



Reserve Bank of India

Country Paper

on

**Use of High-frequency Indicators by Central Banks: Experience and
Plans going forward**

SAARCFINANCE Database Seminar and Working Group Meeting

November 2, 2022, Male, Maldives

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Summary

Data is an essential requirement for any central bank in its effective policy formulation. From traditional annual and quarterly data, focus has been shifted to high frequency indicators (HFIs) in recent times. Technological advancement and COVID-19 pandemic has accelerated this process of using high frequency data including big data and machine learning. Nowcasting emerged as one of the effective tools of shorter horizon forecasting. The RBI uses high frequency data in its various functional domains covering monetary policy, research and statistical analysis, financial markets and financial stability, regulation and supervision and payment systems.

The Reserve Bank uses high frequency data to make assessment on economic activity and growth and inflation projections using nowcasting techniques. The RBI also focuses on use of high frequency data from unconventional sources like Google, social media, online sources and remote sensing. HFIs provide major inputs to the financial market regulations and day-to-day operations of the RBI in financial market. The RBI uses HFIs for macro-prudential surveillance of the financial system, conduct of systemic stress tests and development of models for assessing financial stability. The Regulation and Supervision departments of the RBI use HFIs particularly data on the CRILIC, which help to assess the default behaviour of the borrowers, time taken for curing the defaults and the efficacy of the resolution mechanisms in addressing the stress. The RBI collects data in the form of returns in various frequencies, including weekly, fortnightly and monthly from the reporting entities.

There are many challenges associated with use of HFIs such as, lack of long time series data, missing observations, problems due to revisions in database, difficulty to arrive on holistic view, requirement of increased capacity and infrastructure, application of new analytical techniques and lack of integration with other external databases. The RBI has initiated multiple steps for establishing a robust infrastructure and automation of the data. The Reserve Bank envisages to expand and deepen the use of HFIs in its all functional domains, going forward.

Introduction

Data is defined as a collection of individual facts. Data can come in the form of text, observations, figures, images, numbers, graphs and symbols. There are zettabytes¹ worth of data around us. Data is a raw form of knowledge, on its own, it doesn't carry any significance or purpose. We need to interpret data for it to have a meaning. Data may be simple and even seem useless until it is analyzed, organized, and interpreted. Statistical data is the numerical data obtained by applying statistical measure on raw data. Analysis using the statistical data tends to be more accurate than the raw data as it is an aggregate of facts. The government, business, scientific institutions, public organizations and international agencies use statistical data to formulate policies and take informed decisions. Data collection, data analysis and presentation of data are critical elements of central banking. It forms the backbone for central bankers to frame more effective and targeted policies, better early warning systems and supervisory overview.

High frequency data refers to time-series data collected at small intervals. Depending on the intervals, high-frequency data can be of daily, weekly or monthly frequencies. Volume of the data is very high for this kind of data. The large amount of data would allow to apply models with higher statistical precision. Currently, with so much data being produced and stored, there is an emerging challenge of the Big Data. Big data describes data sets that are far too large and complex to analyze with traditional data analysis methods. Main characteristics of big data include massive volume (millions or trillions of records), the speed at which information is generated and processed (within seconds or hours) and various data types (structured/unstructured, numeric/text, audio/video, etc.). Companies, financial institutions and government organizations mine big data for variety of reasons which prominently include better understanding of customers, targeted marketing efforts, managing fraud and similar risks and better forecasting of macro-economic situation.

The sources of data can be classified broadly into two categories, namely traditional and non-traditional. Traditional data sources are those which come from surveys, census and administrative records. These are mainly collected and compiled by government

¹ One zettabyte is approximately equal to one billion terabytes.

organizations/statistical authorities. On the other hand, non-traditional data sources come from earth observation (satellite images), mobile telecommunications (call records), social networks (sentiment analysis), and citizen-generated data (civil society data). Many of these are considered as big data with large volumes of unstructured information which require new capacities for their analysis.

Central banks collect statistical data and economic information through their research and statistics departments and publish them through their various publications. Generally, central banks collect and compile data relating to national output including agricultural, industrial and financial sectors, employment, balance of payments, price, credit, government finances, financial markets, banking regulation and supervision, financial stability, payments, firms' balance sheets and data published by institutions like Bloomberg and various real estate advertising platforms. On account of advancement in technology, data sources have expanded significantly in recent years with higher frequency and granularity. Organizations will be able to collect more and more data from various sources, but this wealth of information is truly beneficial only if these data are reliable and accurate. By ensuring that data is transparent and reliable, central banks can build trust among public.

Against above backdrop, the Country Paper covers the use of high frequency indicators in functional domains of the Reserve Bank of India with focus on following areas;

- Monetary policy, Research and Statistical Analysis
- Financial Markets and Financial Stability
- Regulation and Supervision
- Payment Systems

The Paper focuses on experience and challenges with regard to the use of high frequency indicators in the RBI. The Paper provides a broad outline on the future plan of actions of the Reserve Bank in expanding and deepening use of high frequency indicators.

Monetary policy, Research and Statistical Analysis

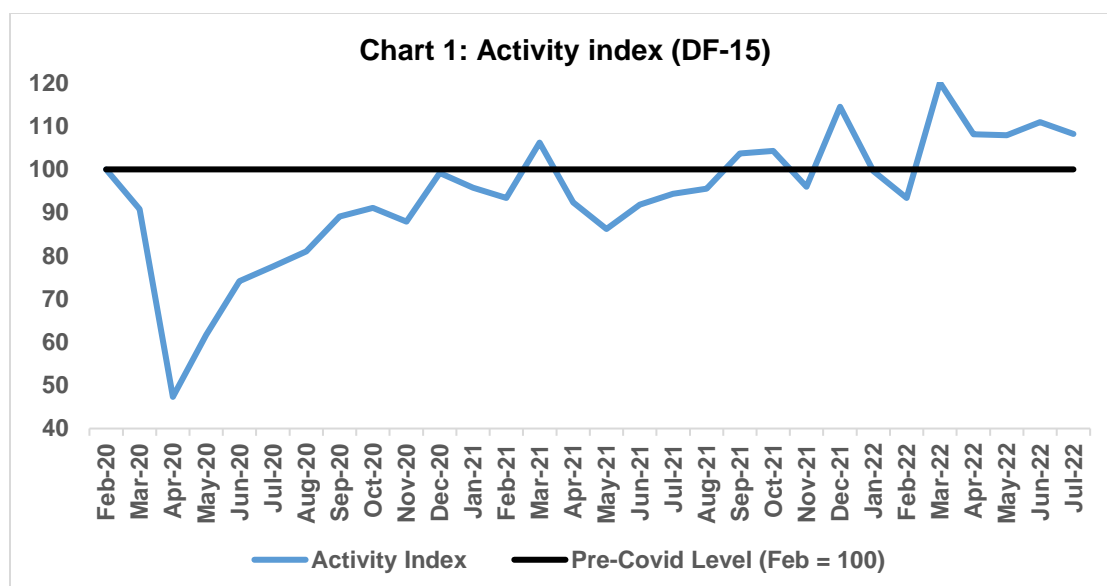
Data is extremely important for the research and statistical analysis which would help central banks to formulate better policies. Timely information on economic activity is crucial for central banks for exercising precise judgments in its monetary policy decisions. The RBI focuses on all sorts of available data to arrive on precise judgments. However, most recently, there is an increased impetus to the analysis based on high frequency data (HFIs) on account of variety of reasons including technological advancement. During each round of the monetary policy of the Reserve Bank of India (RBI), available information set for decision-making is found to be highly asynchronous. For instance, for the bimonthly policy monetary policy, gross domestic product (GDP) is available quarterly and the conventional high frequency indicators (HFIs) at best on monthly basis with a lag of one or two-months (RBI Bulletin Aug 2022). The COVID –19 pandemic has accelerated this process of using high frequency data. Nowcasting exercises emerged as effective tools of shorter horizon forecasting, aimed at predicting the present, the very near future, and the very recent past (Banbura, Gianonne, and Reichlin, 2010). A list of indicators tracked by Reserve Bank of India is given in Table 1.

Table 1: List of High Frequency Indicators

1. Index of Industrial Production	10. Railway	16. External Trade
2. Eight Core Industries Index	10.a Passenger traffic	16.a Merchandise Exports
3. Electricity Demand (Energy Met)	10.b Freight traffic net tonne kilo m	16.b Merchandise Imports
4. Production of Automobiles	10.c Freight traffic freight originating	16.c Services Exports
5. Exports of tractors	11. Port Cargo	16.d Services Imports
6. Sales of Automobiles	12. Domestic trade	16.e Import of Capital Goods
6.a Total Automobiles sales	12.a GST E-way bill	17. Employment
6.b Passenger Vehicles sales	12.b GST E-way bill intra-state	17.a CMIE Unemployment Rate

6.c Domestic Sales of tractors	12.c GST E-way bill inter-state	17.b CMIE Labour Force Participation rate
6.d Two wheeler Sales	12.d GST revenue	17.c EPFO Net pay roll addition
6.e Three wheeler Sales	13.Construction	17.d Naukri Index
7.Vehicle registration	13.a Steel Consumption	17.e Monster.com
7.a Vahan Total Registration	13.b Cement production	17.f PLFS Annual
7.b Registration of Transportation vehicles	14.Tourism and hospitality	17.g PLFS Quarterly (for urban)
7.c Vahan Registration of Non- Transportation vehicles	14.a Hotel occupancy rate	18.Purchasing Managers Index
8.Toll collection	14.b Average Revenue Per Room(ARR)	18.a PMI: Manufacturing
8.a Toll Collection-Volume	14.c Revenue Per Available Room	18.b PMI: Services
8.b Toll Collection-Value	14.d Foreign tourist arrivals	18.c PMI: Composite
9. Aviation	15.Petroleum consumption	19.Mobility Indicators
9.a Domestic air passenger traffic	15.a ATF	
9.b International air passenger traffic	15.b Diesel	
9.c Domestic air cargo	15.c Petrol	
9.d International air cargo		

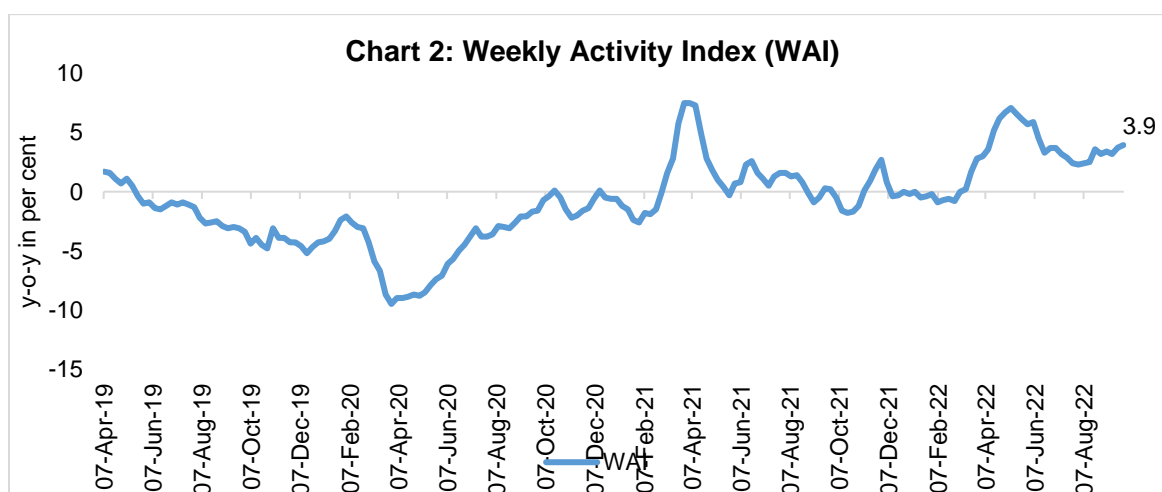
The Reserve Bank uses nowcasting techniques to make assessment on economic activity and growth. The Reserve Bank's macro surveillance model uses HFIs of economic activity to nowcast India's GDP. In the model, first a Monthly Activity Index based on carefully selected 15 HFIs using a Dynamic Factor Model is arrived at and then using the Activity Index in Bridge Estimation, the nowcast of the GDP is obtained. In addition, Machine Learning (ML) Models are also used in GDP nowcasting (Chart 1).



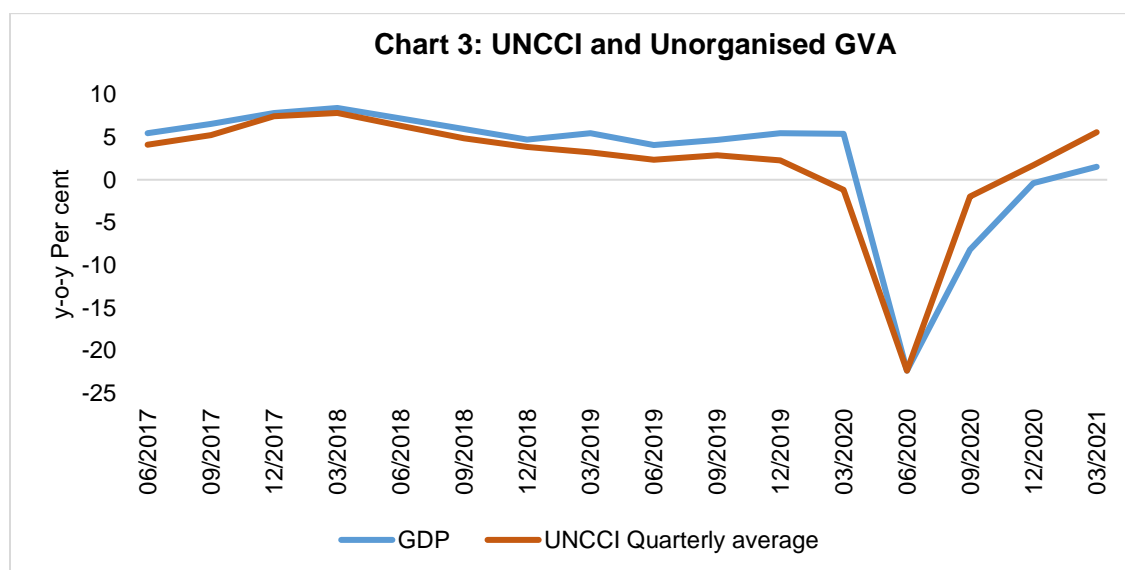
Note: The Activity Index is constructed by extracting the common trend underlying from a set of carefully selected high frequency indicators of the economic activity using a Dynamic Factor Model (DFM)

Source of Figure: RBI Monthly Bulletin, State of Economy, September 2022.

With the availability of ultra-high frequency indicators (at daily and weekly frequency) in recent times, two different weekly indices have been developed using daily/weekly indicators – (i) a 7-indicator weekly activity index (WAI) using the dynamic factor model reflecting changes in economic activity on a year-on-year basis; (ii) a 15-indicator weekly diffusion index (WDI) reflecting directional movement on a sequential basis which compliments the model-based WAI. The WAI tracked the ebbs and flows in economic activity during the pandemic years followed by the more recent disruptions caused by the Russia-Ukraine war since February 2022 (Chart 2).



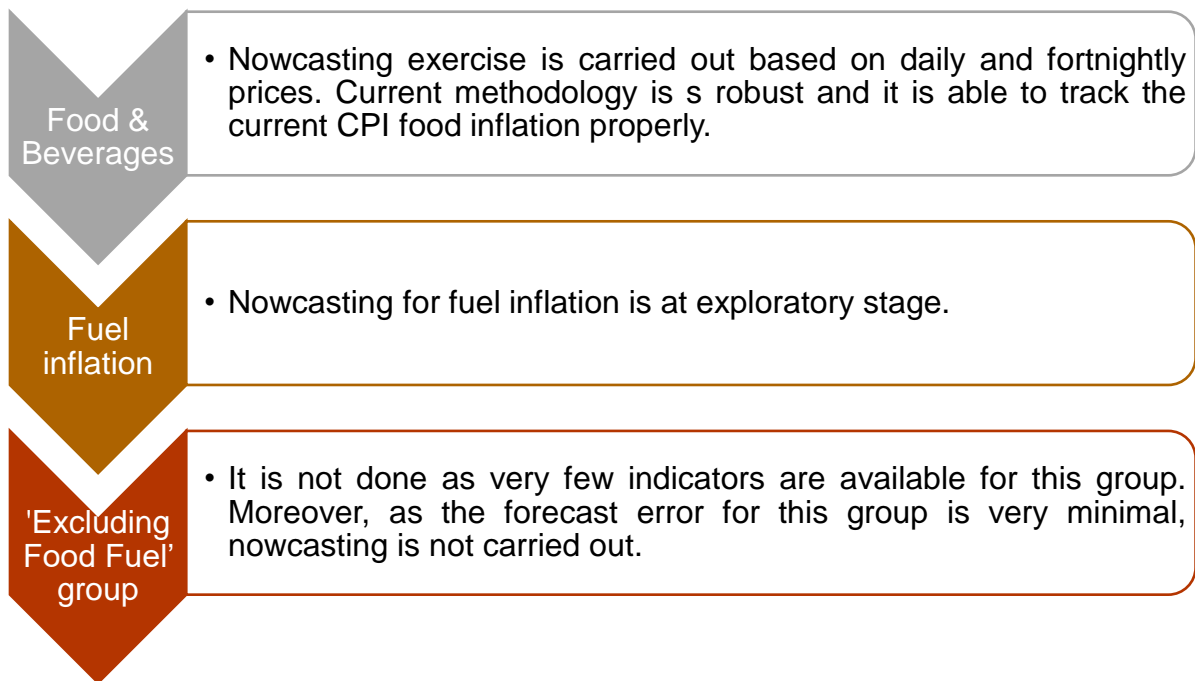
A composite high frequency indicator- Unorganised Sector Composite Coincident Indicator (UNCCI)- has been developed for monitoring unorganised sector activity at a monthly frequency. The UNCCI showed reasonable co-movement with growth in derived unorganised sector quarterly series such as overall GVA, agriculture GVA and construction GVA, informal sector wages and monthly IIP manufacturing (Chart 3).



The HFIs have been utilized to track performance of indicators reflecting prevailing conditions in rural and urban sectors. It helps to gauge into demand and employment scenario across rural and urban regions. HFIs are used for tracking specific sectors in the economy. For example, in the context of the pandemic, HFIs in contact intensive sectors such as travel, tourism and hospitality were used to trace recovery in sub-sectors.

RBI applies nowcasting technique for the forecast of inflationary trends (Chart 4). Efforts are underway to expand it further.

Chart 4: Nowcasting of inflation in RBI



In addition, nowcast of nominal sales growth (y-o-y) of listed private non-financial manufacturing companies is done at every quarter using macro-economic indicators available at monthly frequency.

RBI also focuses on use of high frequency data from unconventional sources like Google, social media, online sources and remote sensing in their analysis and research. A snapshot is given in Chart 5.

Chart 5: Use of high frequency data from unconventional sources



- Sentiments on macroeconomic variables including inflation, economic growth and industrial production are extracted from daily news reported in major newspapers using natural language processing (NLP) and tracked using sentiment indices.
- Price information on food and beverages items are collected from online grocery portals on daily basis and aggregated at various levels to compile food price index.
- Advertisement prices for residential properties are collected from online websites across cities to compile online House Price Index.
- Google Trends data has been explored to track/ predict macroeconomic indicator, viz. private final consumption expenditure.
- Remote sensing database has been explored with focus on sensitive agro-commodities in the Indian food consumption basket. The empirical results using the satellite imagery-based Normalised Difference Vegetation Index (NDVI) is useful in monitoring crop condition in near-real time.
- The daily online data on onion prices is collected from one of the largest onion market in Asia. The data on climate factors affecting production of onion is captured through different websites such as NASA, IMD and ISRO.

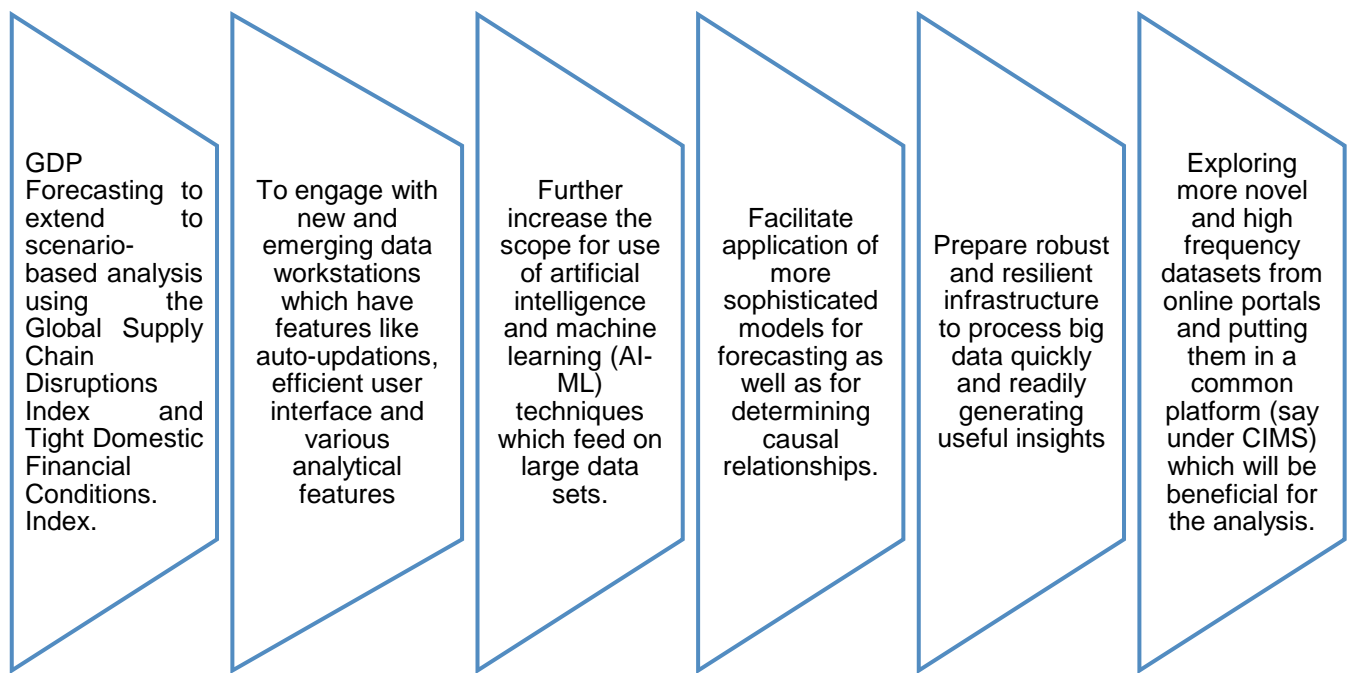
Challenges associated with Use of High-Frequency Indicators:

- The multiple and unscheduled revisions in certain indicators limit the veracity of results based on these indicators. These revisions also necessitate regular revisit of previous data entries to ensure correctness of the data.
- The data release schedule for indicators varies from each other. For example, PMI, financial indicators steel consumption *etc.* are released on the first week of the month; IIP, exports and imports, inflation data are released in the middle of the month while, government sector data, core industries data and a few auto sector indicators are released by the end of month. Therefore, a system needs to be in place for regular tracking and updating of data. At the same time, the statistical models need to be capable of handling jagged-edged data for most efficient usage of the HFIs.
- Due to the unavailability of long time series of the selected HFIs, time period for certain indicators turned out to be shorter relative to number of observations required for standard time series analysis. Therefore, despite crucial information content, these

indicators must be excluded from the model-based exercises. However, this limitation is transitory in the Indian context and will be resolved in the course of time.

- The datasets of high-frequency indicators, by definition, have large amount of data that makes them prone to human error and therefore, these datasets need careful handling for correct analysis.
- Changes in online retailer's websites affect data collection process and repeated advertisements for the same property on the same website.
- Removal of noise or irrelevant news articles in text analysis needs lot of data cleaning.
- Changes in data collection methodology or sampling schemes in Google Trends data source cause variability in the time series.
- Non-availability of retail prices for perishable items is a challenge, as estimating the mark-up from mandi to retail prices is challenging task.
- Existing data processing system needs to be updated to cater to the requirement of new class of ultra HFIs. Given the sensitivity of model performance to appropriate statistical properties of the data, researchers and analysts should be careful about this aspect while using HFI-based models.

Path Ahead



Financial Markets and Financial Stability

The Reserve Bank is responsible for the resilient functioning of the financial system and the broader economy, and for ensuring financial stability. As part of this mandate, the Reserve Bank is tasked with the regulation, development and oversight of the interest rate markets including the government securities market, money markets, foreign exchange markets, derivatives on interest rates/prices and credit. As a part of the liquidity management and maintaining orderly condition in the forex market, the RBI conducts various financial market operations. The RBI uses various high frequency indicators in its financial market regulation and operations. The high-frequency data are used as indicators of – financing conditions, risk build-up, policy impact assessment, and interconnectedness. HFIs provide major inputs to the day-to-day operations as well as in decision making. Most of the HFIs are also aggregated on a weekly/monthly basis and used in the internal reviews/research notes.

Financial Market Regulation Department of the RBI assesses the financing conditions by analysing a set of financial markets data – rates, issuance, redemption and rollover ratio (ratio of issuance to redemption). Attempts have been made to analyse financial markets data to identify market expectations of the future course of monetary policy. Department has computed ex post “excess return” as the difference between the OIS fixed rate and the floating overnight reference rate and studied their statistical properties. Financial markets data reported to trade repository (TR) are quite useful in assessing concentration and interconnectedness in derivatives market. For instance, Legal Entity Identifier (LEI) information could be used to calculate exposures across asset classes of specific entities and identify interlinkages. Exposure of banks to major corporate entities / groups is being tracked using LEI. Recently, network analysis of OTC markets was undertaken to understand the interdealer currency derivatives network.

A list of high frequency indicators tracked by the RBI are given in Table 2.

Table 2: High Frequency Financial Market Indicators

Indicators	Use
Call /Notice Money Rate	<p>Call Money is unsecured overnight interbank market rate. The Weighted Average Call Rate (WACR) is the operating target of the Monetary Policy, and the objective is to keep WACR aligned with the policy rate.</p> <p>The data is monitored for volume, volatility and rates on daily basis. The spread of WACR with repo acts as an indicator of systemic liquidity in the system. It guides RBI in efficiently conducting liquidity operations. One of the challenges in call money market in India is that volumes have been low and as such the call rate does not paint the entire picture on the money market.</p>
Net Liquidity injected/ Absorbed	<p>The daily net LAF indicates the net liquidity absorbed or injected from/in the banking system due to RBI operations and Refinance facilities. It aids the Reserve Bank in efficiently conducting liquidity operations.</p>
Government Balances with RBI	<p>The changes in government balances with RBI is monitored daily. It reflects the impact on systemic liquidity due to government receipts and spending. It aids the RBI in efficiently conducting liquidity operations.</p>
CRR Balances held by Commercial banks	<p>The changes in Cash Reserve Requirement balances in the system is monitored on a daily basis. It reflects the impact on systemic liquidity due to banks building up or drawing down reserves. It aids the RBI in efficiently conducting liquidity operations.</p>
G-Sec Term premium	<p>The daily data of G-Sec Term premium is calculated as the spread of 10-yr G-sec yield over policy Repo rate. Increase in term premium shows that investors are demanding higher compensation for holding the bond over a longer time period.</p>

3/5/10 year AAA Corporate Bond spread	The corporate bond spread (over G-secs of similar tenor) is used as an indicator of stress in the corporate bond market. The daily frequency data are obtained from yields on AAA rated corporate bonds over similar tenor G-secs. However, the heterogenous nature of the issuers and lack of liquidity, particularly in the longer end of the curve, leads to fluctuations in the yields in even the AAA corporate bond segment and hence influences the spread.
NSE VIX	The daily NSE VIX helps to gauge the investors' perception of market volatility. Historically, its negative correlation with NIFTY index provides an insight into equity market movements. The challenge of using NSE VIX is that its Implied volatility is a forecast for future volatility and realized volatility may differ from Implied volatility.
FPI Investments in Debt/ Equity segment (from NSDL)	The daily indicator acts as a gauge of FPI interest in the Equity and Debt markets. The FPI flows has impact on performance of Rupee in the foreign exchange market.
Forward Premia	The daily Forward Premia for various tenors in the USDINR market is used as an indicator for strength of dollar demand (among other things) in the Forward Market in the relevant tenor.
Currency Market Derivatives volume and Open Interest	The open interest and volume across exchanges is an indicator with daily frequency for derivatives market activity.
Market Repo	Market repo is collateralised borrowing/ lending among the market participants, with CCIL providing guarantee for settlement of all deals. The rates are used as indicator for liquidity condition in the money market. One of the challenges in Market repo rates is the range of rates vary widely, as compared to the unsecured segment, due to market microstructures playing important role.

Triparty Repo	In the Triparty Market Repo, collateralised borrowing/lending with the eligible collateral takes place between participants. The rates are used as indicator for liquidity condition in the money market.
REER/NEER- 6 currency	The 6 currency REER/NEER is computed daily to measure competitiveness of Indian Rupee <i>vis-à-vis</i> its 6 major trading partners. It is used as an indicator for relative change in INR <i>vis-à-vis</i> other countries.
Commercial Paper	Commercial paper is an unsecured money market instrument issued in the form of a promissory note, at discount for maturities up to 1 year. The rates and volume are used to gauge credit conditions in the economy. Any tightening in the credit market would be reflected in the CP market.
Certificate of Deposit	CD are negotiable money market instrument with minimum amount of ₹ 1 lakh and the maturity not less than 7 days. The rates are used as indicator for credit conditions in the economy.

The Financial Stability Unit (FSU) of the RBI is responsible for conduct of macro-prudential surveillance of the financial system, preparation of financial stability reports, conduct of systemic stress tests to assess resilience and development of models for assessing financial stability. The stress test analysis is done using the actual balance sheet data (quarterly frequency) provided by banks and NBFCs. However, high-frequency data are used for evaluating the domestic and global macro-financial conditions. In this perspective, the Bank for International Settlements (BIS) proposed the Early Warning Indicators (EWI) approach for predicting banking crises using several indicators of financial vulnerabilities (Credit-GDP gap, Debt service ratio (DSR), Property price gap, etc). Overtime, the approach for monitoring financial system stability has changed from a micro-level analysis (banks and financial institutions) to a broader set of macro-financial indicators for capturing systemic risks. Given the interdependence and complex

interactions of different elements of the financial system with macroeconomic variables, there required a host of indicators (PMI, world uncertainty index, financial condition index, exchange rates, bond yields and interest rate spreads) for tracing systemic risks. Over the years, a wide group of high-frequency indicators has been added to the analysis to monitor risks and vulnerabilities.

Challenges

- TR data on standalone basis will not provide a complete picture in absence of balance sheet and other financial data for understanding leverage. There is a need to integrate the TR data with other internal/external databases.
- Products regulated by RBI are also traded on stock exchanges. In absence of availability of all information at one place, it will be difficult to have a wholistic view of the market.
- OTC trading (both cash and derivatives) is increasingly being executed on electronic venues, some of them have been referred to as “dark pools” as price and trade information are not disseminated on such platforms. The market monitoring should proportionately increase with the rising importance of these venues.
- New ways of analysing data need to be examined. For instance, the FX markets in India are primarily a market for hedging currency risk. Accordingly, the possibility of using the FX turnover data as an indicator for broad economic activity, in particular related to foreign trade needs to be assessed.
- HFIs mostly reflect volatility in the variables rather than any fundamental changes. Hence taking decisions based solely on sentiment driven market movements of these HFIs is not prudent and there are other fundamentals that need to be included when arriving at certain policy decisions.

Path Ahead

Analysis of high-frequency indicators is part of central banks’ policy toolkit as it facilitates active monitoring of financial system for minimizing and containing systemic risks. A wider and reliable set of high-frequency indicators would be used for monitoring systemic risks in sync with evolving macro-financial developments.

Regulation and Supervision

The 'Prudential Framework for Resolution of Stressed Assets' dated June 7, 2019 has mandated that all lenders shall report credit information, including classification of an account as SMA to Central Repository of Information on Large Credits (CRILC), on all borrowers having aggregate exposure of ₹ 50 million and above with them. The CRILC-Main Report shall be submitted on a monthly basis. In addition, the lenders shall submit a weekly report of instances of default by all borrowers (with aggregate exposure of ₹ 50 million and above) by close of business on every Friday, or the preceding working day if Friday happens to be a holiday. The CRILC is broadly used, *inter alia*, as an additional input for assessing the default behaviour of the borrowers, time taken for curing the defaults and the efficacy of the resolution mechanisms in addressing the stress.

RBI's Department of Supervision collects data in the form of returns in various frequencies, including weekly, fortnightly, monthly, etc. from the reporting entities. Data on liquidity, credit default, CRILC (central repository of information on large credits), exposure to sensitive sector and asset, liability and equity is collected in the frequency of up to one month. Data collected from the entities are compiled into various reports (credit digest, dossier, information notes) for submission to the Top Management of the Bank. The senior supervisory managers of the supervised entities have access to information on liquidity, exposure to sensitive sectors, credit defaults, which enable them to ensure adherence / implementation of circulars. The data collected at such smaller intervals is used for making time series analysis and is available for use by many other departments for their use in various reports and analysis.

Challenges

Errors (though less frequent) in reported data is a challenge

Path Ahead

Development of data quality indicator and identification of violation of RBI instructions through an automated system are in the process of development.

Payment System

DPSS has been publishing daily payment systems data since 1st June 2020. The data so published includes RTGS, NEFT, and other retail payment systems data like UPI, IMPS, NACH, AePS, NETC, BBPS, CTS etc. Moreover, credit cards, debit cards and Prepaid Payment Instruments (PPIs) Card data is also published which covers only off-us transactions (not On-Us transactions). It may be noted that this data is further bifurcated into 'at PoS' and 'at E-commerce' transactions. Also, settlement data from CCIL involving Government Securities Clearing, Forex Clearing and Rupee Derivatives is also published on a daily basis.

Challenges

- Availability of settlement data in timely manner is an issue. Sometimes, when even one product system faces technical difficulty then the publication of the whole payment systems data is affected.
- Revision in data is another concern.
- If the high-frequency indicators are not automated, then considerable time is devoted in compilation and publication of the data on a daily basis.

Path Ahead

RBI is looking to automate the compilation of the daily data.

Conclusion

Central banks have an active interest in high frequency data. Technological advancement and COVID-19 pandemic has further accelerated the use of high frequency indicators. There is a concerted effort to improve technology and automation, develop institutional strategies and increase staff awareness in this area. The RBI uses high frequency data in its various functional domains. The Reserve Bank uses high frequency data to make assessment on economic activity and growth and for inflation projections. The RBI also focuses on use of high frequency data from unconventional sources like Google, social media, online sources and remote sensing. HFIs provide major inputs to the financial market regulations and day-to-day operations of the RBI in financial market. The RBI uses HFIs for macro-prudential surveillance of the financial system, conduct of systemic stress tests and development of models for assessing financial stability. The Regulation and Supervision departments of the RBI use HFIs which includes returns in various frequencies from the reporting entities.

The use of HFIs is constrained by various factors such as, lack of long time series data, missing observations, problems due to revisions in database, difficulty to arrive on holistic view, requirement of increased capacity and infrastructure, application of new analytical techniques and lack of integration with other external databases. Other areas of concern are legal aspects around privacy, algorithmic fairness, data quality, cyber security and the development of a formal strategy for the use of big data.

In recent years, the RBI has initiated multiple steps for establishing a robust infrastructure and automation of the data. Going forward, the Reserve Bank envisages to expand and deepen the use of HFIs in its all functional domains.

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