.

The study then determines the existence of the long-term relationship between the variables using the ARDL bounds test. The estimate of the F-statistic in the model is 3.14, which is

higher than the 5% level of significance (Table 6.6). This implies that there is a long-term relationship among the variables and an ECM is a more suitable model for this analysis. Estimates of the long-term coefficient are given in Table 6.7. All the coefficients are significant. The long-term coefficient of QE is positive. A 10-percentage-point increase in QE leads to a 2.1% increase in Nifty returns. Based on the portfolio-rebalancing and signalling theory, the US increasing its asset purchases should have a positive impact on the Nifty.

In line with expectations, the coefficient of the CRR and bonds is negative. Among the other rates included in the model, the coefficient of the repurchase rate is positive, contrary to the expectations. A possible reason could be the lack of transmission of the policy variable to actual borrowing rates in the economy.

On the other hand, the coefficient of the Fed rate is positive, contrary to the expectation. A few possible reasons are: since the Fed had long-held rates near zero, an increase in policy rates reflects improvement in US economic growth. Strong growth in the US would drive world economic growth up, benefitting all nations, especially higher export growth for India. Higher market returns in the US can also be interpreted as an improvement in sentiment globally, which has a positive effect on Indian markets. Important to note is that the Fed has held the policy rate at zero from 2008 to 2015, which covers most of the period under analysis. There has been only one rate-normalization cycle when the Fed increased policy rates by 2.5 percentage points. Improving global economic growth, alongside rising growth in India, has likely outweighed the negative impact of the increase in the policy rates in the USA.

The negative coefficient of the 10-year IGB yield signifies that the debt and equity markets are substitutes for each other for investors. The coefficient of both the liquidity variables, the reverse repo and net purchase of OMO are negative, in line with expectation. The RBI also uses various other tools like the repo rate, the Marginal Standing Facility (MSF), the Standing Liquid Facility among others to manage liquidity in the system.

Among the short-run coefficients, the lagged variable of the Nifty and the net open market purchase by the RBI are significant. The significance of the lagged variable of the Nifty is on expected lines and in line with other findings. Most other variables in the model, the repo,

reverse repo, the CRR and the Fed policy rate, are likely to have an immediate effect on the markets. These are stock variables. Hence, when we take monthly returns we are unlikely to find a short-term impact of these variables. The same analogy holds for crude oil prices as well. On the other hand, the net open market purchase is a flow variable. The coefficient of the error-correction term (ECT) is significant and negative, as desired. The movement away from the long-run equilibrium adjusts with a speed of 69% every month (Table 6.8). Therefore, 69% of any disequilibrium in Nifty returns due to changes in other variables were corrected within a month. Thus, the model shows that while domestic policy rates and crude oil prices are important determinants of Nifty returns, economic growth and inflation do not have any major impact.

The results of six diagnostic tests for a robustness check on the ARDL model are given in Table 6.9. The residuals of the Nifty model have no autocorrelation, serial correlation and heteroscedasticity problems. The residuals do not follow a normal distribution pattern. The model is correctly specified. Fig 6.9 gives the result of the cumulative sum (CUSUM) test. The model is stable. Thus, the econometric model is stable and satisfies most of the criteria for being a good model. The model has been able to estimate the determinants of Nifty returns. Empirical findings from the model can be backed by theoretical and anecdotal explanations.

The results of the counterfactual analysis are given in Figs 6.10–6.13. We note the movement of the Nifty returns for Periods 1, 2, 3 and 4 as CF1, CF2, CF3 and CF4. In period 1, there was a sharp rise in the Nifty after QEI. Were there no QE, the Nifty would have fallen steeply. In the next period, the Nifty had been higher (than it would have been in the absence of QE). In the third period, when QE was again being increased, the Nifty also increased. In the absence of QE, the Nifty is likely to have fallen significantly. In the last period, while the Nifty was broadly flat, the absence of QE would have pushed up the Nifty. Therefore, it is observed that QE measures in the US led to higher returns in the Indian equity market than would have been possible. The impact was especially visible when QE was initiated in the US.

6.5 Summary and Conclusion

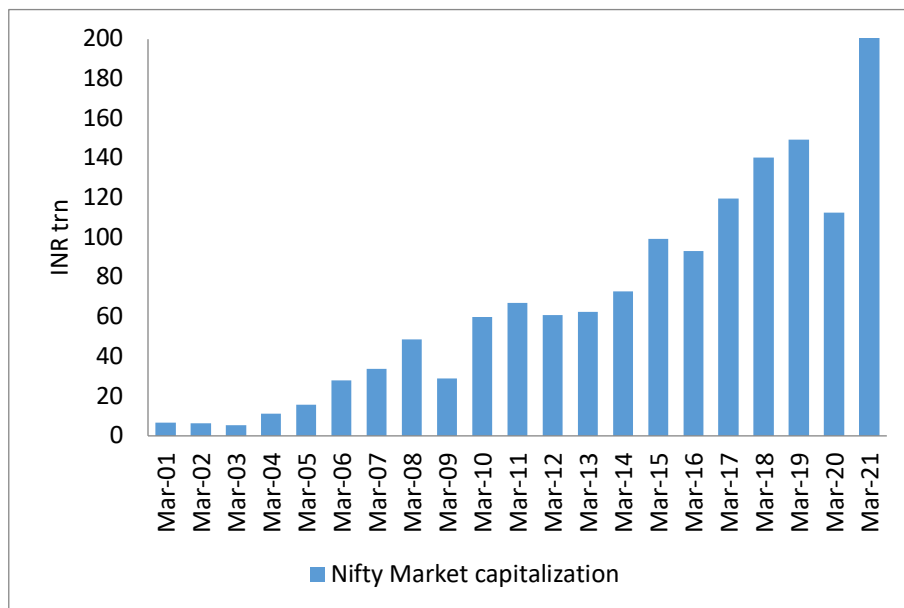
The chief objective of this chapter is to study the impact of US QE measures on the Indian equity market. Monthly Nifty returns have been taken as a proxy for the equity market. Taking data from September 2008 and June 2019 and using an ARDL bounds co-integration approach, the model finds that US QE and Nifty returns have long-term relationships.

QE is a significant variable for the Nifty. A 10-percentage-point increase in QE leads to a 2.1 percent increase in Nifty returns. The US policy rate also has a major impact on the Indian market. Both these impact the market via the FII channel. The other CVs found significant for the Nifty are the RBI's policy variable – the repo rate. Other tools used by the RBI to alter liquidity and money supply, the reverse repo, CRR and OMO, were also found to be important for the Nifty.

From the counterfactual analysis, it is found that the continuous QE measures by the US have kept Nifty returns higher than otherwise. Hence, there has been a spillover, leading to an asset-price upswing in India. This is a matter of concern. First, the level of dependence on FII flows is worrying. A sudden outflow of FII money from the Indian stock market could lead to a crisis similar to that faced by the Asian economies and Mexico in the 1990s. The second area of concern is the mispricing of financial assets. Any uptick in the stock market without sound fundamentals is unsustainable. Mispricing of assets can create financial sector bubbles in the economy.

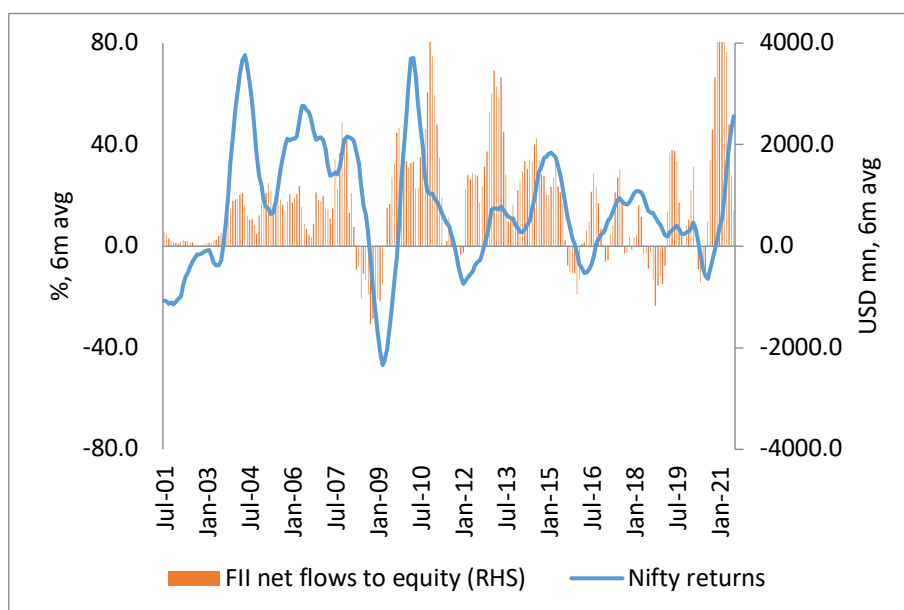
Tables and Figures

Fig 6.1: Market capitalization of the Nifty



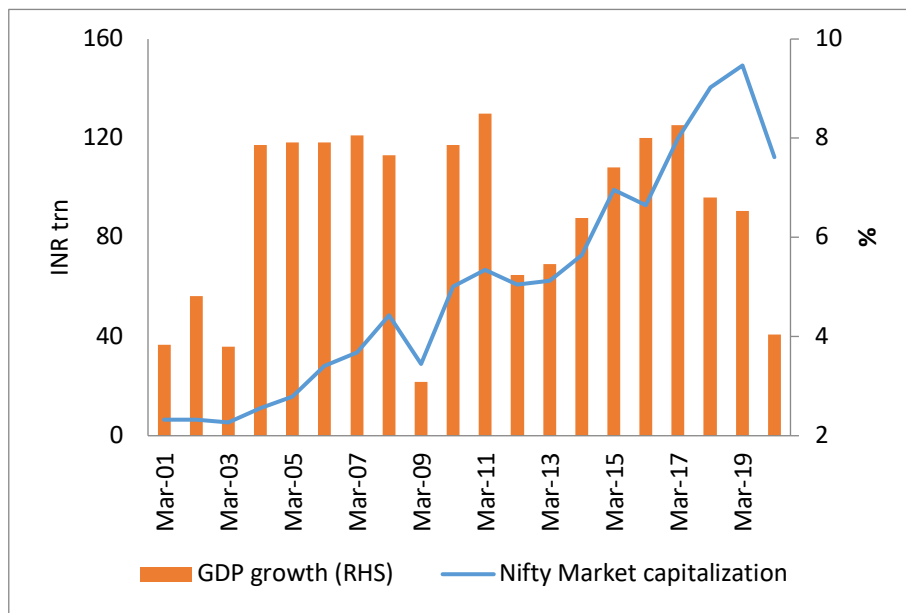
Source: NSE

Fig 6.2: Co-movement of Nifty returns and FII flows to equity



Source: NSE, NSDL

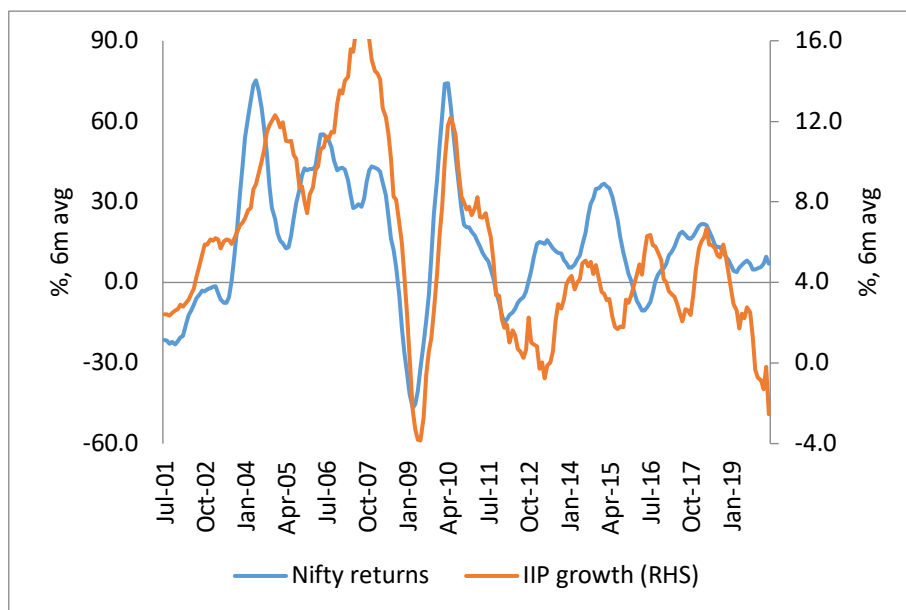
Fig 6.3: Relationship between Nifty market cap and GDP growth



Note: The pandemic year, 2020-21, has been excluded

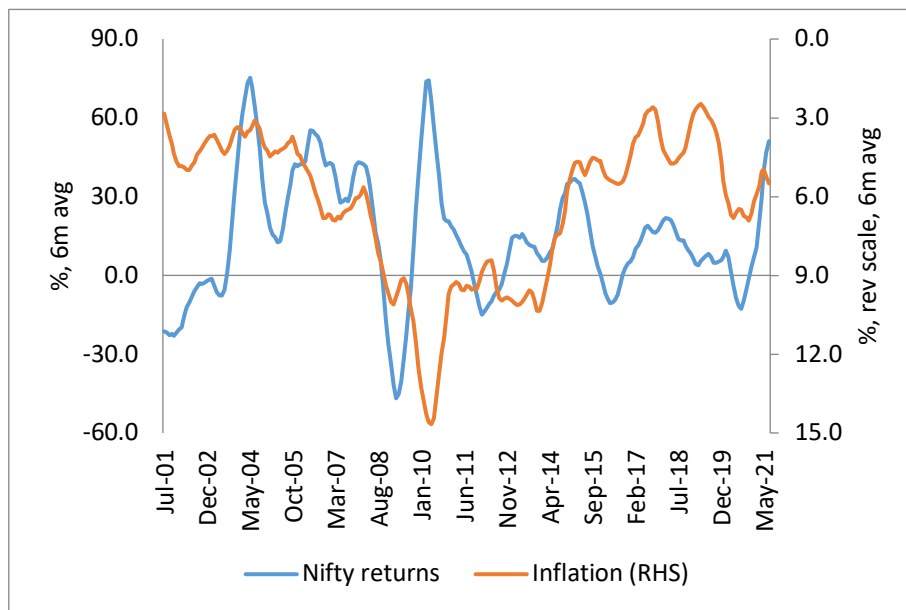
Source: NSE, CSO

Fig 6.4: Co-movement of Nifty returns and industrial production



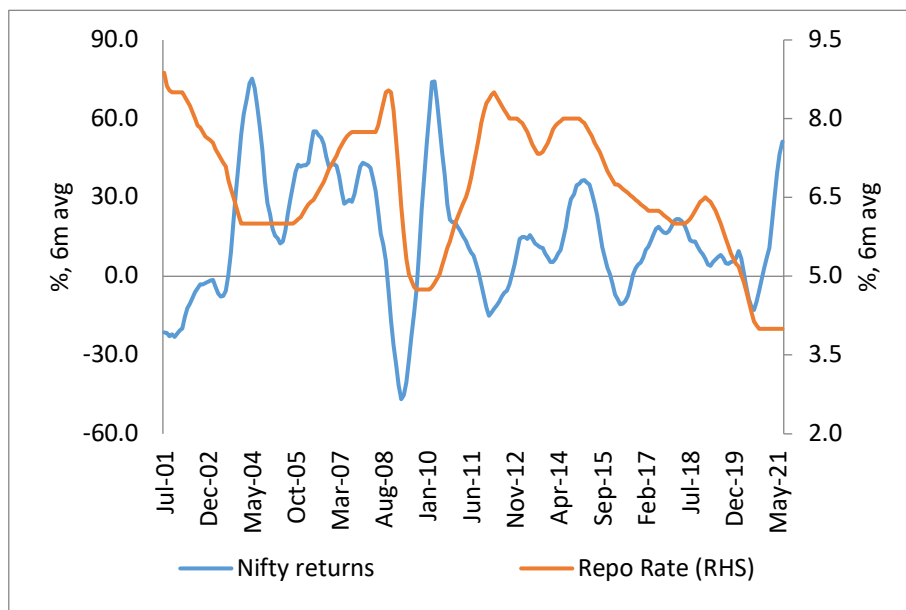
Source: NSE, CSO

Fig 6.5: Co-movement of Nifty returns and inflation



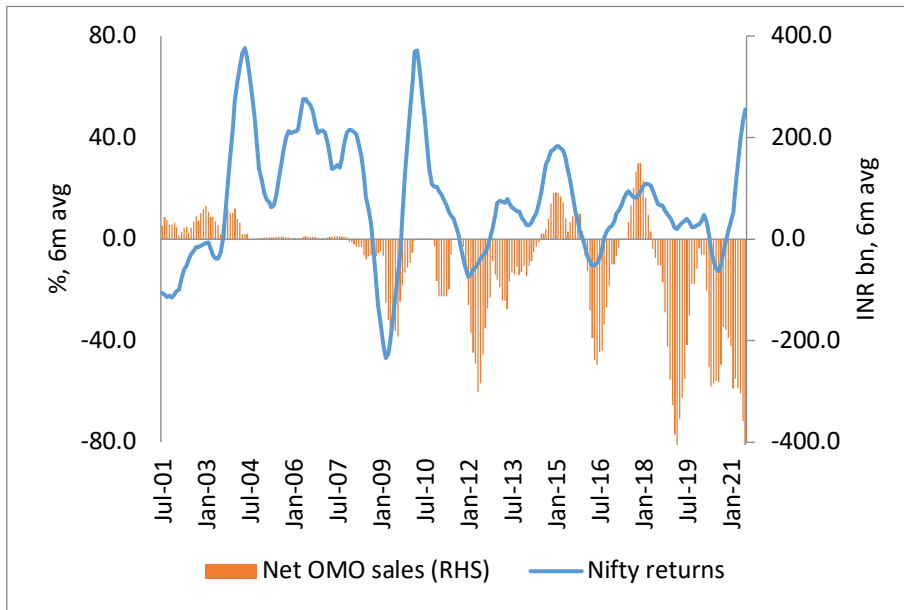
Source: NSE, CSO

Fig 6.6: Relationship between Nifty returns and the repo rate



Source: NSE, RBI

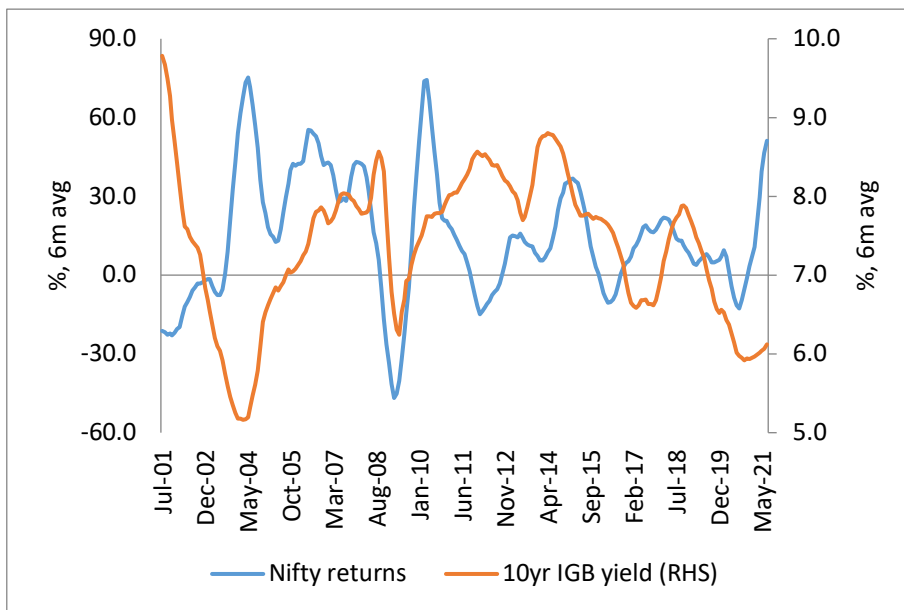
Fig 6.7: Impact of Net OMO sales on Nifty returns



Note: Net OMO purchase is the difference between purchase and sale of OMO

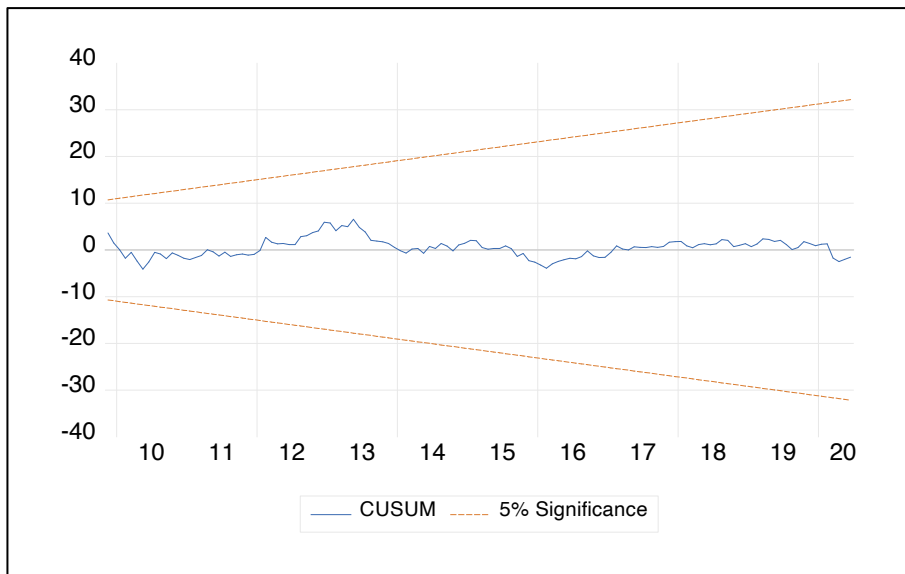
Source: NSE, RBI

Fig 6.8: Co-movement of Nifty returns and the 10-year yield



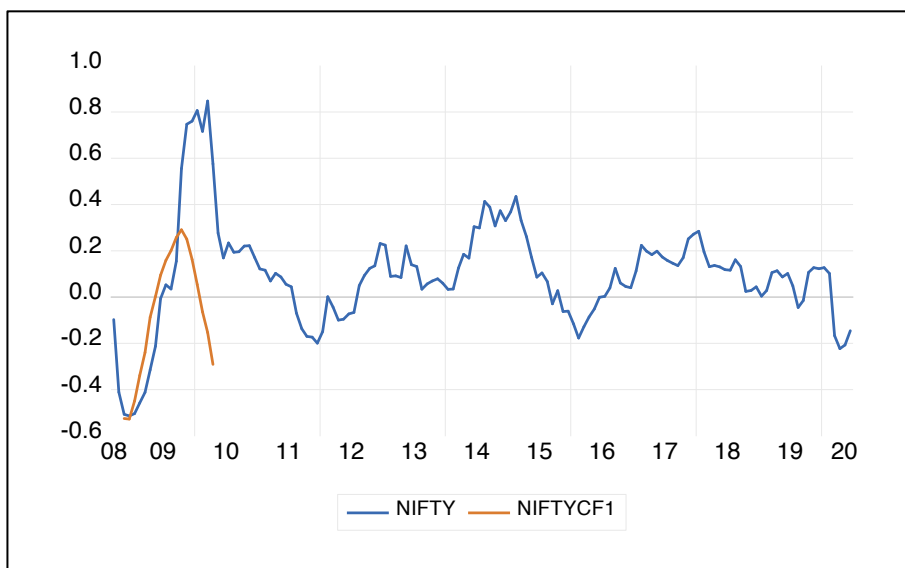
Source: NSE, RBI

Fig 6.9: Findings of the CUSUM test from the equity model



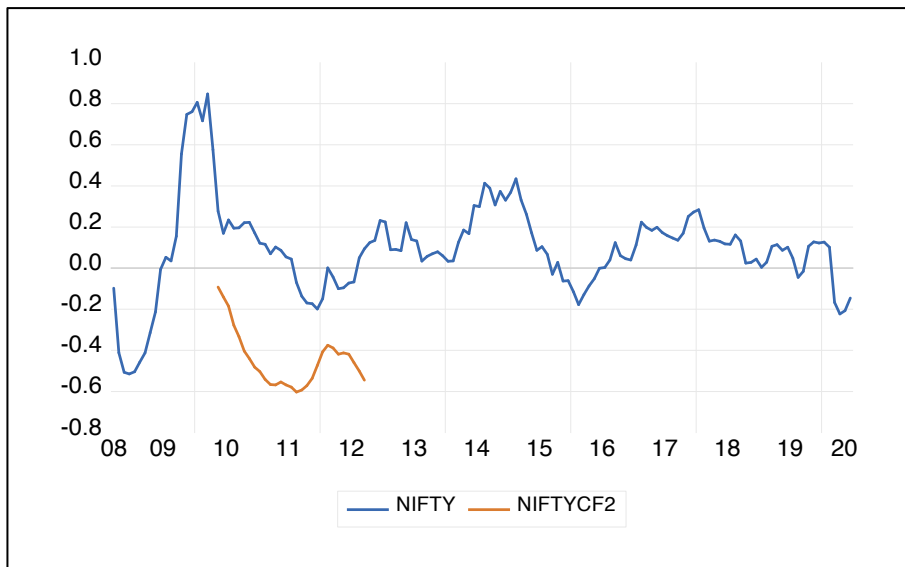
Source: Authors' estimates based on the ARDL model

Fig 6.10: Movement of Nifty returns in Period 1



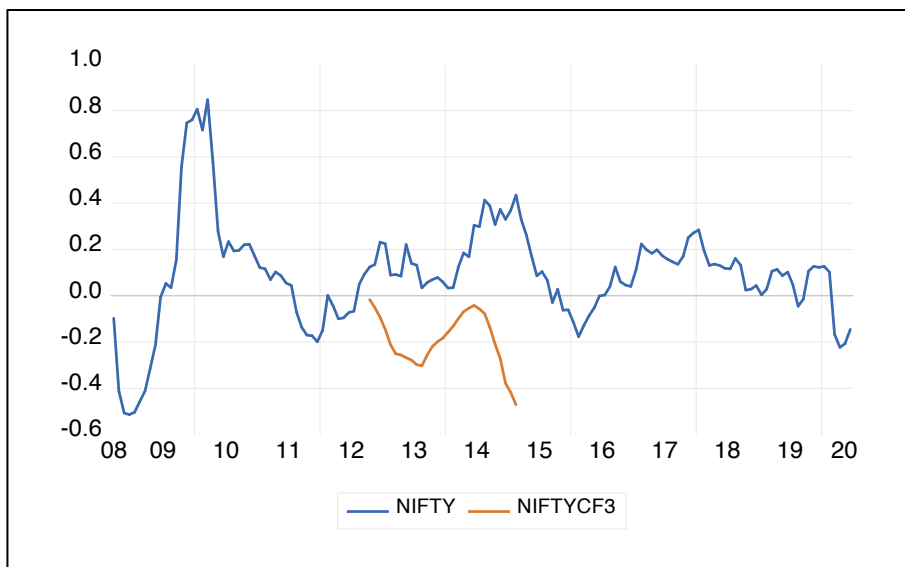
Source: Authors' estimates based on the ARDL model

Fig 6.11: Movement of Nifty returns in Period 2



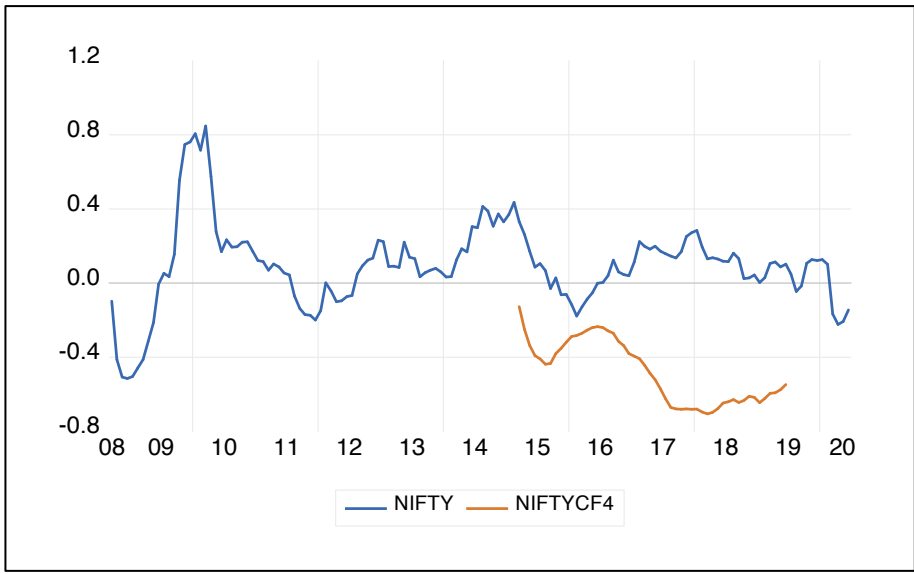
Source: Authors' estimates based on the ARDL model

Fig 6.12: Movement of Nifty returns in Period 3



Source: Authors' estimates based on the ARDL model

Fig 6.13: Movement of Nifty returns in Period 4



Source: Authors' estimates based on the ARDL model

Table 6.1: Activity in the National Stock Exchange

Year	Number of listed companies	Trading volumes, in trillion rupees
2000-01	785	13
2001-02	793	5
2002-03	818	6
2003-04	909	11
2004-05	970	11
2005-06	1069	16
2006-07	1228	19
2007-08	1381	36
2008-09	1432	28
2009-10	1470	41
2010-11	1574	36
2011-12	1646	28
2012-13	1666	27
2013-14	1688	28
2014-15	1733	43
2015-16	1808	42
2016-17	1817	51
2017-18	1931	72
2018-19	1931	79
2019-20	1949	90
2020-21	1968	154

Source: CMIE

Table 6.2: List of variables in the equity model

Variable	Description	Unit	Source	Expected Signs
bond	India 10-year government bond yield	%	RBI	-
crr	India Cash Reserve Ratio	%	RBI	-
fedrate	US Federal Funds rate	%	Federal Reserve Economic Data (FRED)	-
lcrude	Brent crude oil price	dollar/barrel	FRED	-
lomo	India net OMO purchases	INR	RBI	-
qe	Federal Reserve asset purchase as a percent of total outstanding bonds	Ratio	Federal Reserve Archive	+
repo	India repurchase rate (policy rate)	%	RBI	-
revrepo	India reverse repo rate	%	RBI	-
nifty	Returns to Nifty 50 index	%	Bloomberg	+

Source: Authors' estimates

Table 6.3: Descriptive statistics of the equity model

	bond	crr	fedrate	lcrude	lomo	nifty	qe	repo	revrepo
mean	0.0767	0.0452	0.0058	1.8200	-0.6563	0.0926	0.9468	0.0662	0.0576
median	0.0778	0.0400	0.0016	1.8371	-0.7391	0.1018	0.9495	0.0650	0.0600
maximum	0.0894	0.0900	0.0242	2.0395	0.0000	0.8478	1.6342	0.0900	0.0750
minimum	0.0530	0.0300	0.0005	1.2187	-1.9682	-0.5144	0.0064	0.0400	0.0325
Std Dev	0.0073	0.0089	0.0073	0.1525	0.2436	0.2283	0.3023	0.0117	0.0118
Skewness	-0.4767	1.4730	1.3739	-0.6475	-1.1084	0.3764	-0.5143	-0.1612	-0.8384
kurtosis	2.9547	6.2009	3.4088	3.4466	9.5157	5.2644	5.0210	2.0986	2.8636
Jarque-Bera	5.3896	111.9704	45.6598	11.1037	272.6081	33.6907	30.4265	5.4225	16.7451
Probability	0.0675	0.0000	0.0000	0.0039	0.0000	0.0000	0.0000	0.0665	0.0002
Sum	10.8909	6.4225	0.8280	258.4372	-93.1947	13.1489	134.3998	9.4010	8.1850
Sum of sq deviation	0.0076	0.0113	0.0076	3.2794	12.8876	7.3515	10.1636	0.0193	0.0198
Observations	142.0000	142	142	142	142	142	142	142	142

Source: Authors' estimates

Table 6.4: Estimated statistics of unit root test of the equity model

	ADF		PP	
	At level	At first difference	At level	At first difference
bond	-3.9852 **		-4.2661 ***	
crr	-5.8720 ***		-5.8991 ***	
fedrate	-4.6784***		-4.4975***	
lcrude	-2.5616	-8.4592 ***	-2.1612	-8.3086 ***
lomo	-5.5188 ***		-5.4643***	
nifty	-3.5043 **		-2.8456	-8.3368 ***
qe	-5.3120 ***		-2.8146	-9.2924 ***
repo	-2.1411	-10.7923 ***	-2.5304	-10.8059 ***
revrepo	-1.5247	-10.2433 ***	-1.8760	-10.4035 ***

*, ** and *** denote the level of significance at 10%, 5% and 1% levels, respectively

Source: Authors' estimates

Table 6.5: Optimal lag length of the equity model

	Lag 0	Lag 1	Lag 2	Lag 3	Lag 4	Lag 5
AIC	-2.2204	-2.2394*	-2.2257	-2.2125	-2.1975	-2.1843
SIC	-2.0248 *	-2.0221	-1.9866	-1.9518	-1.9150	-1.8801

Source: Authors' estimates based on the ARDL model

Table 6.6: Estimated statistics of bound test – equity model

Significance level (in %)	Critical values		F statistics
	Lower Bound	Upper Bound	
10	1.95	3.06	3.41
5	2.22	3.39	
2.5	2.48	3.70	
1	2.79	4.10	

Source: Authors' estimates based on the ARDL model

Table 6.7: Estimated long-run coefficients of equity model

Dependent variable	Coefficient	T-statistic	P-value
bond	-5.1178**	-2.3163	0.0224
crr	-3.0670**	-2.4448	0.0161
fedrate	4.1354 **	2.1764	0.0317
lcrude	0.2225 ***	2.7833	0.0063
lomo	-0.0624 *	-1.6858	0.0947
nifty	-0.3045 ***	-4.9770	0.0000
qe	0.2125 ***	2.9135	0.0043
repo	4.7988 *	1.9396	0.0550
revrepo	-3.8411*	-1.9380	0.0552

*, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively

Source: Authors' estimates based on the ARDL model

Table 6.8: Estimated short-run coefficients of equity model

Dependent variable	Coefficient	T-statistic	P-value
D(nifty(-1))	0.7249 ***	4.4570	0.0000
D(qe(-1))	0.1857	1.1286	0.2614
ECT(-1)	-0.6960 ***	-3.6462	0.0004

*, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively

Source: Authors' estimates based on the ARDL model

Table 6.9: Estimated values of diagnostic tests – equity model

	L M version	p-value	F-version	p-value
Serial correlation	0.1191	0.7300	0.1079	0.7421
Normality	33.7584 ***	0.0000		
Heteroscedasticity	9.0410	0.5282	0.8891	0.5457

*, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively

Source: Authors' estimates based on the ARDL model

CHAPTER VII

SUMMARY and CONCLUSION

7.1 Background

Beginning in 2007, global financial markets were under much stress from the Global Financial Crisis (GFC). The collapse of the US housing market led to a financial crisis in the US and engulfed the entire world. The US went into recession and unemployment increased.

The central bank of the US, the Federal Reserve (Fed) initially resorted to conventional measures to support the economy. It reduced the benchmark policy rate to zero, and held the *nominal* interest rate at around zero from 2008 to 2015. By reducing the nominal interest rate, the Fed can bring down *real* interest rates. By changing the real interest rate, the preference for asset classes changes as also the willingness of individuals or firms to consume and invest. These changes help the economy recover, and increase employment.

Nevertheless, despite reducing the policy rates to zero, there was no major improvement in the economy. The problem with conventional monetary policy measures is that nominal interest rates cannot be pushed below zero. Doing so creates other problems. If nominal rates are negative, people will hold money instead of depositing it in a bank if the short-term nominal interest rate goes below zero. When conventional policy measures failed to alleviate the financial distress, the Fed resorted to unconventional monetary policies (UMPs).

In conventional monetary policy measures, the central bank is not directly involved in lending to the private sector or the government, or in outright purchase of government bonds, corporate debt or other types of debt instruments. The most common form of an UMP is a Large-Scale Asset-Purchase (LSAP) program, commonly termed Quantitative Easing (QE). Here, the central bank increases money supply by infusing financial institutions with capital to promote increased lending and equity (Gagnon et al., 2011, Krishnamurthy & Vissing-Jorgensen, 2011). The recurring nature of the QE programs and the rising size of balance sheets highlights the importance of studying the effect of these policies in depth. The objective of QE was to reduce the real interest rate in the economy to help it grow.

While QE was adopted by developed economies to boost asset prices, transmission channels were not always limited to only the country implementing the QE. Effects spilled over to other countries, especially Emerging Market Economies (EMEs). The transmission of QE to asset prices may take place through several channels. Three broad ones are: the **portfolio-balancing** channel in which the purchase of longer-duration assets reduces their availability to private investors, leading to demand for substitute assets increasing, including EME assets (Gagnon et al., 2011; Vayanos & Vila, 2009; Bauer & Rudebusch, 2014; Hamilton & Wu, 2011; Neely, 2010; D'Amico et al., 2012).

Via the **signaling** channel, markets interpret QE as a signal of changes in future policy rates, or changes in the macroeconomic outlook. If QE commitments are believed to keep future policy rates low, expectations of short-term rates would be low (Bauer & Rudebusch, 2014; Krishnamurthy & Vissing-Jorgensen, 2011; Woodford, 2012; Campbell et al., 2012; Christensen & Rudebusch, 2012). The third way is via the **liquidity** channel, i.e., greater reserves on the balance sheets of private banks, more easily traded (than long-term assets) in secondary markets. This reduces borrowing costs and boosts overall lending.

While the abundance of liquidity in the US economy was the *raison d'être* for the US economy, the abundance of liquidity in EMEs creates a number of problems. Central banks may be compelled to reduce the interest rate difference to restrict large inflows. If the central bank decided to do nothing, the impact on EME could be via the exchange rate since the dollar is the international currency. Liquidity inflows could lead to competitive easing. What should the central banks of EME do?

7.2 Objective

While there is a vast amount of literature on the impact of QE on developed economies and some on the impact on EMEs, there is limited work on the spillover to Indian financial markets. The closest is the study by Patra et al. (2016a), where the objective is to discover the impact of global spillovers on monetary policy transmission only. While this work shares the same objective with Lakdawala (2018); the methodology and the choice of variables is different. Quite a few studies have focussed on the spillover onto EMEs, but they have clubbed economies and commented on the entire basket. Clubbing economies which have fundamental differences do not take into account political and monetary-policy backgrounds

of individual economies. Nor does it allow other determinants of financial assets to be included in the analysis.

Three major categories in the Indian financial market are the money, equity and debt markets. From the structure of each, the proxy variable of each is identified. The Weighted Average Call Rate (WACR), the 10-year Indian Government Bond (IGB) yield and Nifty returns are the three dependent variables representing respectively the money market, the debt market and the equity market. Control variables (CVs) have been identified for each of the markets from existing literature and statistical analysis.

This study uses the Auto-Regressive Distributed Lag (ARDL) methodology to empirically estimate the impact on financial markets. Most existing studies have employed an event-study methodology; this fails to eliminate the impact of other potential significant events and announcements outside QE event dates. Many of the studies have adopted the Vector Auto-Regression (VAR) model, where all variables in the model are assumed to be endogenous. Adopting the ARDL model is more suitable since the hypothesis is that the causation runs from the US economy to the Indian financial market, not the other way around. The model is also suitable since the integration order of the variables are a mix of $I(0)$ and $I(1)$.

This study makes an attempt to explore the nexus between US QE and India's financial markets since the US is the largest economy in the world, the largest trading partner of India, the biggest market for its exports, and the highest for Foreign Institutional Inflows (FII) to India. Unsurprisingly, monetary policy events in the US are likely to have a huge effect on India. To proxy the US QE variable, many studies have used the term spread or the shadow-policy rate. This study has used the balance sheet data of the Fed like Bhattarai et al. (2021). While the term spread can be affected by events other than QE, balance-sheet data can be impacted only by QE.

Four major objectives of this study:

- (1) To identify the spillover channels of US QE in each of the financial markets – the money market, the debt market and the equity market
- (2) To empirically examine the impact of US QE on each financial market
- (3) To explore the other factors that impact each financial market
- (4) To identify the trend of each financial market if there was no QE by the US

7.3. The study has seven chapters -

Chapter I: Introduction

This chapter traces the history of financial crises around the world and the policy measures adopted. It focuses on the limitations of conventional monetary-policy tools and the evolution of UMPs. By briefly touching upon the timelines, the importance of the new policy measures is established. This leads to the objective of the study, which is to understand the spillover of UMP measures by the world's largest economy, the US, on a developing economy like India

Chapter II: Theoretical background and literature review

This chapter comprises two sections. The first part deals with facts surrounding the QE adopted by the four major central banks – the Fed, the European Central Bank (ECB), the Bank of Japan (BoJ) and the Bank of England (BoE). There are three ways in which the effect of US QE measures have spilled over to the Indian financial market – the portfolio-balance channel, the signalling channel and the liquidity channel.

In the second part of the chapter, existing literature on QE is discussed. QE has lowered the interest rate in developed economies and some literature show evidence of a low interest rate improving growth. Work on EMEs (some of which includes India in the EME basket) shows that there has been significant spillover of the US QE on bond yields and stock-market returns of EMEs.

Chapter III: Methodology

The third chapter focuses on identifying the merits of using an ARDL model in contrast to the event-study and VAR methodologies, which have been extensively used. The superiority of the ARDL model to others, the work-flow of the ARDL model, the diagnostic tests, the implications of the coefficients are discussed in detail. All the variables, along with the source and frequency are discussed. The proxy variable and CVs for each category of the financial market are introduced.

Chapter IV: Impact on the money market

In this chapter the long-run and short-run spillover effects of the US QE on the money market are analyzed. To proxy the money market, the Weighted Average Call Rate (WACR) is used.

The CVs in the WACR model are liquidity, the repo rate, the exchange rate, Brent crude oil, and industrial production growth. The repo rate and the lagged value of the WACR are significant. The WACR has a long-term relation with QE. The long-term coefficient is significant. A one-percentage-point increase in QE leads to a 0.3-basis-point rise in the WACR. The counterfactual analysis shows that the WACR would have been higher when the QE program was rising and lower when QE was being reduced, then it would have been without QE. The chapter concludes there were significant impact of US QW on the WACR. The Reserve Bank of India had to alter policy rates and liquidity to counter the shock, not ideal policy choices for the Indian economy at that time.

Chapter V: Impact on the debt market

In this chapter the impact of US QE on the debt market is analyzed. The benchmark 10-year Indian Government Bond (IGB) yield is chosen as the proxy variable for the debt market. The CVs for the debt market were the 3-month Indian Treasury Bill (ITB) yield, industrial production growth, Brent crude oil, inflation, and liquidity under Open Market Operations (OMO). The study finds that the 3-month ITB yield, Brent crude oil prices, US QE and the lagged values of the 10-year IGB yield are significant variables. There exists a long-term relation between QE, the 10-year IGB yield and the CVs. A 10-percent increase in QE leads to a 4-basis-point hardening in yields. From the counterfactual analysis, it is noted that US QE led to volatility in long-term yields despite policies undertaken by the RBI. This implies that debt market assets may be mispriced due to QE and lack of complete control of the RBI on monetary policy.

Chapter VI: Impact on the equity market

This chapter studies the impact of US QE on the equity market. The Nifty returns are identified as the proxy variable for the equity market. The CVs in the equity market are the policy rates (The RBI's repo and reverse repo, the US policy rate), reserve requirements (the Cash Reserve Ratio), Brent crude oil prices, liquidity under OMO, the 10-year IGB yield and its own lagged values. All variables were found to be significant. Nifty returns have a long term relation with US QE and the CVs. It is observed that a 10-percentage-point increase in QE leads to a 2.1% increase in Nifty returns. From the counterfactual analysis, it is found that the continuous QE measures by the US have kept Nifty returns higher than otherwise. The upswing in the equity market is a cause of concern as FII can be volatile as it has been seen in the past in the case of the East Asian Financial crisis.

7.4 Policy relevance & scope of work

By studying all the financial markets, the work presents a holistic picture of the impact on asset prices in India. The empirical estimates are a guide to policy-makers to ascertain what can be the nature of the impact of future QE policies. The rise in Nifty returns, the hardening of both the 10 year IGB yields and 3 month ITB yield imply that the US QE led to a certain degree of asset-price inflation in India.

With the development of the financial markets, the ability to take risks has increased, which has led to economies being more exposed to financial crises (Rajan, 2005). The global crisis of 2008 saw a sharp monetary easing in India and US. Thereafter, the reversal of the highly-accommodative monetary policy in 2010 coincided with a major tightening in banking-sector liquidity. From being large lenders to the RBI under the reverse-repo window, the banking system started borrowing large amounts from the RBI under the repo window. Prior to the policy-rate tightening started in 2013, the RBI sharply tightened banking liquidity.

The pro-active efforts by the RBI were successful in containing the spillover of US monetary policy on the Indian financial market. It may also explain why certain authors found the impact of such policies on the Indian market to be insignificant. This leads us to the broad conclusion – loss of complete control of the RBI over the domestic situation. This is in line with the fact that competitive easing is also a threat to the independence of the monetary policy (Rajan, 2015).

If a country has a flexible exchange rate and capital-account convertibility, it cannot have an autonomous monetary policy. However, restrictions on cross-border capital movements (especially outflows by residents) and the RBI's ability to intervene in the foreign-exchange market have allowed the RBI to manoeuvre the monetary-policy of the economy in the desired way. The RBI has been successful in tightening monetary policy in 2010 and 2011 and again in 2013 and 2014, while most developed countries maintained a prolonged pause.

This work helps identify the channels of transmission; which can help policy-makers in regulating these markets. It also shows that the initial episodes of QE had more impact than the latter ones. This implies that the domestic economy needs to be guarded against the

uncertainty of policy actions of the large central banks. Informing and educating the populace about QE and its possible impact; clarity in communication regarding its policy action and rationale; regulation of the markets may help the RBI overcome the spillover effects of UMP. Rajan (2005) discusses monetary policies that can reduce the incentives of taking risks.

Since the spillover channels and empirical evidence of it have been identified, it is necessary to protect the domestic economy from the idiosyncrasies of the central banks of developed economies. Strengthening international monetary policy coordination is a tool to reduce the spillover impact. Ostry & Ghosh (2013) talk about a ‘neutral assessor’ who can advise regarding alternative policy strategies and the use of ‘guideposts’ to limit the negative spillover effect. Jeanne (2014) provides a framework whereby countries may find it suitable to coordinate when there is shortage of global demand. Mishra & Rajan (2016) talk about measures by which developed countries can internalize the spillover of vigorous and repeated monetary policy actions.

Three areas of work could not be done. First, what is the impact of asset-price inflation on the different sectors – like the impact of the rise of the 10-year IGB yield on commercial banks’ balance sheets. Second, what is the impact on the real economic variables of India –growth, inflation, unemployment. Third, what is likely to be the impact when the UMP are withdrawn or balance sheets normalized. Answers to these three questions are critical for more effective monetary-policy decisions of the RBI. The rationale and efficiency of such programs are also debated. An increase in the supply of liquidity does not guarantee an increase in demand for it (Group of Thirty 2015). The impact of QE on the forex market has been kept outside the purview of the work, since India’s exchange rate is not floating, and the RBI intervenes to manage the exchange rate. So the findings from the model would be trivial.

Given the very short time that has passed since the introduction of large-scale asset purchasing programmes, the empirical results should be seen as a work in progress, and the conclusions as tentative. Huge uncertainties persist concerning the strength and pace of transmission of US quantitative easing to financial and real activities. In fact, the pre-crisis norm of domestic and cross-border monetary-policy transmissions may have been severely impaired following the GFC. The ongoing experiments with balance-sheet policies, a set of tools neither the practising central banks nor the private sector is familiar with, could imply

that it takes time for economic agents to learn how such policies are transmitted and adjust their behaviour accordingly. All this adds difficulties to this work.

“There are two ways to conquer and enslave a nation. One is by the sword. The other is by debt.”

– John Adams

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ANNEXURE I

Papers published from the thesis.

1. Paul, M. & Kalluru, S. R. (2022). Impact of US UMP on Indian Stock Market. In: N. Yoshino, R. N. Paramanik, A. S. Kumar (eds) *Studies in International Economics and Finance* (pp. 647-662.). Singapore: Springer.
2. Paul, M. & Kalluru, S. R. (2022). US QE and the Indian Bond Market. *Journal of Quantitative Economics*, 20, 137–157
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