A STUDY OF PREDICTIVE STRENGTH OF INDIAN OVERNIGHT SWAP MARKET VS OTHER COUNTRIES

2018-19

Authored by: Dipanwita Dutta

A study of Predictive strength of Indian Overnight Swap Market vs Other Countries

{This Report submitted to the Indian Institute of Banking & Finance (IIBF), Mumbai for the Award of Diamond Jubilee & C.H. Bhabha Banking Overseas Research Fellowship(DJCHBBORF) 2018-19}

Prepared By:

Dipanwita Dutta,

Chief Manager,

Strategic Management & Economic Advisory Division,

Punjab National Bank,

Corporate Office: 4th Floor, East Wing,

Plot No-4, Sec-10, Dwarka, New Delhi.

DECLARATION

I, hereby declare that this project report entitled, 'A study of Predictive strength of Indian Overnight Swap Market vs Other Countries' submitted to the Indian Institute of Banking & Finance (IIBF), Mumbai for the Award of Diamond Jubilee & C.H. Bhabha Banking Overseas Research Fellowship (DJCHBBORF) for 2018-19 is an original research work carried out by me. It has not been submitted for any other degree, part of degree or examination, conference etc. There is no violation of copyright. Indian Institute of Banking & Finance (IIBF) will have the rights to preserve, use and disseminate this Report in print or electronic format.

Place: New Delhi

Date: 24.05.2021 (Dipanwita Dutta)

DECLARATION

I hereby declare that this project report entitled, "A study of Predictive strength of Indian Overnight Swap Market vs Other Countries" is a bonafide and genuine research work carried out by me under the CH Bhabha Banking Overseas Research Fellowship (DJCHBBORF) (Year 2018-19) of Indian Institute of Banking & Finance (IIBF), Mumbai. There is no violation of copy right. Indian Institute of Banking & Finance shall have the rights to preserve, use and disseminate this report in print or electronic format for academic/research purpose.

Date: 24.05.2021
Place: New Delhi.

Signature: Dipanwita
Name: DIPANWITA DUTTA
Address: SMEAD, HO (4th Flr), E-Wing
Punjab National Bank
Plot-4, Sector-10
Dwarka
New Delhi-.75

“The financial markets generally are unpredictable. So that one has to have different scenarios… The idea that you can actually predict what's going to happen contradicts my way of looking at the market.”

------George Soros

This report is dedicated to my beloved father

Late Shri Dipak Dutta

ACKNOWLEDGMENTS

Throughout the writing of this research report I have received a great deal of support and assistance. It is my honour to thank them for their kindness and support.

I would first like to thank my supervisor, Dr. Indrani Manna, whose expertise was invaluable in formulating the research questions and methodology. Her insightful feedback pushed me to sharpen my thinking and brought my work to a higher level.

I express my deep sense of gratitude to Mr. Biswaketan Das, Chief Executive Officer, Mr. S. Muralidharan, Director (Academics), and all the eminent members of the DJCHBBORF Research Committee of the Indian Institute of Banking and Finance (IIBF), Mumbai, for their patient support and for all of the opportunities I was given to further my research. I am also thankful to all the faculty & other staff members of IIBF, Mumbai, (especially Dr. Kratika Shrivastava) for their continuous support during the research work.

I would like to acknowledge my colleagues from my esteemed institution, Punjab National Bank, especially, Mr. Nitin Narang, Research Desk, Treasury Division of PNB for their wonderful collaboration and helping me in collating much needed data.

In addition, I would like to thank my parents and my family for their wise counsel and sympathetic ear and being there for me. Finally, I could not have completed the work without my teachers and my employer Punjab National Bank which provided me the base and platform on which the core research work is developed.

Last but not the least, I wholeheartedly thank God for providing the opportunity and strength to complete the work despite immense obstacle.

A STUDY OF PREDICTIVE STRENGTH OF INDIAN OVERNIGHT SWAP MARKET VS OTHER COUNTRIES

DISCLAIMER

The opinions expressed are of the authors and not necessarily reflect those of the Organization in which she is employed. Views expressed here have been based on information obtained from materials which are believed to be reliable, but these have not been independently verified. This Report is only for information; recipients are advised to use their judgmental view to take a call.

CONTENTS

CHAPTERS

CERTIFICATE OF SUPERVISOR

This is to certify that this Research Report entitled "A STUDY OF PREDICTIVE STRENGTH OF INDIAN OVERNIGHT SWAP MARKET VS OTHER COUNTRIES" has been prepared by Ms Dipanwita Dutta, and submitted to the Indian Institute of Banking and Finance (IIBF), Mumbai for the award of the Diamond Jubilee & C.H. Bhabha Banking Overseas Research Fellowship (DJCHBBORF), under my supervision. The research work done in this Report is Satisfactory and recommended for the Award.

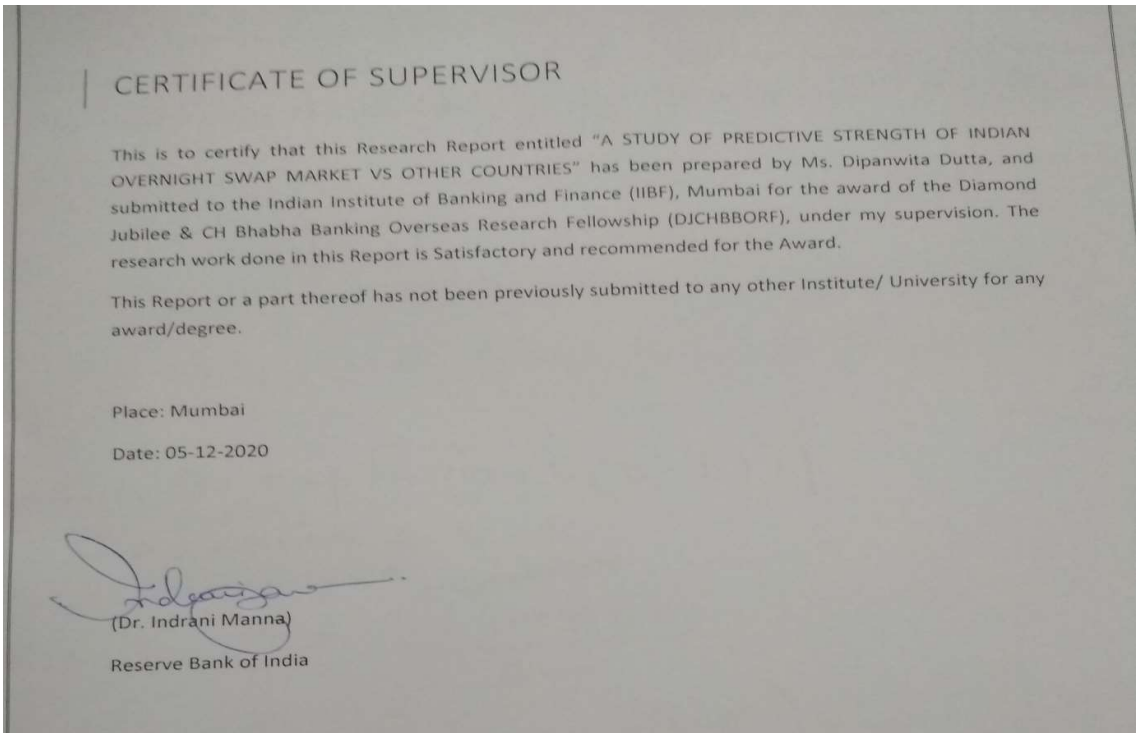
This Report or a part thereof has not been previously submitted to any other Institute/ University for any award/degree.

Place: Mumbai

Date: 05-12-2020

(Dr. Indrani Manna)

Reserve Bank of India


CERTIFICATE OF SUPERVISOR

This is to certify that this Research Report entitled "A STUDY OF PREDICTIVE STRENGTH OF INDIAN OVERNIGHT SWAP MARKET VS OTHER COUNTRIES" has been prepared by Ms. Dipanwita Dutta, and submitted to the Indian Institute of Banking and Finance (IIBF), Mumbai for the award of the Diamond Jubilee & CH Bhabha Banking Overseas Research Fellowship (DJCHBBORF), under my supervision. The research work done in this Report is Satisfactory and recommended for the Award.

This Report or a part thereof has not been previously submitted to any other Institute/ University for any award/degree.

Place: Mumbai

Date: 05-12-2020

(Dr. Indrani Manna)

Reserve Bank of India

LIST OF ABBREVIATION

ANZ	Australia and New Zealand Banking Group Limited
AONIA	AUD Overnight Index Average
ASTROID	Anonymous System for Trading in Rupee OTC Interest Rate Derivatives
AUD	Australian Dollar
BIS	Bank for International Settlements
BOJ	Bank of Japan
CCIL	Clearing Corporation of India Limited
CCP	Central Clearing Counterparty
CET	Central European Time
CME	Chicago Mercantile Exchange
DTCC	Depository Trust & Clearing Corporation
EBF	European Banking Federation
ECB	European Central Bank
EFFR	Effective Federal Funds Rate
EONIA	Euro Overnight Index Average
EUR	EURO, official currency of Europe
EUREPO	A single reference rate for a unified Euro G.C. Repo Market (DISCONTINUED FROM 2015)
EURIBOR	Euro Interbank Offer Rate
FBIL	Financial Benchmarks India
FI	Financial Institution
FIMMDA	Fixed Income Money Market and Derivatives Association of India
FRA	Forward Rate Agreements
GBP	British pound sterling
HHL	Hui-Heubel Liquidity ratio

HFT	Held for Trading
HTM	Held to Maturity
ICAAP	Internal Capital Adequacy and Assessment Process
ICE	Intercontinental Exchange
IDR	Indonesian rupiah
IndONIA	Indonesia Overnight Index Average
INR	Indian rupee
IRD	Interest Rate Derivative
IRF	Interest Rate Futures
IRRBB	Interest Rate Risk in the Banking Book
IRS	Interest Rate Swap
JPY	Yen, official currency of Japan
LIBOR	London Inter-bank Offered Rate
MEC	Market-Efficiency Coefficient
MIBOR	Mumbai Interbank Offer Rate
MIFOR	Mumbai Interbank Forward Offer Rate
MMSR	Money Market Statistical Reporting
NSE	National Stock Exchange
NTIRR	Non-traded interest rate risk
NZD	New Zealand Dollar
OIS	Overnight Index Swap
OTC	Over the Counter
P.D.	Primary Dealers
QEP	Quantitative Easing Policy
RBI	Reserve Bank of India
RRB	Regional Rural Bank

SARON	Swiss Average Rate Overnight Index
SEBI	Securities and Exchange Board of India
SONIA	Sterling Overnight Index Average
SLR	Statutory Liquidity Ratio
STCI	Securities Trading Corporation of India
UK	United Kingdom
U.S.	United States
USD	United States Dollar

EXECUTIVE SUMMARY

Interest rate derivatives (IRDs) have been by far the most actively traded global OTC derivative instrument, and within this segment, Interest Rate Swaps (IRS) hold the largest market share. The most commonly used IRS in India is the overnight index swaps (OIS) where the floating leg of the swap is linked to an overnight index.

Overnight Index Swaps (OIS) created between two market participants when one participant is swapping an overnight interest rate, and the other one is swapping a fixed interest rate. This instrument allows financial institutions to swap the interest rates they are paying without going for a refinance or change the terms of the loans they have taken.

OIS carries significant weight in the interest rate derivative market. Due to its multidimensional usage, the global OIS market has recorded spectacular growth, especially, post-financial crisis. The growing importance of OIS is also stemming from the fact that it is used as a predictor of future interest rate trajectory and its usage for hedging interest rate risk of the balance sheet.

There has been a considerable amount of studies on interest rate futures, but there has been limited study on the predictive power of OIS in emerging markets and their limitations, ways and means to improve them.

In this study, the primary objective is to assess the market depth and liquidity of the Indian OIS market vis-à-vis some other markets. Second, the study tries to assess the effectiveness of OIS as a predictor of interest rate in India and whether the liquidity impacts its effectiveness.

The swap market has witnessed exponential growth in the past few decades. In India, interest rate swaps are commonly traded on 2 benchmarks viz MIBOR and MIFOR. Scheduled commercial banks (excluding Regional Rural Banks), primary dealers (PDs) and all-India financial institutions (F.I.s) are the main participants of the Interest Rate Derivative market.

Next, the market liquidity of OIS is measured by vis-à-vis other markets. The countries which show better liquidity are U.S., U.K., New Zealand as their zeros (a measure of liquidity higher zeros imply more liquidity) are lower than their counterparts. In terms of market resilience, the European Union and the U.K. is scoring better than their counterpart as their MEC value tends towards 1. India lags behind both in terms of zeros and MECs making it an average country in terms of OIS market. Indian OIS market is a developing one. However, it is not the one with the highest volume, highly resilient and has high liquidity. However, it is slowly catching up with the world.

OIS rates are widely perceived as investors' expectations of future overnight interest rates over the horizon of the contract. The predictive prowess of Indian OIS market vs two other highly liquid markets is tested. It was found that in Indian Market OIS in 1year and 5-year category is most liquid and deep and thus manifests market viewpoint more accurately than their shorter-term counterpart. In the developed market, however, the predictive capacity is higher for short term OIS as markets are resilient and liquid in the shorter term too.

Banks are exposed to interest rate risk as to the main chunk of its asset and liability interest-rate sensitive. It is important for banks to manage their interest rate risk. Further, financial institutions using OIS as a hedge will contribute to the depth of the market. This Overnight Index Swap has the potential to help banks and financial firms in India to assess expectations for borrowing costs and hedge the risks of rate changes to their bond portfolios.

Indian OIS curve has the predictive capability, and the financial institution may leverage OIS for hedging their interest rate risk. Indian OIS market has undergone many reforms and constantly improving and much ahead of the OIS market of some developing economies.

There is further scope for estimating the hedging effectiveness of OIS in the different financial institution and also the impact hedging on the predictive power of the OIS.

CHAPTER 1

DERIVATIVE AND OVERNIGHT INDEX SWAP

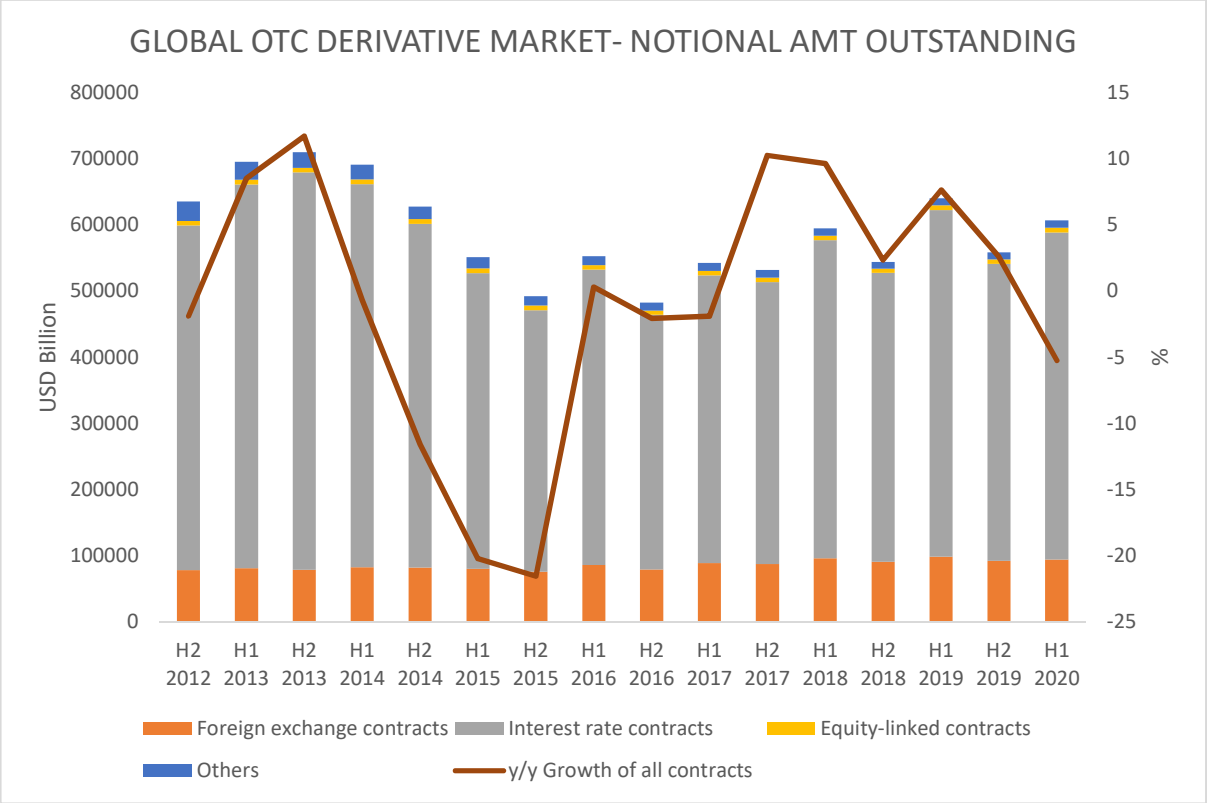
Derivative

A derivative is a financial instrument which derives its value from the change in the value of an underlying asset like change in a specified interest rate, security price, commodity price, foreign exchange rate, index of prices or rates, a credit rating or credit index, or similar variable. A derivative instrument requires no initial net investment or little initial net investment relative to other types of contracts that have a similar response to changes in market conditions. It is most often settled at a future date (Pawaskar and Ghose 2019).

There are many types of derivatives in the world. Out of all the derivative markets, global interest rate derivatives (IRD) market is the largest. Average daily turnover in over the counter (OTC) markets is $2.7 trillion ($6.5 trillion in Apr'2019) while that of exchange-traded markets, where futures and options are the most actively traded instruments, is $5.1 trillion ($ 6.6 trillion in April 2019) as per data of BIS Triennial Survey of foreign exchange and OTC derivatives trading, 2016. (statistics: BIS 2018)

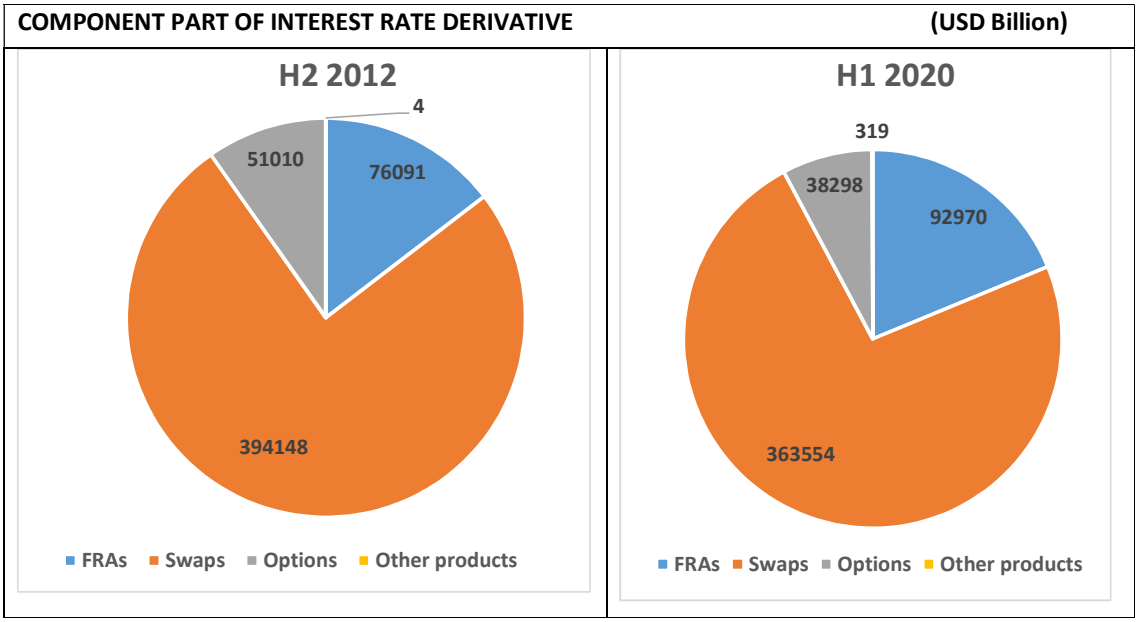
IRDs have been by far the most actively traded global OTC derivative instrument, and within this segment, Interest Rate Swaps (IRS) hold the largest market share. An interest rate derivative instrument has an interest rate or set of different interest rates as an underlying asset. Interest Rate Swap refers to a financial contract between two parties, who are exchanging or swapping a stream of interest payments for a 'notional principal' amount on multiple occasions during a specified period. Such contracts generally involve the exchange of a 'fixed to floating' or 'floating to fixed' rates of interest. The most commonly used IRS in India is the overnight index swaps (OIS) where the floating leg of the swap is linked to an overnight index, compounded every day over of the payment period. (Pawaskar and Ghose 2019). Let us delve deeper into an Overnight Index Contract.

Graph 1.1



Source: stats.bis.org

Graph 1.2



Source: stats.bis.org

Overnight Index Swap

These are average rate swaps that are being increasingly used by banks themselves for hedging. During a normal business day, a bank will make a large number of cash payments and receipts. These will ultimately flow down to the cash desk within the Treasury, who will have the final responsibility to fund the net payments or lend out the net receipts. At the end of each working day, the desk will ensure that its books, either in separate currencies or all netted back to a single home currency, are squared within limits. Given the estimated future cash requirements of the bank, part of the expertise of the desk is to decide how much money will be borrowed or lent, and for what period of time. The remaining balances are invariably sourced into the bank overnight market on an uncollateralised basis. The overnight rates available in this market depend upon the net positions of all the contributing banks and can fluctuate violently from day to day.

Most financial centres publish an official overnight rate, usually calculated by averaging the observed rates reported by the commercial banks. For example, 41 banks spread across the Eurozone (plus 7 non-Euro international banks) supply their overnight rates to the European Central Bank by 6 pm CET each business day; the ECB then publishes an arithmetic average called the Euro Overnight Index Average (EONIA) by 7 pm.

In order for the banks to perform some limited risk control over the fluctuations, Overnight Indexed Swaps (OIS) have been developed. This is the generic name for a class of swaps that pays some temporal average of the overnight rate and receive a fixed rate.

Let us understand the mechanics of Overnight Index Swap through an example.

Say, for instance, Institution **A** has a floating rate loan of Rs. 100 Cr and after analysing the riskiness of the portfolio, it decided that it would much rather be paying a fixed interest rate on its loan. On the other hand, Institution **B**, which has a fixed loan amounting Rs 100 Cr would much rather be paying a variable interest rate—based on the overnight rate—on its loan.

However, as per terms and condition, neither institution can renegotiate their current loans. In this case, these two institutions could create an Overnight Index Swap (OIS) with each

other. Herein, institution A swap their loan with institution B paying a fixed rate and receiving a floating rate. In contrast, institution B pays a floating rate and receives a fixed rate.

The interest of the overnight rate portion of the swap is compounded and paid at reset dates, with the fixed leg being accounted for in the swap's value to each party.

The floating leg's present value is determined by either compounding of the overnight rate or by taking the geometric average of the rate over a given period. (Investopedia 2019)

At maturity, the only difference in interest rate swapped not the entire value.

The following attributes need to be specified to complete a definition of Overnight Index Swap.

- Notional Amount
- Start and End Date
- Underlying Referenced Overnight Index
- The direction of the contract, i.e. which party will be paying Fixed vs Floating.

A Mathematical Interpretation of Swapping Interest amount

Let us say Universal Bank has entered into an OIS on a notional principal of Rs. 5 million and has agreed to receive Mumbai Interbank Offer Rate (MIBOR) overnight floating rate for a fixed payment of 6% on the notional principal with Select Bank. The swap was entered into on 1 April 2020 and was to commence on 2 April 2020 and run for a period of 7 days.

- Notional Amount = Rs. 5 million
- Maturity: 7 working days
- References the (Mumbai Interbank Offer Rate (MIBOR)
- Universal Bank agrees to pay a fixed overnight rate of 6%
- FBIL announces the benchmark rate for Overnight Mumbai Interbank Outright Rate (MIBOR) on a daily basis, except Saturdays, Sundays and local holidays. Here we have taken a hypothetical rate of interest.

The amount payable by Universal Bank on the floating rate will be calculated on the notional principal every day at the respective MIBOR rate and will be compounded on a daily basis, as shown below. (Please note the rate for Saturday and Sunday are the same as the market is closed on Sundays).

The fixed leg interest payment is worked in the normal way for 7 days at 6%, and the difference between the two is the amount Universal Bank has to pay or receive on maturity. It may be noted that the interest payments are not exchanged on a daily basis but are exchanged only on maturity.

Table 1.1: MATHEMATICAL EXAMPLE OF OIS

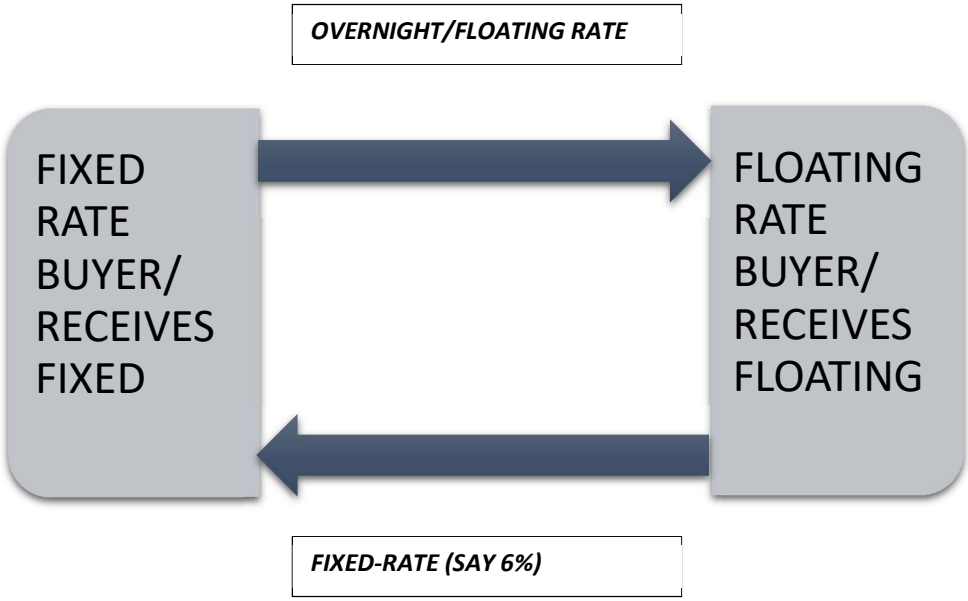
Notional Principal	5,000,000
Company Receives Fixed	6%

(amt in Rs)

Payable by Universal Bank					
Cash Flow on Floating leg					
S.n	**date**	**day**	**MIBOR (hypothetical)**	**Principal + interest**	**interest**
1	02-04-20	Thursday	4.61	5,000,000	631.51
2	03-04-20	Friday	4.50	5,000,632	616.52
3	04-04-20	Saturday	4.55	5,001,248	623.44
4	05-04-20	Sunday	4.55	5,001,871	623.52
5	06-04-20	Monday	4.60	5,002,495	630.45
6	07-04-20	Tuesday	4.55	5,003,125	623.68
7	08-04-20	Wednesday	4.59	5,003,749	629.24
8	09-04-20	Thursday	4.58	**5,004,378**	
Receivable of Universal Bank					
Principal + Interest on Fixed Leg			5,000,000 x 6% x7/365 = 5,005,753		
Net Receivable					
A. Payable on Floating Leg				5,004,378	
B. Receivable on Fixed Leg				5,005,753	
C. Net (Universal Bank receives) [B-A]				**1,375**	

At maturity, the Universal Bank buyer of the fixed leg which receives fixed and pays floating will receive net interest of Rs. 1375/-. Note that, here no principal is exchanged the only net of receivable and payable is transacted.

Figure 1: MECHANICS OF OVERNIGHT INDEX SWAP



Risk Associated with Overnight Index Swap

- Counterparty Risk associated with this trade is the risk that the counterparty will default and therefore will not be able to meet its end of the deal. However, since only the difference in interest rate is exchanged, the exposure is lower. (Andreou 2019).

- The Market Risk associated with this trade is the Overnight Rate changing each day and therefore affecting the associated value of the position. (Andreou 2019).

- Legal risk including the risk arising from unenforceable contracts or non-compliance with laws, rules and regulations. Market safety could be affected in the case of legal uncertainty with regard to widely used derivative products. (Pawaskar and Ghose 2019)

CHAPTER 2

LITERATURE REVIEW & OBJECTIVE OF THE STUDY

Literature Review

In India, Overnight Index Swap is not a widely researched area, and very few research study has \been carried out to analyse the market. One of the key among them (Ghosh and Acharya 2010) stated that Gsec rate and call rate had a positive and significant correlation with the OIS rate, while the inflation rate was not contemporaneously related with the OIS rate. The other factor that significantly caused the OIS rate movement was the liquidity conditions in the Indian money market. (Bernanke 1990) in his paper compared the predictive power of the number of interest rate and spread and found that spread between commercial paper rate and treasury bill rate is the best predictor of the interest rate. (Bernanke 1990) in his study, however, did not take any market instrument like OIS as a predictor. (Lloyd 2018) in his paper assessed the use of OIS rates as a measure of monetary policy expectation. Therein, he studies key developed economies like the U.S., U.K., etc. and has found that OIS predictability varies across maturity. (Chang and Feunou 2013) measured uncertainty surrounding the central bank's future policy rates using implied volatility computed from interest rate option prices and realised volatility computed from intraday prices of interest rate futures. Further, their measures of policy rate uncertainty improve the estimation of policy rate expectations from overnight index swap (OIS) rates by predicting the risk premium in the OIS market. Besides many studies have been devoted to assessing the history and developmental framework for OIS market like- (Sendyona 2014,) who tried to assess the evolution of Interest rate future and a main contributory factor to their evolution.

(Ooka, Nagano, & Baba, 2006) in their paper highlighted the merits of OIS. They held that the OIS market could provide hedging tools against overnight interest rate risks and also expand arbitrage opportunities. In this way, they can provide liquidity to the money market. Further,

the authors also viewed that OIS provides an effective way to extract market perceptions about monetary policy stance.

Not only is this OIS market is expected to indicate market risk owing to counterparty risk and predict a black swan event in the market. (Taylor & Williams, January 2009) In their paper tested whether the various risk variables can explain the Libor-OIS spread using. They concluded that counterparty risk could be a factor in explaining the spread between the Libor rate and the OIS rate.

(Finlay & Olivan, 2012) in their paper describes how overnight indexed swap rates and government bond yields can be used to estimate a zero-coupon yield curve and infer market expectations for risk-free interest rates. They also studied the expectation of inflation.

Not only this, but Interest rate futures are also acknowledged as a risk mitigation tool and often used for hedging. (Chen 2011), (Salvam and Rita January 2011) are the authors who also held that for risk reduction through the derivative product. The use of hedging increased volume of interest rate futures. Research (Melamed 1981) has also shown that liquidity is a necessary condition for the futures markets' success.

There has been a considerable study on interest rate future. Still, there has been limited study on the predictive power of OIS in emerging market and their limitation, ways and means to improve them. Use of OIS as a hedging tool and their effectiveness is also not widely researched. Hence to cater to these needs, I am planning to conduct the above study.

Major objective/s

- Here the primary objective is to assess the market depth and liquidity of the Indian OIS market vis-à-vis some other markets.
- To assess the effectiveness of OIS as a predictor of interest rate in India and whether the liquidity impacts its effectiveness.

Research Question

To cater to the above objective, our research will broadly answer the following:

1. To assess the comparable position in terms of depth and liquidity of the Indian OIS market vis-à-vis other markets
2. To assess the predictive power of OIS in India for the future Interest rate in India
3. Assess the strength of predictive power of OIS, if any, in India *vis-à-vis* some select economies?
4. Whether increased usage of OIS for hedging balance sheet risk will help increase liquidity or depth of the market and impact predicting power?

The Need of the Research

OIS carries significant weight in the interest rate derivative market. Due to its multidimensional usage, the global OIS market has recorded spectacular growth, especially, post-financial crisis. The market expanded by 68% during 2007 to in 2016 (source: BIS Triennial Survey). Compared to that the growth of Indian OIS market is insignificant. But despite that, OIS is considered as one of the principal indicators of risk and liquidity of the market. In India, currency derivative is the significant derivative product not interest rate derivative. The growing importance of OIS is also stemming from the fact that it is used as a predictor of future interest rate trajectory and its usage for hedging interest rate risk of the balance sheet. Hence, through this study, we attempt to analyse whether, in India, OIS can be utilised both for its predictive power and hedging balance sheet risk.

Scope, framework & applicability of the study to our Banking Industry

The interest rate is the crux of the banking business. Given that, interest rate prediction will give a better tool to the banker for managing its interest rate sensitive assets. Hence,

assessing the predictive power of OIS and utilising the same in managing the interest rate sensitive asset of the bank will be of much use for the banking industry. (Acharya 2018) Deputy Governor, Viral Acharya of the Reserve Bank of India in his speech mentioned that Public Sector Bank's share in secondary market trading of G-Secs is about 33%, their share in hedging activity in the Interest Rate Swap (IRS) and Interest Rate Future (IRF) segments are only 4.61% and 13.40%. This mentioned fact necessitates not only an assessment but also improvement. Not only this, a clear assessment of the effectiveness of hedging through interest rate derivative may help domestic banks to hedge their interest rate risk appropriately. The above study will also pinpoint the limitations/challenges towards using the predictive power of OIS and using OIS as a hedging tool. By plugging out the above loopholes/challenges, we may bring out some policy prescription for further developing OIS market.

Going ahead, the analysis is divided into four different chapters.

Chapter 3: In this section, we will provide a brief overview of the contemporary Overnight Index Swap market of India vis-a-vis the world. Towards this end, a brief comparison of the development stage of the OIS market of some key economies as well as some emerging economies can be made.

Chapter 4: In this chapter the predictive power of OIS in India for future Interest rate and strength of predictive power of OIS, if any, in India vis-à-vis some select economies is assessed

Chapter 5: This chapter concludes the entire study and our recommendation.

CHAPTER 3

COMPARATIVE POSITION OF INDIAN OIS MARKET VIS A VIS SELECT MARKETS

A short note on the Evolution of SWAP market

The swap market has witnessed exponential growth in the past few decades. One of the many agreed-upon facts of the swap market is its "dramatic growth". And "the rapid growth" has contributed to much of confusion/misinformation about the "hows" and "whys" of the swap.

During the 1970s increased foreign exchange risk to multinational companies after the collapse of Breton Woods accord necessitated the role of hedging which was done through "parallel loan agreement".

Parallel loans are loans in which two parties, each in a different country, lend money to each other in an effort to hedge against currency risk. They are also called back-to-back loans. Let us understand parallel loan agreement with an example. A U.S. company ABC corp with a subsidiary ABC1 at the U.K. would be paired with a U.K. company, say XYZ corp and its subsidiary at XYZ1 at the U.S. Now, under this arrangement ABC corp would make a dollar-denominated loan to the XYZ1 and XYZ corp would make a pound denominated loan to ABC1. The loans would be having parallel interest and principal repayment schedule.

However, the arrangement had two major drawbacks.

First, the 'default risk'; since the loans are independent default by one didn't release the other from contractually obligated payments.

Second is the inflated balance sheet. Although the two loans effectively cancel out each other, for accounting and other regulatory purposes, they were needed to be shown in the balance sheet.

To address the above issues, eventually, currency swap emerged from the parallel loan agreement by turning it into a single instrument. Although privately arranged swap existed in the 1970s, the public introduction of SWAP was done by the currency swap between IBM and World Bank in 1881. The currency swap involved the exchange of a fixed rate cash flow in one currency for a fixed we cash flow in other currency. Now, if we replace one fixed-rate leg with floating rate cash flow, the resulting in to "Currency coupon swap".

Now a special case currency coupon swap occurs when both currencies are the same. This is nothing but interest rate swap. For an interest rate swap, all of the principal amounts are expressed in the same currency units.

For an interest rate swap, all of the principal amounts are expressed in one currency units. Hence, no re-exchange at maturity.

On the path of evolution of the swap market, currency swap was first to appear. The earliest swap was done on a one-off basis, which involved the search for matching counterparties – in terms of currencies, principal and maturity. Since they were custom-tailored one-off products, they involved virtually no direct exposure for the broker.

Interest rate swap began to appear paving the way for the more standardised product. With U.S. dollar interest rate swap there were few areas in which counterparties had to match than was the case for currency swaps. As the product became homogeneous, the intermediary could look for many counterparties that together matched the notional principal rather than one. Interest rate swap started becoming a market product evolving from a client-specific tailored made an agreement to a standardised product.

However, the development of swap markets was not contained to only the exchange rate and interest rate. It expands to bring within its fold other commodities as well. But here we contain our discussion to the development up to interest rate swap.

The dominant intermediaries in the early stage of development of the swap market were investment banks. As the market evolved, the commercial banks started entering the market and subsequently taken the lead role. The "Euro money" survey 1988 cements this notion of the commercial bank becoming dominant in the swap market.

Availability of liquidity in the swap market also contributed to the growth of the swap market. Although swap was tradable in the secondary market, much of this trade consists of unwinding or reversing a trade. The alternative method to unwind is to writing a mirror swap agreement to cancel out the original agreement.

Some of the popular overnight Indices across the world are: -

- SONIA: Sterling Overnight Index Average. SONIA is the U.K.'s risk-free rate for U.K./sterling markets.
- EONIA: Euro Overnight Index Average. EONIA is the European Union's rate for euro markets.
- SARON: Swiss Average Rate Overnight Index. SARON is Switzerland's rate for the Swiss Franc markets.
- TONAR Rate: Japanese Overnight Index Rate the unsecured overnight rate. Tokyo Overnight Average Rate.
- Federal Funds Rate: U.S. Overnight Index Rate. Federal Funds Rate is the USA's rate for the U.S. Dollar market.
- Indian Overnight Indexed Swap (OIS) is an interest rate swap based on the Overnight Mumbai Interbank Outright Rate (MIBOR) benchmark published by Financial Benchmarks India Pvt. Ltd (FBIL).

EVOLUTION OF INDIAN OVERNIGHT INDEX MARKET: INDIA

The SEBI Committee headed by LC Gupta examined the need for financial derivatives in India from a broader perspective and recommended the introduction of interest rate and currency derivatives in November 1996. Subsequently, RBI permitted scheduled commercial banks, primary dealers (PDs) and all-India financial institutions to undertake Forward Rate Agreements/Interest Rate Swaps (FRAs/IRS) as plain vanilla products for their balance sheet management and market-making on 7 July 1999. While introducing OTC derivative products in a phased manner keeping in view the hedging needs of the real sector, RBI has focused on

improving transparency and reducing counterparty risk in the OTC derivatives markets by creating neutral and independent infrastructure providers. (Pawaskar and Ghose 2019)

The standardisation of Interest Rate Swap (IRS) contracts is aimed to be achieved in terms of the minimum notional principal amount, tenors, trading hours, settlement calculations etc., in consultation with the market participants. As the first step, standardisation has been made mandatory for INR Mumbai Inter-Bank Offer Rate (MIBOR)-Overnight Index Swap (OIS) contracts, from 1 April 2013.

In India, interest rate swaps are commonly traded on 2 benchmarks viz MIBOR and MIFOR. Scheduled commercial banks (excluding Regional Rural Banks), primary dealers (PDs) and all-India financial institutions (F.I.s) are free to undertake IRS as a product for their own balance sheet management or for market making. CCIL has, with effect from 28 March 2014 commenced CCP clearing for IRS trades referenced to the MIBOR and MIOIS benchmark. (STCI Primary Dealer Limited (STCI PD) n.d.)

On 3 August 2015 CCIL launched an anonymous electronic trading platform for Interest Rate Swaps (IRS) referenced to Overnight MIBOR benchmark known as ASTROID (Anonymous System for Trading in Rupee OTC Interest Rate Derivatives). The system is available for trading from 9.00 am to 5.00 pm from Monday to Friday. The minimum lot size is Rs 5 Crs with a tick size of 0.0025%. (STCI Primary Dealer Limited (STCI PD) n.d.)

Salient Feature of Indian Overnight Index Swap

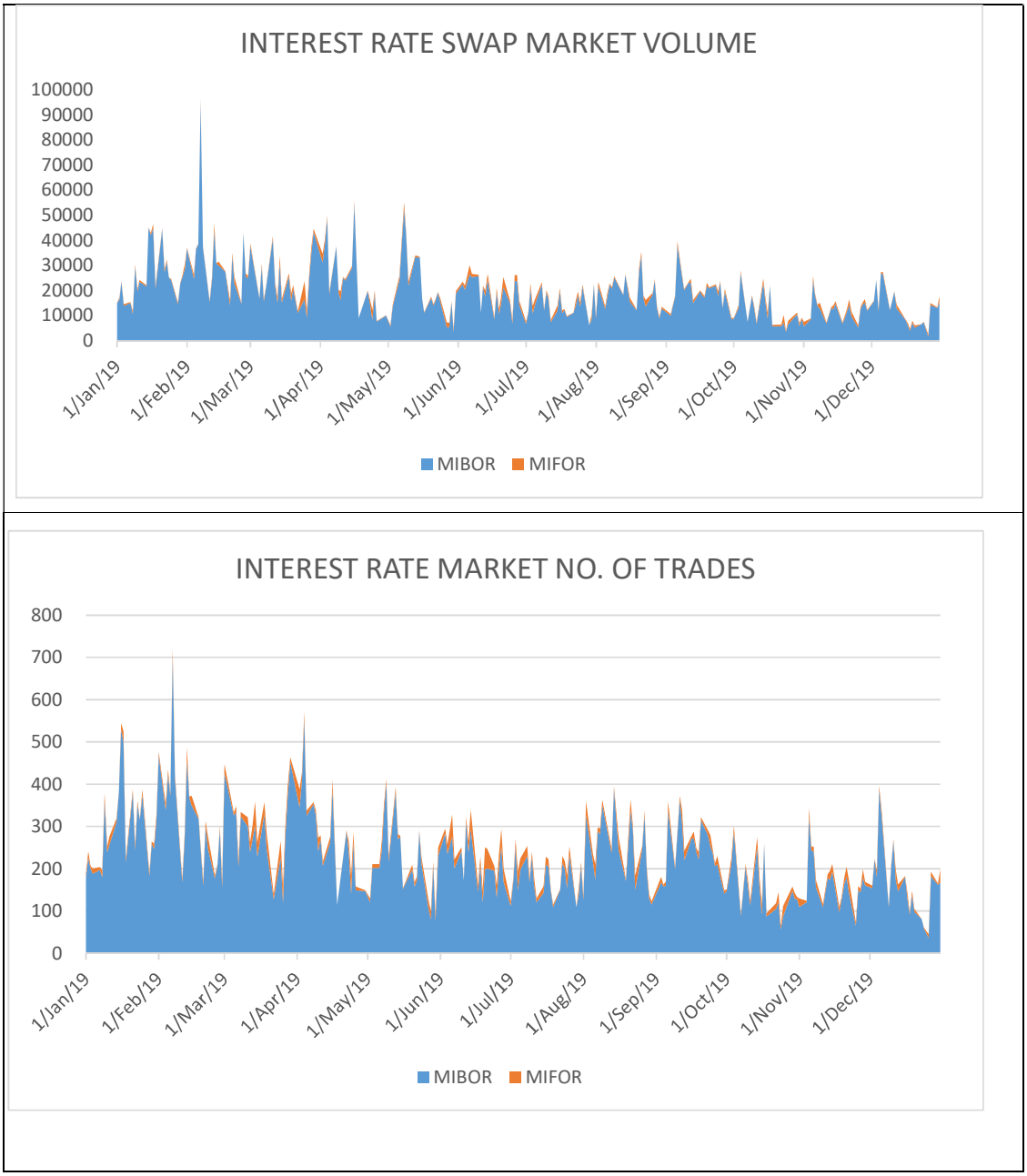
A two-way quote in the OIS parlance would mean that the dealer is ready to Pay and Receive Fixed Rate. The quote should also specify the tenor. If not otherwise specified the FIMMDA-NSE Overnight MIBOR should be taken as the benchmark.

Notional principal amount: Rs. 25 Cr and in multiples of Rs. 5 Cr thereafter.

Tenor: Months: 1, 2, 3, 6, 9, 12 months and 2, 3, 5, 7, and 10 years.

Settlement calculations: i) for contracts of 1 year and below at maturity, and ii) for contracts beyond 1 year on a semi-annual basis.

Benchmark: MIBOR



Source: ccil.in

OVERNIGHT INDEX MARKET: EUROPEAN UNION

With the advent of the Euro, the transformation of numerous national markets into a single currency market has provided an excellent opportunity for the development of new benchmarks such as the EURIBOR (unsecured) and EUREPO (secured) indices for the money

market. This new environment led to an increasingly homogenous and integrated swap market in the euro area. (Euribor ACI 2008)

The Euro Over-Night Index Average or EONIA swap market has grown manifold after that. This sharp increase in volume and the fact that EONIA Swaps are the most liquid segment of the euro money market reflects the benchmark character the EONIA swap market plays within the euro money market derivative product range. Therefore EURIBOR ACI and the European Banking Federation (EBF) decided to introduce a new Index, the EONIA Swap Index. This new index was established on 20 June 2005. (Euribor ACI 2008)

Overnight index swaps (OIS) have become especially popular hedging and positioning vehicles in euro financial markets. In the euro market, OISs are overwhelmingly referenced to the euro overnight index average (EONIA) rate – a weighted average of interest rates contracted on unsecured overnight loans in the euro area interbank market. Trading in EONIA swaps is highly concentrated in maturities of three months or less, and EONIA swap rates are widely considered to be the pre-eminent benchmark at the short end of the euro yield curve. Banks, pension funds, insurance companies, money market mutual funds and hedge funds all make extensive use of EONIA swaps to hedge and speculate on short-term interest rate movements. (Remolona and Wooldridge 2003)

For euro swaps, the choice of the floating rate tends to depend on the contract's maturity. For short-dated swaps, EONIA is the most common basis for the floating rate leg. EURIBOR was commonly referenced following monetary union, but by 2000 had been superseded by EONIA at the short end of the swap curve. For longer-dated swaps, EURIBOR remains the key reference rate. (Remolona and Wooldridge 2003)

European swap market witnessed phenomenal growth from 2000 to 2007. However, after the great financial crisis of 2008, the volume at the swap market started dwindling down. The key reasons for the same were: environment of high excess liquidity combined with the low level of interest rates and the low volatility of overnight interest rates (as measured by the euro overnight index average or EONIA) significantly reducing the need to hedge interest rate risk. During the period under consideration, OIS volumes have periodically shown signs of upward volatility since the market reached all-time lows in 2016. Volumes in the OIS segment started recovering slowly and fitfully from the all-time lows recorded in 2016 but still remain

considerably lower than in pre-crisis times. Further, specific events of relevance to monetary policy seem to stimulate activity in this market. (Euro money market study 2018 2019)

Looking at the composition of participants in the OIS segment, MMSR data show a strong concentration. From a geographical perspective, counterparties located in Germany and France account for more than 80% of the activity in the OIS market. The major market makers are investment banks, while at present, the vast majority of transactions are conducted via CCPs. Participants access the OIS market for hedging, portfolio rebalancing and positioning for possible central bank rate movements. (Euro money market study 2018 2019)

From a maturity perspective, the three-month OIS maturity bucket generates the highest level of activity in terms of volume and number of transactions, while the average ticket size decreases as maturities increase. (Euro money market study 2018 2019).

OVERNIGHT INDEX SWAP: JAPAN

In Japan, the OIS market was launched in mid-1997, but it was not until quite recently that it started to grow. The main reasons for this delayed growth are as follows: 1) Overnight interest rates remained at effectively zero per cent during the period from the introduction of the zero interest rate policy (February 1999) through the end of the QEP (March 2006), except for certain periods. 2) Under these circumstances, short-term interest rates also remained at extremely low levels. These market conditions discouraged financial institutions from entering the market. It is because they did not need to hedge against short-term interest rate risks, nor did they find profitable arbitrage opportunities. (Ooka, Nagano, & Baba, 2006)

Around 2006, transaction volume began to grow as market participants began to anticipate the end of the quantitative easing policy (QEP). During this initial phase of development, the main participants remained a small group of overseas financial institutions. The main purpose of the OIS rate remained: to earn profits from arbitrage transactions with other markets to take advantage of the rise in the short-term interest rates and to hedge against short-term interest rate risks. (Ooka, Nagano, & Baba, 2006)

As market liquidity of OIS transactions improved, many market participants started to see the OIS rate as one of the most important reference rates in the yen money markets. In particular,

they use the OIS rate to extract market expectations about a near-term policy rate hike by the BOJ based on the grounds that the underlying floating rate of OIS is the BOJ's policy rate.

In 2015 Japan went live with swap trading mandate. New rules required over-the-counter derivatives to be executed on registered exchange-like platforms, making Japan the first jurisdiction in the Asia-Pacific region to implement swaps trading commitments that global leaders signed in 2009 at the G20 summit.

OVERNIGHT INDEX SWAP: UNITED STATES

Introduced in 1995, overnight index swaps are used to either hedge or speculate on changes in the overnight interest rate. As a hedge, overnight index swaps are used to manage interest rate risk and liquidity. The terms of OISs range from 1 week to 2 years or more, with spreads typically ranging from 1.5 to 5 basis points. At maturity, the parties determine the net payment by calculating the difference between the accrued interest of the fixed-rate and the geometric averaging of the floating index rate on the notional swap principal. (https://thismatter.com/money/derivatives/overnight-index-swaps.htm 2009)

For swaps based on the United States dollar (USD), the referenced floating rate is the daily effective federal funds rate.

In the United States, futures referencing the effective federal funds rate (EFFR) have traded for more than 30 years, and overnight index swaps (OIS) referencing EFFR have traded for almost 20 years.

OVERNIGHT INDEX SWAP: AUSTRALIA

The market for overnight indexed swaps has grown rapidly in Australia since it began in late 1999. Daily turnover was about $2 billion in 2000/01. This compares with turnover of about $34 billion a day in bank bill futures contracts and $6 billion a day in physical bank bills, the other main ways in which institutions can take views on movements in short-term interest rates. The main participants in the overnight interest rate swaps market are banks, reflecting

the relatively specialised nature of the market. The terms to maturity for overnight indexed swaps typically are within one week to one year, with the bulk of the trading concentrated in relatively short maturities. For example, 50% of daily turnover is in maturities out to three months. (Overnight Indexed Swap Rates 2002)

In Australia, Overnight Index Swap is generally centrally cleared just like other plain vanilla swaps. The main methods of dealing are direct via telephone, via brokers or via electronic platforms. The increasing sophistication of financial markets has created a space for brokers, dealers and clients to access markets via electronic platforms.

OVERNIGHT INDEX SWAP: UNITED KINGDOM

OIS are contracts involving payments based on the average overnight interest rate that prevails over their lifetime. For sterling contracts, the relevant overnight interest rate is the sterling overnight index average (SONIA). Since SONIA is typically close to Bank Rate, forward OIS rates are a common measure of the expected future path of Bank Rate.

The SONIA OIS market is a well-established OTC swap market which has traded since the inception of SONIA in 1997. This market has grown significantly since the financial crisis. (Working Group on Sterling Risk-Free Reference Rates 2018)

In Q1 2018 average daily notional turnover of cleared SONIA OIS with maturities of 12 months or less is nearly £60 billion. Daily volumes SONOA OIS are variable: they are higher on MPC meeting dates or days with significant economic data releases, but lower volumes are seen on other trading days. Higher activity in SONIA OIS is spread across the short-end of the yield curve, with the highest volumes observed in trades with 3 to 6-month maturities. (Working Group on Sterling Risk-Free Reference Rates 2018)

OVERNIGHT INDEX SWAP: INDONESIA

In Indonesia, Overnight Index Swap market was not developed as interest rate swap had low liquidity (MULYA 11 December 2009), and there was no interest rate future (Ekberg 2015);

making hedging literally impossible. The Indonesia Overnight Index Average (IndONIA) is officially introduced by Bank of Indonesia on 1 August 2018 in an effort to improve the interbank money market transaction interest rate based on interbank lending and borrowing. The IDR Overnight Index Swap (OIS) uses IndONIA, as the reference rate for its floating leg. The credibility of interest rate benchmarks was expected to support interest rate derivatives transactions such as the OIS. (Reforming major interest rate benchmarks 2019) All derivative transactions of interest rate are prioritised to be settled through Closeout netting. At the 1st phase, OIS settlement was to be done at the end of the OIS tenors.

Following table gives us a snapshot of overnight index swap market across the world

Table 3.1: Snapshot of some OIS market across world

Country	**Launch Of the Market**	**Reference Rate**	**Country**	**Launch Of the Market**	**Reference Rate**
India	2013	Mumbai Interbank Offer Rate (MIBOR)	Europe	1999	Euro Overnight Index Average (EONIA)
United States	1985-87	effective Fed Funds Rate	Japan	1997	Bank of Japan o/n rate
United Kingdom	The 1980s	Sterling Overnight Interbank Average Rate (SONIA)	Australia	1999	Cash Rate/ Australian Overnight Interbank Average Rate (AONIA)
Indonesia	With new benchmark 2018	Indonesia Overnight Index Average (IndONIA)			

Measuring Liquidity

The concept of liquidity is broad and complex. This has been acknowledged by many researchers in the field. For example, Shin (2005) states that liquidity defies a simple definition and Tirole (2011) explains why liquidity cannot easily be apprehended through a single statistic.

Liquidity is not directly observable. The existence of several dimensions of liquidity requires numerous different empirical measures. Several proxies are being used, but none of them captures all the dimensions of the concept (Silva 2013). In this regard, Goyenko et al. (2009) perform a horserace of both monthly and annual liquidity measures to evaluate their merits. Sarr and Lybek (2002), Lesmond et al. (1999), Hasbrouck (2004, 2009) and Lesmond (2005) also compare several liquidity proxies based on monthly and daily data.

There are many dimensions of liquidity. The key among them are:

- Tightness or reduced transaction cost.
- Immediacy is the velocity by which orders are transmitted to the market and settled.
- The depth refers to the presence of abundant orders both above and below the price at which security is trading.
- Breadth is the existence of numerous and large in volume orders with minimal impact on prices.
- Resilience is associated with the ability of the market to correct the order imbalances, which tends to move the price farther from the intrinsic value of the security.

A. Value turnover: an indicator of realised liquidity that is computed as the daily sum of the value of all the transactions.

B. Turnover ratio: It is defined as the ratio between the value turnover and the market capitalisation of a listed company:

Turnover Ratio: $\frac{Value\ Turnover}{Market\ Capitalisation}$

C. Bid-ask spread: It is measured as the absolute difference between the bid and ask prices or as a percentage spread. The latter is more convenient in comparisons of different securities provided that higher price tends to show higher absolute spreads. It is a measure of implicit transaction costs. Normally, high transaction costs reduce the demand for trades and, resultantly the number of active participants in a market. The reduction of the number of participants in the market due to high transaction costs influences market breadth and resilience.

   The absolute bid-ask spread is expressed as:

$$\text{Spread} = P_a - P_b$$

   Where, and P_a& P_b is the ask and bid prices, respectively.

   The percentage spread is defined as:

$$\text{Spread\%} = \frac{\text{Pa} - \text{Pb}}{(\text{Pa} + \text{Pb})/2}$$

D. The effective bid-ask spread is also used to capture transaction costs, which is the trading price of the security and the prevailing mid-quote when the trade occurs.

$$\text{Effective Spread} = 2\ X\ \frac{\text{P} - \text{Pm}}{\text{Pm}}$$

E. Amihud (2000)suggests the following ratio as an indicator of market impact:

$$\text{Illiquidity} = \text{Average}\ x\frac{Rt}{Vt}$$

   Where R_t is the stock return at t and V_t is the value turnover at t.

   One drawback of this indicator is its non-definition for zero volume days. Nonetheless, it is useful to capture the price impact of trades and is widely used as a liquidity proxy.

Hasbrouck (2009) argues that among the daily proxies, the Amihud illiquidity measure is most strongly correlated with the transactions and quotes based price impact coefficient.

F. Zeros. Lesmond et al. (1999) compute the proportion of days with zero returns as a proxy for illiquidity. They present two reasons to support this indicator: (i) securities with lower liquidity are more likely to have zero volume days and thus more likely to have zero return days; (ii) stocks with higher transaction costs have less private information acquisition (since it is more difficult to overcome higher transaction costs) and thus, even on positive volume days, they are more likely to have no-information-revelation, zero return days.

$$\text{Zeros} = \frac{No\ of\ trading\ session\ with\ zero\ returns}{No.of\ trading\ sessions}$$

G. Hui-Heubel Liquidity ratio (HHL) attempts to capture the price impact, breadth and resilience dimensions of liquidity. It relates the volumes of trades and their impact on prices and is computed as an average of specific (5-day) periods in a sample, in order to smooth volatility. The Hui-Heubel Liquidity ratio uses the turnover ratio in the denominator, scaling price movements by the speed of rotation of the equity in the markets. The higher the liquidity of an asset, the lower will HHL be.

$$\text{HHL} = \frac{(P\ MAX - P\ MIN)\ /P\ MIN}{TURNOVER\ RATIO}$$

H. The Market-Efficiency Coefficient (MEC) was proposed by Hasbrouck and Schwartz (1988) to distinguish short-term from long-term price changes. Indeed, price movements are more continuous in liquid markets, even if new information influences equilibrium prices and consequently, for a given permanent price change, the transitory changes to that price should be minimal in resilient markets.

$$\text{MEC} = \frac{VAR\ (T)}{P\ X\ VAR\ (t)}$$

Where, 'VAR (T)' is the variance of returns over the longer period, 'VAR (t)' is the variance of the return of the shorter period and 'P' is the number of shorter periods embedded in the longer period.

MEC should be close to one in more resilient markets (even though, slightly lower than one), in the sense that overreaction and under-reaction to new information should be minimal. Prices of assets with high market resilience may exhibit lower volatility (less transitory changes) between periods in which the equilibrium price is changing. Excessive short term volatility/overshooting leads to significantly lower than one MEC figures.

Measuring Liquidity of OIS Market of select economies

Here to assess the liquidity of the OIS market, including India, we have utilised two measures from the above Zeros and MEC.

Data: Bid rate of the fixed leg of OIS is extracted from Reuter's terminal for different countries and different maturities.

Calculation and of Zeros:

As defined in the preceding section, Zeros = $\frac{No\ of\ trading\ session\ with\ zero\ returns}{No.of\ trading\ sessions}$

Here, one day's trading is defined as one trading session. Hence, no of days is equal to the number of trading sessions. Days with zero variations are taken as a proxy to the zero returns—Time series data for a period of one year.

Calculation of MEC:

As defined in the preceding section, MEC = $\frac{VAR\ (T)}{P\ X\ VAR\ (t)}$

Where, 'VAR (T)' is the variance of returns over the longer period, Here the longer period is taken as 5 days.

'VAR (t)' is the variance of the return of the shorter period. Here the shorter period is taken as 1 day.
'P' is the number of shorter periods embedded in the longer period. Here, it is 5.

The MEC is calculated on a moving average basis for the sample period of one year. The values so arrived at is averaged, and MEC figure for the particular instrument arrived at.

The values arrived at given in Table 3.2.

Zeros and MECs show the following.

The countries which show better liquidity are U.S., U.K., New Zealand as their zeros are lower than their counterparts. In terms of market resilience, the European Union and the U.K. is scoring better than their counterpart as their MEC value tends towards 1.

India lags behind both in terms of zeros and MECs making it an average country in terms of OIS market.

Table 3.2: Estimation of OIS Market Liquidity

	No of trading session with zero returns	No.of trading sessions	zeros	MEC
India 1m	72	241	0.30	0.19595
India 6m	50	241	0.21	0.19597
India 12m	38	241	0.16	0.19599
India 5 Year	20	241	0.08	0.19608
Europe 1m	91	256	0.36	0.20061
Europe 6m	49	256	0.19	0.20070

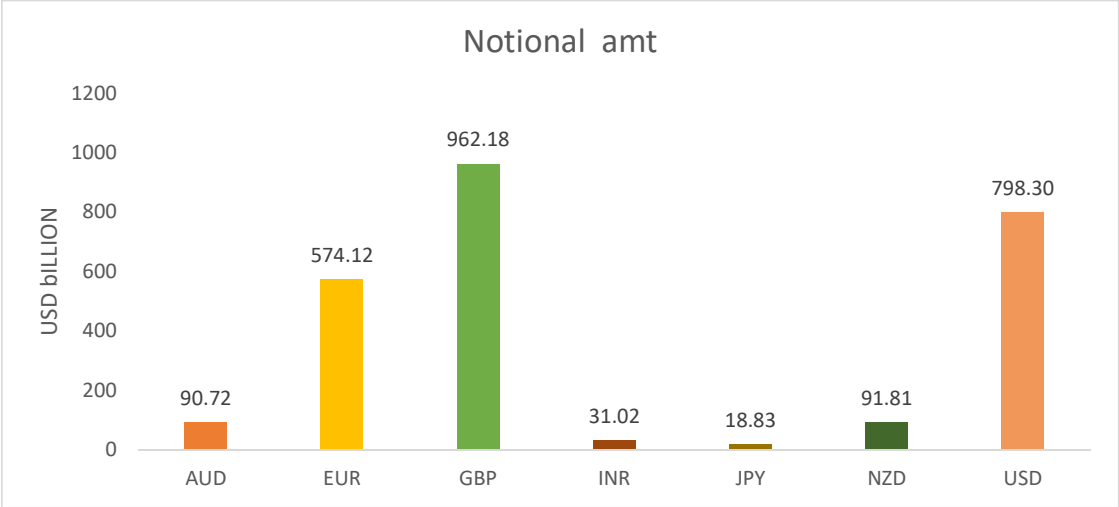
	No of trading session with zero returns	No.of trading sessions	zeros	MEC
Europe 12m	21	256	0.08	0.20089
Europe 5 year	6	256	0.02	0.17722
US 1m	29	253	0.11	0.19856
US 6m	11	253	0.04	0.19855
US 12m	5	253	0.02	0.19854
US 5 year	11	253	0.04	0.19858
UK 1m	87	256	0.34	0.20000
UK 6m	5	256	0.02	0.19974
UK 12m	5	256	0.02	0.19946
UK 5 year	5	256	0.02	0.20010
Australia 1m	76	252	0.30	0.19771
Australia 6m	34	252	0.13	0.19738
Australia 12m	25	252	0.10	0.19740
Australia 5 year	3	252	0.01	0.20053
New Zealand 1m	95	250	0.38	0.19839
New Zealand 6m	9	250	0.04	0.19831
New Zealand 12m	8	250	0.03	0.19841
New Zealand 5 year	64	250	0.26	0.00101

As per BIS Quarterly Review, December 2019, interest rate swaps viz., overnight index swaps (OIS), basis swaps etc. remained the most traded instruments, accounting for 64% of the total global turnover (compared with 69% in2016). Turnover of the dollar- and euro-denominated contracts maintained their global share of OTC turnover (50% and 24%, respectively). Apart from the increase in turnover, OIS market volume is also impacted by more comprehensive reporting of non-market facing trades. (Bank for International Settlements December 2019).

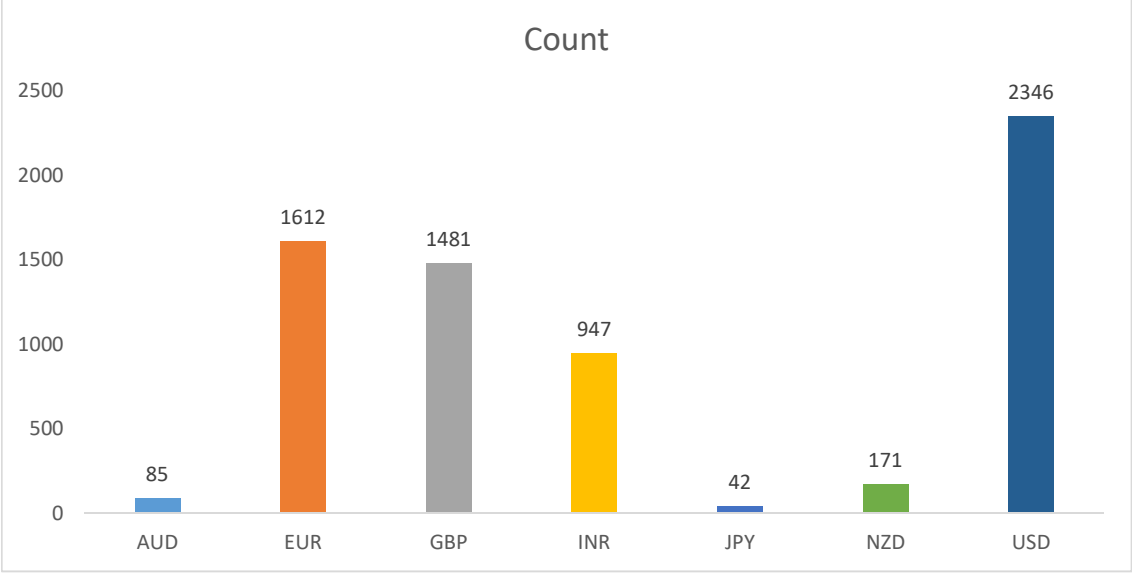
In the recent past, I have accessed part information of Clarus Financial Technology on data on the Overnight Index Swap market. They summarise trading in OIS markets. Data is collected from five different sources viz., Depository Trust & Clearing Corporation (DTCC), DTCC's C.A. Web Service (DTCC_CA), (Billabong International Ltd) BBG, Intercontinental Exchange (ICE), CME Group (CME).

The following data summarised OIS trade between 13 August 2020 and 11 September 2020 and compared 8 countries both in terms of cleared and un-cleared trade and notional principal expressed in USD.

Graph 3.1



Graph 3.2



Source: clarusft

The above analysis shows that Indian OIS market is a developing one. However, it is not the one with the highest volume, highly resilient and has high liquidity. However, it is slowly catching up with the world.

In the next chapter, I will test the predictive power of Indian OIS market.

CHAPTER 4

PREDICTIVE POWER OF INDIAN OIS MARKET

Overnight Index Swap Market as Market Predictor

OIS rates are widely perceived as investors' expectations of future overnight interest rates over the horizon of the contract. Since there is no initial cash flow liquidity premium on OIS contracts should be small and, as an OIS contract is in zero net supply, it is not clear which party would demand a liquidity premium. A zero-net-supply asset exists only in offsetting transactions. Every derivative has two counterparties with opposite positions. For every lender, there is a borrower; the net supply of debt in the world is zero.

As already stated, an OIS is an over-the-counter traded interest rate derivative with two participating dealers who are in agreement to exchange fixed and floating interest payments for a notional principal for the life of the contract. The floating leg of the contract is essentially constructed combing the accrued interest payments from a strategy of investing the notional principal in the defined overnight reference rate and then repeating this on an overnight basis for the duration of the entire contract, i.e., investing principal plus interest each time. The reference rate for the U.S., the U.K., Eurozone and Japanese contracts are the effective federal funds rate, SONIA, EONIA and TONAR, respectively. The 'OIS rate' here represents the rate on the fixed leg of the contract. For a plain vanilla OIS contract with a maturity of one year or less, money is only exchanged at the conclusion of the contract. Only the net cash flow is exchanged between the parties upon settlement.

In other words, if the accrued fixed interest rate payment exceeds the floating interest payment, the dealer who took on the former payments must pay the other at settlement. Importantly, there is no exchange of principal at any time for OIS contracts of all maturities. Due to these nature of OIS contract viz., risk-free, low cash flow, low liquidity premium, low counterparty risk and low transaction cost this is a mainly seen as an instrument gauging monetary policy expectation.

OPERATING TARGET AND FLOATING LEG OF OIS

Monetary Policy authority generally tracks down a variable to formulate the policy. It is often seen as a first immediate effect of a monetary policy change. Ulrich Bindseil defined operational target as under **Invalid source specified.**:

The operational target of monetary policy is considered to be an economic variable, which the central bank aims to control, and normally can control, to a very large extent on a day-by-day basis via the use of its monetary policy instruments. It is the variable the level of which the monetary policy decision making committee of the central bank actually decides upon in each of its meetings.

The operational target thus

- gives guidance to the implementation officers in the central bank what really to do on a day-by-day basis in the inter-meeting period, and
- serves to communicate the stance of monetary policy to the public.

The author also holds that at present the short-term inter-bank interest rate is the appropriate operational target. In other words, it is the overnight rates like MIBOR (India), SONIA (U.K.) etc. which acts as an operational target for the monetary policymaker of the respective economies.

A granger causality test is run to show the causal relationship between the two variables. These overnight rates, again acts as floating leg interest rate for overnight indexed swap. This forms the base of predictive power OIS.

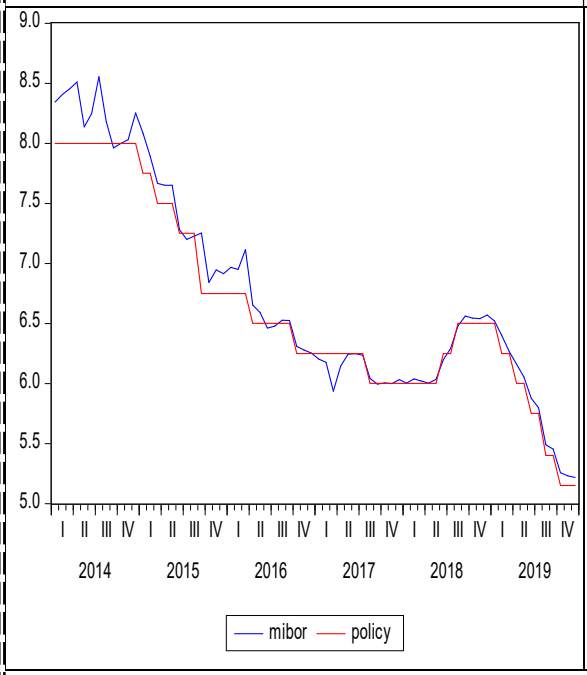
We have run the test on United Kingdom and India – two among the select three economies, whose OIS markets is being empirically tested for its predicting capacity in this Report.

INDIA				**UNITED KINGDOM**			
Null Hypothesis:	Obs	F-Statistic	Prob.	Null Hypothesis:	Obs	F-Statistic	Prob.
POLICY does not Granger Cause MIBOR	70	10.4400	0.0001	POLICY_RATE does not Granger Cause SONIA	70	7.04359	0.0374

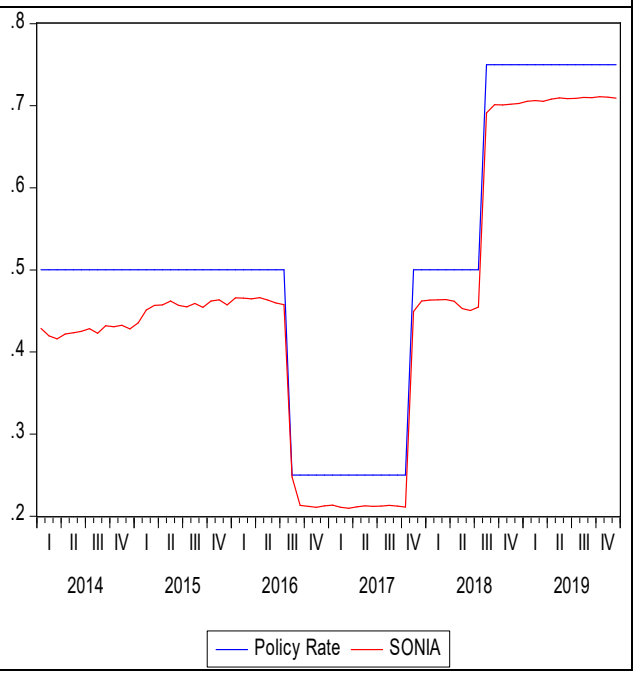
Apparently, the above test suggest high correlation between monetary policy and operating target or floating leg of OIS. In other words monetary policy does causes change in overnight rates. The policy rate granger causes the operating target.

However, does this change of money policy stance is well anticipated by market participants, which often being represented by fixed leg of OIS is the test of predictive power of OIS.

INDIA



UNITED KINGDOM



OIS fixed rates are the interest rates for future periods that mature at different periods. For example, suppose that the interest rate today for borrowing and lending money for overnight is 6% per annum and that the investor expects rate for borrowing and lending after twelve months is 7%.,

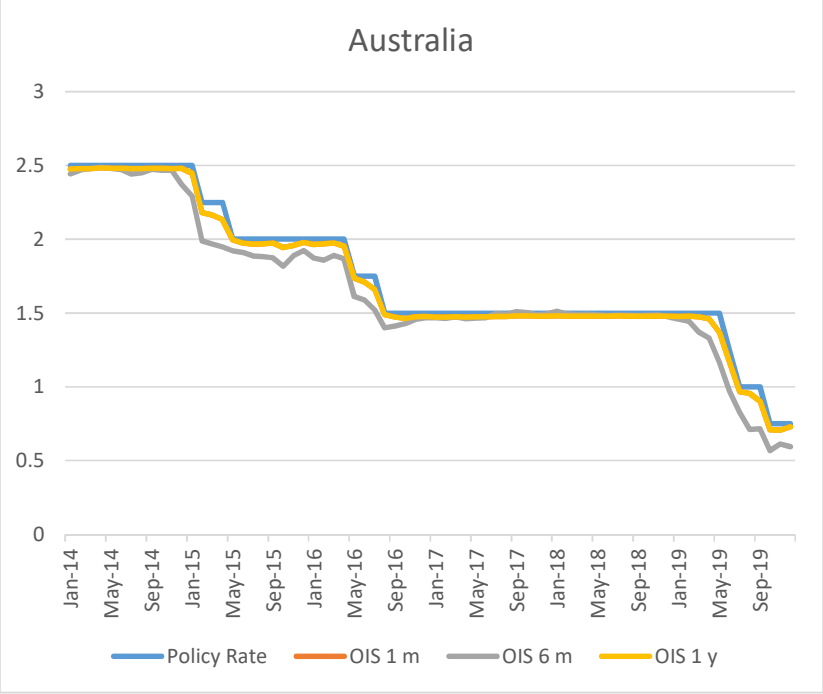
Future interest rates are, of course, not known with certainty. Nevertheless, if OIS rates differ from expected future rates, an investor will be able to create a position that has positive expected profits. The presence of interest rate uncertainty means that the actual profits from these trades may be positive or negative. Risk-averse investors will then require a risk premium to bear this interest rate risk. In equilibrium, this will drive a wedge—the term premium—between the OIS rate and expected short rates so that the expected profits incorporate the risk premium.

Hence a perfect scenario of OIS correctly predicting market interest rate will be a scenario of zero risk premium.

Policy Rate and OIS – In different Countries

Graph 4.1

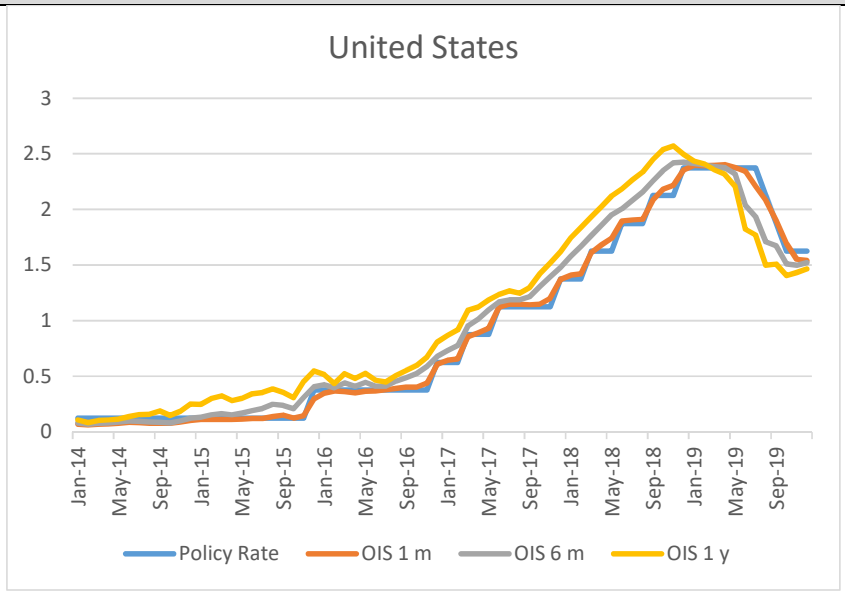
Panel A



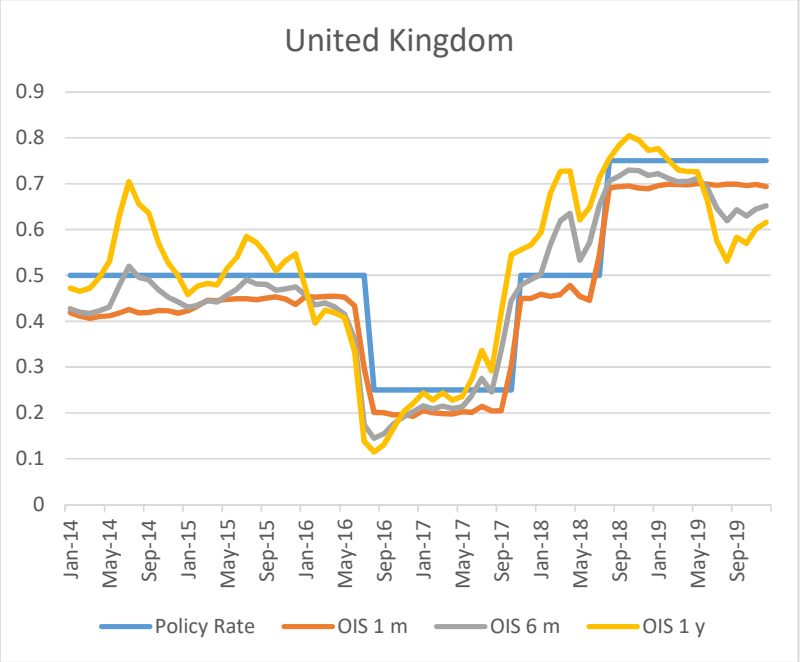
Australian Policy Rate is the Target Cash Rate. It is the interest rate that is set by the Reserve Bank of Australia (RBA). Essentially, it is the rate at which banks borrow for overnight at the money market. The OIS curve movement shows that they are in sync with the policy rate.

Panel B

In the United States, Fed Funds Rate or the policy rate is the rate depository institution lend/borrow from other financial institution. From the graph, it appears that the relationship between OIS and policy rate is direct



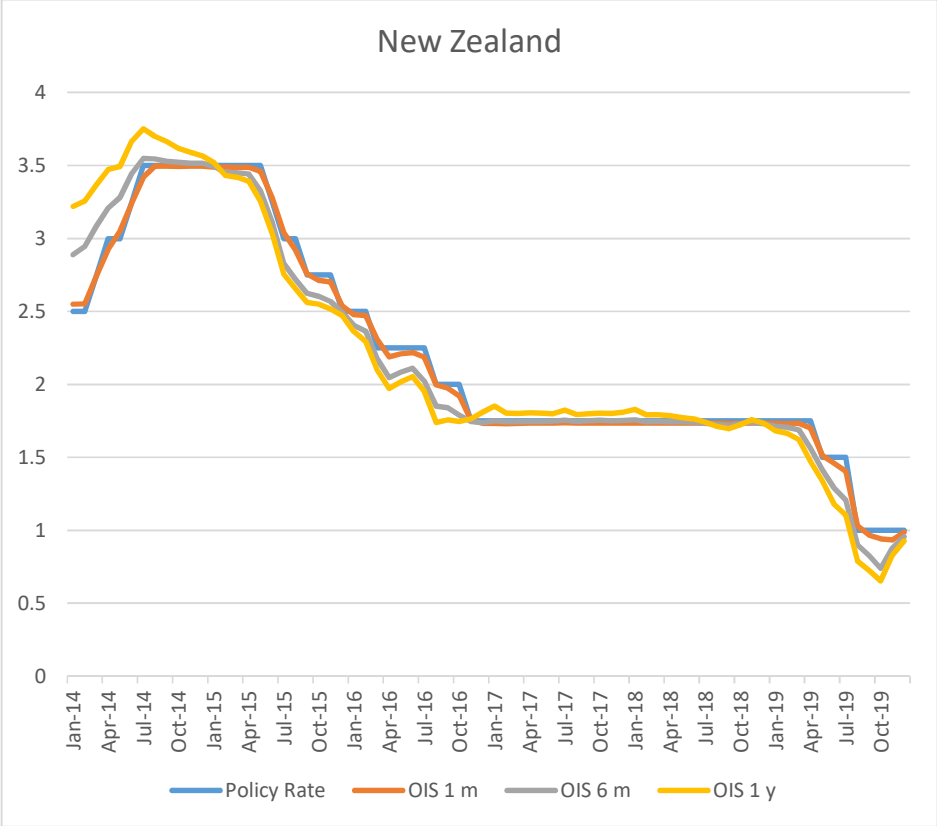
Panel C



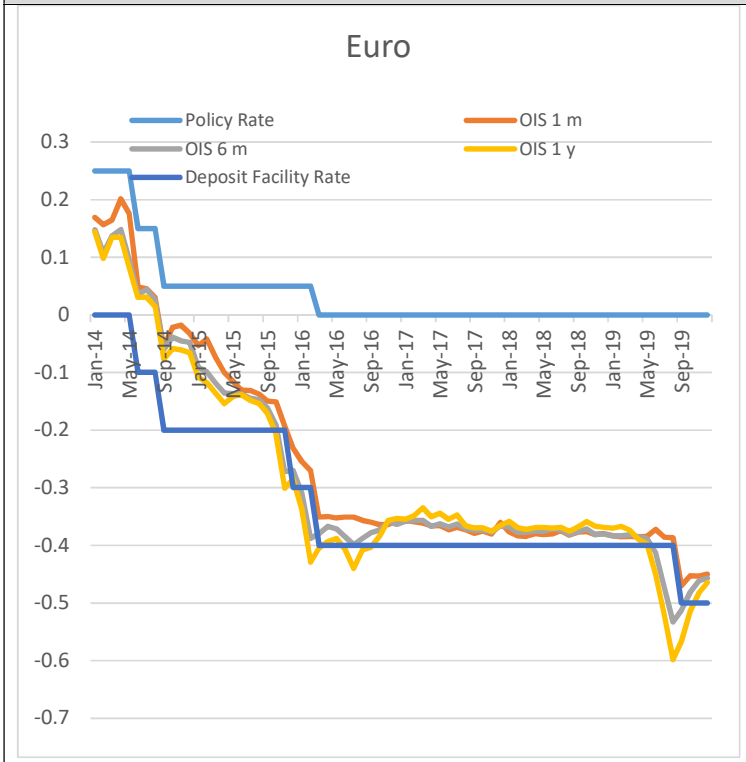
Bank Rate is the interest rate we pay to commercial banks that hold money with the central bank. Subsequently, it influences the rates those banks charge people to borrow money or pay on their savings. From the graph, a direct relationship between OIS and policy rate is seen

Panel D

Official Cash Rate or the policy rate of New Zealand, which is set by its central bank for overnight lending by Central Bank. Apparently, its movement is in sync with the OIS rate



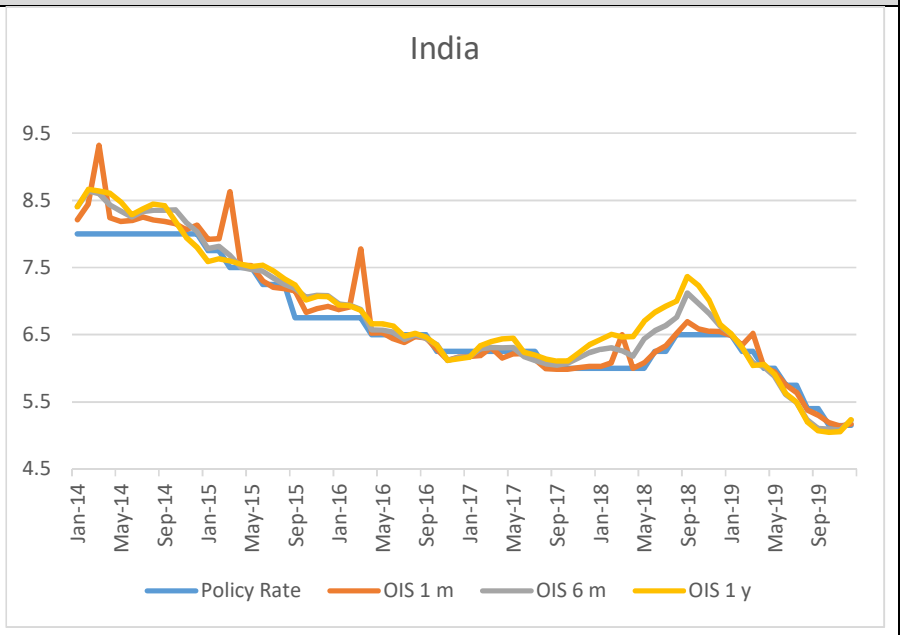
Panel E



In Europe, the policy of negative interest rate was basically applied through Deposit Facility Rate. In essence, it forms the lower corridor of monetary policy. Commercial Bank has to incur the cost for the excess reserve. In a scenario of excess liquidity, money market rates often tend towards the lower corridor; hence in Eurozone the movement of OIS rates are more in tandem with Deposit Facility Rate post introduction of the negative interest rate.

Panel F

In India policy rate Repo movement is in tandem with the movement of OIS rates. Repo is the rate at which commercial banks borrow from RBI



Source: bis.org; Reuters, ecb.europa.

Methodology

Let OIS (n) denote the annualised n-month OIS rate, and the swap's interest rate is FLT (n) is the annualised ex-post realised (net) return from the floating leg of the same contract. (Lloyd 2018)

The floating leg of the contract FLT (n) is calculated by adopting a strategy in which they say investor borrows the swap's notional principal x, then invests in the overnight reference rate of the country and repeats the transaction on an overnight basis, investing principal plus interest each time.

Let the contract trade day be denoted t1, and its maturity is in the n-month (tN-day). The floating leg of the particular contract is calculated based on the overnight reference rate on days t1 to tN. Thus, the contract settlement period is also given by the days t1 to tN.

The floating overnight reference rate for OIS contract on a particular day, say ti, is denoted ON_i, for i = 1, ...N. As per market convention, the expression for the floating leg of n-month (N-day) OIS contract, purchased on day t1 is:

$$\text{FLT (n)} = \left\lfloor \{\prod_{i=1}^{N}(1 + Yi\, ONi)\} - 1 \right\rfloor x\ \frac{360}{N} \quad \text{.....4.1}$$

Where,

Yi is the accrual factor of the form Yi= Di/360, where Di is the day count between business days ti and ti+1.

To compare this floating leg to the fixed leg which is reported on an annualised basis, ON (n) is a multiple of 360/N for a dealer/ an agent who swaps the fixed interest payments with the floating rate over the notional principal x,

Thus, the ex-post realised (annualised) excess rate on the n-month OIS contract purchased during month t is:

$$\text{Excess OIS (n)} = \text{OIS (n)} - \text{FLT (n)} \quad \text{.....4.2}$$

Under the expectations hypothesis, "the fixed leg of the OIS contract must equal the ex-ante expectation of the floating leg". (Lloyd 2018)

$$\text{OIS (n)} = \text{E FLT (n)} \quad \text{.....4.3}$$

If the ex-post realised excess rate as cited above has zero mean, the *ex-ante* forecasting error as per the expectations hypothesis also has zero mean, in that case, the n-month OIS contract will be considered to provide an accurate measure of expected future short-term interest rates. Moreover, even if the average ex-post realised excess rate is non-zero, and the average estimate is driven by ex-ante unexpected events, the n-month OIS contract may still accurately reflect interest rate expectations and not risk premia. (Lloyd 2018)

The above-mentioned methodology is used and utilised for fixed and floating leg of OIS to run a regression to check the predictive power of the overnight index swap. The excess OIS (n) should tend towards zero in an optimal case where the OIS rates have predictive capability.

The basic equation as such can be formed as

$$R_{nt} = \alpha_n + \varepsilon_{tn} \quad \text{.....4.4}$$

Where,

$R_{nt} = OIS_{nt} - FLT_{nt}$ or excess OIS over derived floating rate.

OIS_{nt} = Swap's fixed leg for n month at time t

FLT_{nt} = calculated floating leg, from the given/underlying floating leg after time t for n month. The assumption for calculated floating rate is investor invests in the overnight reference rate and repeats the transaction on an overnight basis until maturity.

α_n= the intercept term for the maturity of n month.

$\varepsilon_{tn=}$ the error term

If the intercept terms tend towards zero, on an average contract will be considered as the correct measure of expected future short-term interest rates and vice versa.

In chapter 3, we have seen economies with more liquid and resilient OIS market vis-à-vis their counterpart. We have selected Australia and U.K. for drawing up a comparative picture of predictive power test of OIS vs that of Indian OIS market. Further, while running the above regression, it is assumed that there is a high correlation between the policy rate and overnight money market rate.

Empirical Evidence/ Estimation

Data:

I. Data on OIS fixed rate is extracted from Reuter's workstation. The following instruments have been used.

   INRAMONMI1M, INRAMONMI6M, INRAMONMI1Y, INRSMONMI5Y

   AUD1MOIS, AUD6MOIS, AUD1YOIS, AUD5YOIS=FMD

   GBP1MOIS, GBP6MOIS, GBP1YOIS, GBP5YOIS=FMD

II. For floating rate calculation following data from the following sources is used:

   Indian Overnight Rates: MIBOR is extracted from Financial Benchmarks India Pvt Ltd

   Australian OIS benchmark: The cash rate also known by the acronym AONIA (AUD Overnight Index Average) is sourced from Reserve Bank of Australia

   OIS benchmark of U.K.: SONIA is sourced from Bank of England database.

To calculate the floating interest rate FLT (n) from the trade date to maturity, equation 4.1 is used, and country-specific day count conventions are not taken into consideration to make it comparable. The excess rate is calculated using equation 4.2 from the OIS rate extracted

from Reuters as described in the data section and floating interest rate as described above. As mentioned in equation 4.3, under the expectations hypothesis, the fixed leg of the OIS contract must equal the ex-ante expectation of the floating leg. In other words, the intercept terms are insignificantly different from zero, and the contract will be considered as a correct measure of expected future short-term interest rates on an average and vice versa.

We have run the regression at equation 4.4 on daily data for the year 2019. But prior to running the regression, the stationarity test on the series has been conducted using the Augmented Dickey-Fuller test. Since there was the presence of unit root, we have taken log of the series. The result of the test is given below: -

Results

Table 4.1 Results of Regression on measuring Predictive Power of OIS

OIS	India	Australia	United Kingdom
One month	**-1.140148** **(-38.25097)**	**-1.524705** **(-55.53802)**	**-0.174796** **(-18.45068)**
6 month	**-1.067035** **(-17.24867)**	**-0.812346** **(-42.61231)**	**-0.268662** **(-89.16611)**
1 year	**-0.823216** **(-30.66953)**	**-0.611958** **(-40.25400)**	**-1.550269** **(-43.96209)**
5 year	**-0.091832** **(-10.00682)**	**-0.670225** **(-26.72014)**	**-1.137896** **(-46.74557)**

(Figures in bracket are t statistics)

Interpretation:

1.1. Table 4.1 presents estimates of average ex-post excess rate on OIS contracts. The OIS estimates for OIS contracts highlighted in green are insignificantly different from zero. Hence, on average, these tenors provide accurate measures of interest rate expectations.

1.2. Not highlighted numbers though significant but widely different from zero and are therefore unlikely to reflect risk premia.

1.3. In Indian Market OIS in 1year and 5-year category is most liquid and deep and thus manifests market viewpoint more accurately than their shorter-term counterpart. While for the shorter-term market is not developed so lower liquidity.

1.4. In the developed market, however, the predictive capacity is higher for short term OIS as markets are resilient and liquid in the shorter term too. They are less traded for maturity beyond one year and hence less useful. For instance, in Australian market, the predictive capacity is lower for the longer end, as they cease to be regularly traded for maturities beyond around one year. (Finlay and Olivan, Extracting Information from Financial Market Instruments 2012)

Robustness check

Ordinary least squares estimators are very sensitive to the existence of observations that lie outside the norm for the regression model in question or outliers in the data. When there is presence of outliers in the data, and least-squares estimation method is used, the results of parameter estimation will not give us accurate information for the said data, as these will lead in a significant value of error. (Nahar and Purwani 2017)

Robust least squares is a wide term. It refers to a variety of regression methods designed to be robust, or less sensitive, to outliers. Robust regression analysis attempts to estimate the improvement in the least-squares linear regression. There are many methods for robust least

squares, some of them are: M-estimation (Huber, 1973), S-estimation (Rousseeuw and Yohai, 1984), and MM-estimation (Yohai 1987). The three methods which are available in eviews differ in their emphases. As per the guidance manual of eviews, these are as follows to quote the exact term from the document.

•M-estimation addresses dependent variable outliers, where the value of the dependent variable differs markedly from the regression model norm (large residuals).

•S-estimation is a computationally intensive procedure that focuses on outliers in the regressor variables (high leverages).

•MM-estimation is a combination of S-estimation and M-estimation. The procedure starts by performing S-estimation, and then uses the estimates obtained from S-estimation as the starting point for M-estimation. Since MM-estimation is a combination of the other two methods, it addresses outliers in both the dependent and independent variables.

In eviews, this add-in performs robust regression computation to obtain estimates of generalised linear models by using the method of iteratively re-weighted least squares (IRLS), which tends to diminish the influence of outliers compared with the standard least squares. (Ref: Eviews Document)

Given the following ordinary least square

$$y_i = x_i'\beta + \varepsilon_i, \quad \varepsilon_i \sim N(0, \sigma^2) \qquad \text{.....4.5}$$

Where ε_i are independent and identically distributed with a scale parameter σ, for a given X nxp, this add-in finds the p estimate of the regression parameter β which solves the following problem.

$$\sum_{i=1}^{n} x_i \cdot \psi\left(\frac{(y_i - x_i'\hat{\beta})}{\hat{\sigma}}\right) = 0. \qquad \text{.....4.6}$$

Where, where ψ is the residual vector.

Applying the robust regression process to our regression model at Equation 4.4 for estimating predictive power of OIS for the policy rate of the economy the results at Table 4.2 are arrived at.

Table 4.2: Results of Robust Regression on Predictive power of OIS

OIS	India	Australia	United Kingdom
One month	**-1.102510 (-60.84369)**	**-1.524705 (-87.871149)**	**-0.170802 (-27.02426)**
6 month	**-0.948959 (-65.01906)**	**-0.812346 (-67.420342)**	**-0.268662 (-141.0768)**
1 year	**-0.771794 (-45.41560)**	**-0.611958 (-61.619174)**	**-1.514390 (-71.97331)**
5 year	**-0.071896 (-15.65745)**	**-0.670225 (-42.27608)**	**-1.116426 (-55.53625)**

(Figures in brackets are t-statistics)

From the above table, it is evident the results of the robustness check does not alter the results/inferences arrived at after running regression at table 4.1.

Apart from above, the model has also been tested with a different set of a variable to check whether the model is robust. For this, we have taken weighted average call rate another overnight rate in place of MIBOR rates. Substituting the new overnight rate in equation 4.1, we derive the new floating leg. Thereafter running the regression at 4.4 the following results are obtained

Table 4.3: Testing regression with new set of variables

OIS	India
One month	**-0.791362** **(-33.93046)**
6 month	**-1.099269** **(-39.94780)**
1 year	**-1.103309** **(-32.22305)**
5 year	**-0.213050** **(-12.89603)**

(figures in brackets are t stat)

Even testing with a new set of variable gives a similar result which testifies for the robustness of the model. The results with the new variable have sign stability or having the same sign, although the degree varies. Further, the new coefficients arrived at vide the captioned robustness test is also significant as in the original model.

Hence, we can infer that the robustness test is not yielding conflicting results and hence we can accept the conclusion arrived at by our model.

CHAPTER 5

CONCLUDING REMARKS

The above study will be of utmost importance to banks and for managing their interest rate risk and also throw some light on challenges of Overnight Index Swap market of the economy and ways to improve them by way of benchmarking our market with that of a developed one with respect to some criteria.

The key outcome of the project may be outlined as under:

A. Overnight Index Swap Market is the prominent one among interest rate swap market, and it has witnessed remarkable growth in the past decade. Due to its multidimensional usage, the global OIS market has recorded spectacular growth, especially, post-financial crisis.

B. Many markets like Europe, Australia, and the U.K. having large volume are the main driving force behind the spectacular growth of the global market.

C. The Indian market, which roughly started in 1996, has witnessed manifold increased and much qualitative development/ reform in recent years.

D. The resilience and depth study carried out of the OIS market of the select economies of the world shows that India is somewhere in the middle of the continuum. For instance, in terms of liquidity and resilience though it has not overtaken developed markets like it is neither the worst performing market. It may be mentioned that developing countries like Indonesia are at the rudimentary stage of development of the OIS market as guidelines regarding clearing of OIS deals operationalised in recent years.

E. Thanks to the recent development, the Indian interest rate derivative market the market has started manifesting predictive strength like developed markets.

F. It is also observed that only two segments in the Indian market are more liquid and aids in predicting future interest rate trajectory better. The result has been tested for its robustness and found satisfactory.

Though the use of OIS is popularised for its use as a hedging instrument, it is difficult to distinguish OIS deals for speculation and OIS for hedging directly from the end data. However, it may be mentioned that banks, in particular, is required to hedge their interest rate risk. If we scheme through the Pillar 3 disclosure of banks, the importance of Interest Rate Risk in the Banking Book is evident. Among other hedging instruments, OIS is a promising one.

Table 5.1 Interest Rate Risk in the Banking Book

Bank	Country	Risk-Weighted Asset	Period	Unit
Australia and New Zealand Banking Group Limited (ANZ)	Australia	9874	Jun-20	AUD-mio
Westpac Group	Australia	6849	Jun-20	AUD-mio
Commonwealth Bank of Australia	Australia	11085	Jun-20	AUD-mio
National Australia Bank	Australia	7079	Jun-20	AUD-mio
Barclays Bank	U. K.	132	Dec-19	GBP-mio
Standard Chartered Bank	The U.K.	8297	Jun-20	USD- mio
NatWest Group	U. K.	812	Jun-20	GBP-mio
State Bank of India	India	80922	Jun-20	INR cr

Bank	Country	Risk-Weighted Asset	Period	Unit
Punjab National Bank	India	358229	Jun-20	INR mio
ICICI Bank	India	530351	Jun-20	INR mio
HDFC Bank	India	321216	Jun-20	INR mio

Source: Basel Pillar 3 statement of the Banks

- ✓ In Australian banks cited above, the Market risk is grouped under traded and non-traded. Non traded risk comprises interest rate risk in the banking book and the risk to the earnings due to foreign exchange rate movements.

- ✓ For U.K. banks, only interest rate position risk with respect to traded market risk is captured. Non-traded interest rate risk (NTIRR) arises from the provision to customers of a range of banking products with different interest rate characteristics. Banks transfer the risk to their treasury desk for managing risks through their asset-liability management.

- ✓ In India, interest rate risk captured above represents mainly the risk arising out of the trading book. Interest rate risk in the banking book is managed through asset-liability management and need to be a part of its ICAAP document. Banks are given an option to add additional interest rate risk on banking book and is required to test sensitivity to interest rate shock and resultant step.

Banks are exposed to interest rate risk as to the main chunk of its asset and liability interest-rate sensitive. Given the prevalence of interest rate risk is it is pertinent to use OIS as one of the key instrument of hedging. It is important for banks to manage their interest rate risk. Further, financial institution using OIS as a hedge will contribute to the depth of the market.

This Overnight Index Swap has the potential to help banks and financial firms in India to assess expectations for borrowing costs and hedge the risks of rate changes to their bond portfolios.

However, unlike currency and equity derivative lack of liquidity in debt derivative often comes in the way of becoming a perfect hedge.

Banks, insurers, primary dealers and provident funds own a major chunk of Indian government bonds, and benchmark 10-year bond is the most traded. However, Banks, for instance, trade over-the-counter interest rate swaps, and the structure itself paves the way for mostly in the one- and five-year segments and not for long-duration contracts.

Some steps that can be taken to develop Indian OIS market:

I. Liquid and Deep Government Bond Market

A precise government yield curve in advanced economies forms a common basis for valuing fixed-income instruments and gauging their risk. However, in India, the liquidity of the government securities market is concentrated in the securities with maturity around the 10-year benchmark. For instance, in terms of value traded in secondary market during the calendar year 2020 top three securities with 9-10 year maturities are 41% of total value traded during the year (data source: CCIL). Hence, high liquidity in some and relatively low liquidity in other segments/maturities of government bonds in India makes it difficult to compute a meaningful yield curve. This makes even measuring interest rate risk difficult, let alone pricing and hedging fixed income instruments and derivatives.

II. Expanding Trading Portfolio

In India, major parts of government securities held by banks (major participants of the market) are under the Held to Maturity (HTM) segment. It may be mentioned in this segment there is no regulatory requirement of marking to market as banks hold them mostly for their Statutory Liquidity Ratio (SLR) requirement. As a corollary to the above, there is little incentive for any market participant for hedging their position or exposure to interest rate risk. Hence, an expansion of the trading portfolio may supplement the necessity of hedging or use of derivatives. It may also be mentioned that a high SLR requirement drives away resources from lendable avenues and the

higher concentration of holding in government securities crowds out private investment.

III. Participation in IRF/IRS will augur well for better price discovery and reduce arbitrage opportunity. Banks are the major players on Short side of IRF/IRS (Duration of assets is longer and for liabilities is shorter). Life insurance companies can go long on IRF/IRS to hedge the interest rate risk, thus creating adequate liquidity.

IV. Effective Portfolio of Hedge.

Interest rate risk of long duration non-participating liabilities and asset can be hedged for further deepening of the OIS market. In the absence of a liquid market, the probability of occurrence of basis risk increases. However, it may be mentioned in most of the developed markets as the maturity increases average ticket size decrease. But for a vibrant market, higher hedging will deepen the market. (Report by the working group on Euro risk free rate on the transfer of EONIA's cash and derivatives markets liquidity to the €STR 2020)

Hence for developing an effective derivative market, the policy direction needs the following orientation:

- Catering to the needs of market players in terms of interest rate derivatives;
- Reviewing various alternative interest rate derivatives creating preconditions for the creation of a liquid interest rate derivatives market.
- Educating of the market stakeholders and participants, and
- Strengthening the benchmark rate
- For a liquid market a the reporting and dissemination of information need to be transparent and fair, so that market participant can take an informed decision which also helps in market depth.
- Better duration matching and reducing reinvestment risk, thus enhancing portfolio returns.

This paper reviews the predictive prowess of the OIS market, vis-à-vis its liquidity. We infer that Indian OIS curve has the predictive capability, and the financial institution may leverage OIS for hedging their interest rate risk. Indian OIS market has undergone many reforms and constantly improving and much ahead of the OIS market of some developing economies.

There is further scope for estimating the hedging effectiveness of OIS in the different financial institution and also the impact hedging on the predictive power of the OIS. This may be food for future research in this area.

WORKS CITED

Acharya, Viral V. 2018. “Understanding and Managing Interest Rate Risk at Banks.” *Speech delivered at the FIMMDA Annual Dinner, 2018* . Hotel Taj Mahal Palace, Mumbai.: Fixed Income Money Market and.

Andreou, Costas. 2019. “Overnight Index Swaps (OIS): An Introduction.” *medium.com.* 23 April. Accessed 31 July, 2020. https://medium.com/financeexplained/overnight-index-swaps-ois-an-introduction-71394f1c4bc9.

Bank for International Settlements . December 2019. *BIS Quarterly Review :* . Quarterly Review, Bank for International Settlements.

2011. *Basics of Hedge Effectiveness Testing and Measurement.* Whitepaper, Canada: FinancialCAD Corporation.

Bernanke, Ben S. 1990. “On Predictive Powe of Interest Rate and Interest Rate Spread.” *New England Economic Review*, November/December: 51-68.

Chang, Bo Young, and Bruno Feunou. 2013. *Measuring Uncertainty in Monetary Policy using implied volatility and realised volatility.* Bank of Canada Working Paper, No. 2013-37, Ottawa: Bank of Canada,.

Chen, Y. 2011. “Derivatives Use and Risk Taking: Evidence from Hedge Fund industry.” *Journal of Financial and Quantitative Analysis* 1073-1106.

Ekberg, J., Chowdhuri, R., Soejachmoen, M.P., Kermanus, B. 2015. “OLIVER WYMAN INSIGHTS.” *https://www.oliverwyman.com/.* September. Accessed 2 September, 2020. https://www.oliverwyman.com/content/dam/oliver-wyman/global/en/2015/sep/Financial_Deepening_In_Indonesia.pdf.

Euribor ACI. 2008. “EONIA Swap Index brochure.” *European Money Markets Institute (EMMI)* . 18 June. Accessed 5 August, 2020. https://www.emmi-benchmarks.eu/assets/files/EONIA_SWAP_INDEX_BrochureV2-2008-01044-01-E.pdf.

2019. *Euro money market study 2018.* money market statistical report, Frankfurt: European Central Bank.

Finlay, Richard, and David Olivan. 2012. “Extracting Information from Financial Market Instruments.” *Bulletin (RBA)*, March Quarter: 45-51.

Finlay, Richard, and David Olivan. 2012. “Extracting Information from Financial Market Instruments.” *RBA Bulletin, March Quarter 2012* 45-54.

Ghosh, Saurabh, and Amarendra Acharya. 2010. “Determinants of Overnight Index Swap (OIS) Rates: Some Empirical Findings from an Emerging Market Economy, India.” *Reserve Bank of India Occasional Papers Vol. 31, No.1, Summer 2010* (Reserve Bank of India) 65-88.

2009. “https://thismatter.com/money/derivatives/overnight-index-swaps.htm.” *https://thismatter.com/.* Accessed 2020.

2019. *Investopedia.* 9 April. Accessed 1 August, 2020. https://www.investopedia.com/terms/o/overnightindexswap.asp.

Júnior, José Luiz Rossi. 2011. *Hedge or Speculation? Evidence of the use of derivatives by Brazilian firms during the financial crisis.* Working Paper 243/2011, Insper.

Lloyd, Simon P. 2018. “Overnight index swap market-based measures of monetary policy expectations.” *Bank of England: Staff Working Paper No. 709.*

Melamed, L. 1981. “The Futures Market: Liquidity and the Technique of Spreading.” *Journal of Futures Markets, 1(3)* 405-411.

MULYA, BUDI. 11 December 2009. “KEYNOTE SPEECH: THE NEED TO STRENGHTEN INDONESIAN FINANCIAL MARKET.” *The Challenge in Developing Indonesia’s Financial Market.* Nikko Hotel, Jakarta: BOI. 1-5.

Nahar, Julita, and Sri Purwani. 2017. “Application of Robust M-Estimator Regression in Handling Data Outliers.” *4th ICRIEMS Proceedings.* Indonesia: The Faculty Of Mathematics And Natural Sciences, Yogyakarta State University. m 53- m 60.

Ooka, Eiko, Teppei Nagano, and Naohiko Baba. 2006. “Recent Development of the OIS (Overnight Index Swap) Market in Japan.” *Bank of Japan Review E-Series* .

2002. “Overnight Indexed Swap Rates.” *RBA Bulletin June 2002* 22-25.

Pawaskar, Vardhana, and Payal Ghose. 2019. “The Changing Dynamics of the Indian Interest Rate Derivatives Market.” *CCIL Monthly Newsletter Rakshitra* 10-22.

2019. “Reforming major interest rate benchmarks.” *Financial Stability Board. .* 11 December. Accessed 5 September, 2020. https://www.fsb.org/wp-content/uploads/P181219.pdf.

Remolona, Eli M, and Philip D Wooldridge. 2003. “The euro interest rate swap market1.” *BIS Quarterly Review, March 2003* 47-56.

2020. “Report by the working group on Euro risk free rate on the transfer of EONIA’s cash and derivatives markets liquidity to the €STR.” *www.ecb.europa.eu.* 19 February. Accessed 10 September, 2020. https://www.ecb.europa.eu/pub/pdf/other/ecb.wgeurofr_transferofliquidityfromEONIA_scashandderivativesmarketstotheeuroshorttermrate~c62c9819a5.en.pdf.

Salvam, V., and S. Rita. January 2011. “Financial Derivatives Advances in Management 4– Real Challenges in India:.” *Advances in Management, vol. 4(1).*

Sendyona, Dr Charles Chris. 2014,. “The Evolution of Interest Rate Futures and Their Market Functions.” *Researchjournali’s Journal of Finance Vol. 2 | No. 11 November | 2014.*

Silva, Paulo Pereira da. 2013. “Modeling and Forecasting Liquidity using Principal Component Analysis and Dynamic Factor Models.” *WORKING PAPER CMVM*, November.

2018. *statistics: BIS.* May. Accessed February 2019. https://www.bis.org/statistics/derstats3y.htm?m=6%7C32%7C617.

n.d. *STCI Primary Dealer Limited (STCI PD).* Accessed 1 AUGUST, 2020. http://stcipd.com/Swaps.aspx.

Taylor, John B., and John C. Williams. January 2009. “A Black Swan in the Money Market.” *AMERICAN ECONOMIC JOURNAL: MACROECONOMICS, Vol1. No.1* 58-83.

Working Group on Sterling Risk-Free Reference Rates. 2018. *Consultation on Term SONIA Reference Rate.* Consultation Paper of Working Group on Sterling Risk-Free Reference Rates, London: Bank of England.

Huber, Peter J. "Robust regression: asymptotics, conjectures and Monte Carlo." *The annals of statistics* 1, no. 5 (1973): 799-821.

Rousseeuw, P. J., & Yohai, V. J. (1984). Robust regression by means of S-estimators. In Robust and nonlinear time series analysis, J. Franke, W. Hardle & D. Martin (Eds.), 256-272. Heidelberg, Germany: Springer-Verlag.

Yohai V.J. (1987), "High Breakdown Point and High Efficiency Robust Estimates for Regression," Annals of Statistics, 15, 642-656

Richa, Yadav. 2015. "Increasing Dominance of F and O Trading in Indian Stock Market with Reference to NSE." Advances in Management 8 (3): 17.

ANNEXURE 1: RESULTS OF REGRESSION

Test of the predictive capacity of Indian OIS market

Dependent Variable: _5y
Method: Least Squares
Date: 09/24/20 Time: 11:16
Sample (adjusted): 1 241
Included observations: 241 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.091832	0.009177	-10.00682	0.0000

R-squared	0.000000	Mean dependent var	-0.091832
Adjusted R-squared	0.000000	S.D. dependent var	0.142465
S.E. of regression	0.142465	Akaike info criterion	-1.055298
Sum squared resid	4.871114	Schwarz criterion	-1.040839
Log likelihood	128.1635	Hannan-Quinn criter.	-1.049473
Durbin-Watson stat	0.233553		

Dependent Variable: _12M
Method: Least Squares
Date: 09/25/20 Time: 06:51
Sample (adjusted): 1 241
Included observations: 241 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.823216	0.026841	-30.66953	0.0000

R-squared	0.000000	Mean dependent var	-0.823216
Adjusted R-squared	0.000000	S.D. dependent var	0.416692
S.E. of regression	0.416692	Akaike info criterion	1.091201
Sum squared resid	41.67171	Schwarz criterion	1.105661
Log likelihood	-130.4898	Hannan-Quinn criter.	1.097027
Durbin-Watson stat	0.770691		

Dependent Variable: _6M
Method: Least Squares
Date: 09/25/20 Time: 06:52
Sample (adjusted): 1 241
Included observations: 241 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.067035	0.061862	-17.24867	0.0000

R-squared	0.000000	Mean dependent var	-1.067035
Adjusted R-squared	0.000000	S.D. dependent var	0.960354
S.E. of regression	0.960354	Akaike info criterion	2.761111
Sum squared resid	221.3472	Schwarz criterion	2.775571
Log likelihood	-331.7139	Hannan-Quinn criter.	2.766937
Durbin-Watson stat	1.550725		

Dependent Variable: _1M
Method: Least Squares
Date: 09/25/20 Time: 06:53
Sample (adjusted): 1 241
Included observations: 241 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.140148	0.029807	-38.25097	0.0000

R-squared	0.000000	Mean dependent var	-1.140148
Adjusted R-squared	0.000000	S.D. dependent var	0.462730
S.E. of regression	0.462730	Akaike info criterion	1.300793
Sum squared resid	51.38850	Schwarz criterion	1.315253
Log likelihood	-155.7456	Hannan-Quinn criter.	1.306619
Durbin-Watson stat	0.536493		

Test of the predictive capacity of Australian OIS market

Dependent Variable: _1M
Method: Least Squares
Date: 09/25/20 Time: 05:06
Sample (adjusted): 1 253
Included observations: 253 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.524705	0.027453	-55.53802	0.0000

R-squared	0.000000	Mean dependent var	-1.524705
Adjusted R-squared	0.000000	S.D. dependent var	0.436672
S.E. of regression	0.436672	Akaike info criterion	1.184677
Sum squared resid	48.05204	Schwarz criterion	1.198643
Log likelihood	-148.8617	Hannan-Quinn criter.	1.190296
Durbin-Watson stat	0.551136		

Dependent Variable: _6M
Method: Least Squares
Date: 09/25/20 Time: 05:11
Sample (adjusted): 1 253
Included observations: 253 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.812346	0.019064	-42.61231	0.0000

R-squared	0.000000	Mean dependent var	-0.812346
Adjusted R-squared	0.000000	S.D. dependent var	0.303226
S.E. of regression	0.303226	Akaike info criterion	0.455268
Sum squared resid	23.17039	Schwarz criterion	0.469234
Log likelihood	-56.59137	Hannan-Quinn criter.	0.460887
Durbin-Watson stat	0.045316		

Dependent Variable: _12M
Method: Least Squares
Date: 10/04/20 Time: 10:07
Sample (adjusted): 1 253
Included observations: 253 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.611958	0.015202	-40.25400	0.0000

R-squared	0.000000	Mean dependent var	-0.611958
Adjusted R-squared	0.000000	S.D. dependent var	0.241809
S.E. of regression	0.241809	Akaike info criterion	0.002611
Sum squared resid	14.73489	Schwarz criterion	0.016577
Log likelihood	0.669743	Hannan-Quinn criter.	0.008230
Durbin-Watson stat	0.046912		

Dependent Variable: _5Y
Method: Least Squares
Date: 09/25/20 Time: 05:19
Sample (adjusted): 1 253
Included observations: 253 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.670225	0.025083	-26.72014	0.0000

R-squared	0.000000	Mean dependent var	-0.670225
Adjusted R-squared	0.000000	S.D. dependent var	0.398972
S.E. of regression	0.398972	Akaike info criterion	1.004092
Sum squared resid	40.11295	Schwarz criterion	1.018058
Log likelihood	-126.0176	Hannan-Quinn criter.	1.009711
Durbin-Watson stat	0.441196		

Test of the predictive capacity of UK OIS market

Dependent Variable: _1M
Method: Least Squares
Date: 09/25/20 Time: 06:33
Sample (adjusted): 1 253
Included observations: 253 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.174796	0.009474	-18.45068	0.0000

R-squared	0.000000	Mean dependent var	-0.174796
Adjusted R-squared	0.000000	S.D. dependent var	0.150688
S.E. of regression	0.150688	Akaike info criterion	-0.943262
Sum squared resid	5.722152	Schwarz criterion	-0.929296
Log likelihood	120.3227	Hannan-Quinn criter.	-0.937643
Durbin-Watson stat	0.054271		

Dependent Variable: _6M
Method: Least Squares
Date: 09/25/20 Time: 06:34
Sample (adjusted): 1 253
Included observations: 253 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.268662	0.023200	-89.16611	0.0000

R-squared	0.000000	Mean dependent var	-2.068662
Adjusted R-squared	0.000000	S.D. dependent var	0.369020
S.E. of regression	0.369020	Akaike info criterion	0.848014
Sum squared resid	34.31631	Schwarz criterion	0.861980
Log likelihood	-106.2737	Hannan-Quinn criter.	0.853633
Durbin-Watson stat	0.723804		

Dependent Variable: _12M
Method: Least Squares
Date: 09/25/20 Time: 06:43
Sample (adjusted): 1 253
Included observations: 253 after adjustments

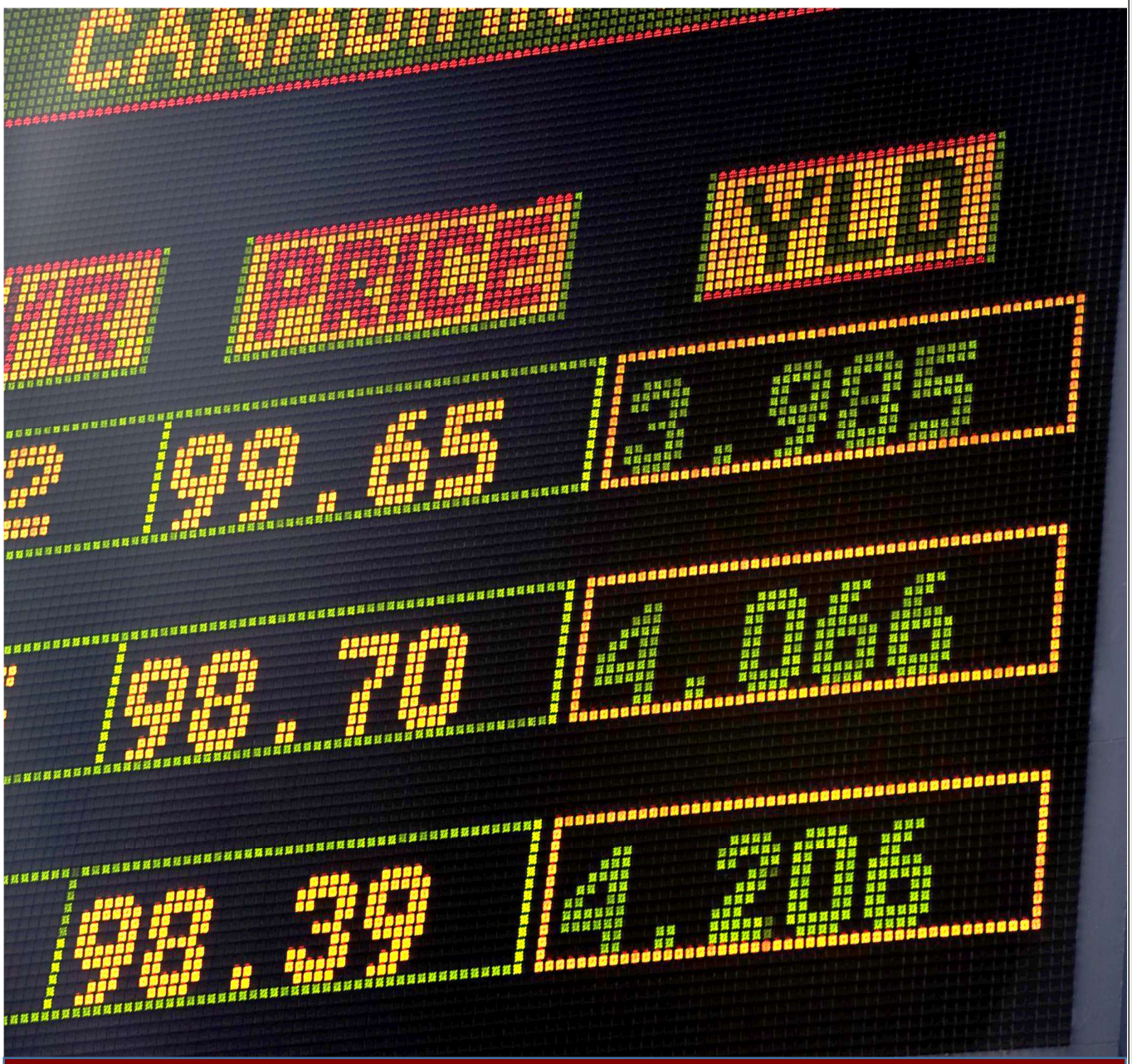
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.550269	0.035264	-43.96209	0.0000

R-squared	0.000000	Mean dependent var	-1.550269
Adjusted R-squared	0.000000	S.D. dependent var	0.560904
S.E. of regression	0.560904	Akaike info criterion	1.685413
Sum squared resid	79.28269	Schwarz criterion	1.699379
Log likelihood	-212.2047	Hannan-Quinn criter.	1.691032
Durbin-Watson stat	0.384870		

Dependent Variable: _5Y
Method: Least Squares
Date: 09/25/20 Time: 06:44
Sample (adjusted): 1 253
Included observations: 253 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.137896	0.024342	-46.74557	0.0000

R-squared	0.000000	Mean dependent var	-1.137896
Adjusted R-squared	0.000000	S.D. dependent var	0.387188
S.E. of regression	0.387188	Akaike info criterion	0.944134
Sum squared resid	37.77854	Schwarz criterion	0.958100
Log likelihood	-118.4330	Hannan-Quinn criter.	0.949753
Durbin-Watson stat	0.307927		


99.65
98.20
98.39