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# Assessing Macroeconomic Influences on Indian Sovereign Bond Yields: An Insight from the ARDL Bound Test Approach

## Ocena wpływów makroekonomicznych na rentowność indyjskich obligacji skarbowych – spostrzeżenia z podejścia opartego na teście granic ARDL

**Keywords:**
ARDL, economic growth, interest rate, monetary policy index

**JEL classification codes:**
E43, E52, C58, O40

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### Abstract

This paper investigates the long-term and short-term determinants of sovereign bond yields in India, a critical macroeconomic indicator closely monitored by investors and central banks. According to term structure theory, the shape of bond yields is a key economic barometer, reflecting the overall health of the economy. Using monthly time series data from April 2001 to March 2021, the study examines variables such as long-term sovereign bond yields, short-term Treasury bill yields, economic growth, inflation, the monetary policy index, exchange rates, foreign exchange reserves, gross fiscal deficit, and global Brent crude oil prices. By accounting for structural breaks under the ARDL framework, in the presence of other controlled variables, the analysis confirmed that short-term interest rates influence long-term interest rates, validating the Keynesian conjecture in the Indian context. Additionally, economic growth, the monetary policy index, and global Brent crude oil price are identified as significant drivers of long-term interest rates. These findings have important policy implications for monetary-fiscal coordination, especially in debates on the appropriate policy mix during boom-and-bust cycles. Consequently, monetary policy should be reviewed comprehensively, incorporating a broad range of macroeconomic variables.

**Słowa kluczowe:**
ARDL, wzrost gospodarczy, stopa procentowa, wskaźnik polityki pieniężnej

**Kody klasyfikacji JEL:**
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### Streszczenie

Rentowność obligacji to wskaźnik najczęściej obserwowany przez inwestorów i bank centralny kraju. Zgodnie z teorią struktury terminowej kształt rentowności obligacji jest kluczowym barometrem gospodarczym i określa się go mianem wskaźnika kondycji gospodarki. W artykule opisano badania długoterminowych i krótkoterminowych determinant rentowności długoterminowych obligacji skarbowych w Indiach. W badaniu wykorzystano miesięczne zmienne makroekonomiczne szeregów czasowych, takie jak rentowność długoterminowych obligacji skarbowych, rentowność krótkoterminowych bonów skarbowych, wzrost gospodarczy, inflacja, wskaźnik polityki pieniężnej, kurs wymiany, rezerwy walutowe, deficyt budżetowy brutto i światowa cena ropy Brent w okresie od kwietnia 2001 r. do marca 2021 r. Uwzględniając załamania strukturalne w ramach ARDL w obecności innych kontrolowanych zmiennych, ustalono, że krótkoterminowe stopy procentowe wpływają na długoterminowe stopy procentowe, co potwierdza słuszność hipotezy Keynesa w kontekście Indii. Stwierdzono również, że wzrost gospodarczy, wskaźnik polityki pieniężnej i cena ropy Brent na świecie również są czynnikami wpływającymi na długoterminową stopę procentową. Ustalenia te mają istotne implikacje polityczne dla obecnych dyskusji na temat kombinacji polityk podczas cykli wzrostów i spadków oraz koordynacji monetarno-fiskalnej. Dlatego też politykę pieniężną należy poddać przeglądowi z uwzględnieniem wszystkich zmiennych makroekonomicznych.

## Introduction

The term structure of interest rates indicates that short-term interest rates influence long-term bond yields in both the short and long run [**Shiller, McCulloch, 1990**]. Keynes posited that the primary determinant of long-term interest rates is the short-term interest rate, predominantly determined by central bank actions. This perspective aligns with the Chartalist theory of modern money [**Wray, 2003, 2012**; **Tcherneva, 2011**] and recent findings in mainstream macroeconomics and monetary theory [**Sims, 2013**; **Woodford, 2001**]. Several recent empirical studies [**Akram, 2021**; **Goyal, 2019**] on the dynamics of government bond yields document a strong connection between the current short-term interest rate and the long-term interest rate after controlling for appropriate macroeconomic and financial variables substantiate Keynes' contention. These findings are relevant to macroeconomic theory and policy.

The government securities (G-Secs) market is often not well understood, yet it significantly influences other markets by producing risk-free interest rates that serve as benchmarks for bonds [**Goyal, 2019**]. Government bond yields play a pivotal role in financial markets, serving as key indicators of economic conditions, investor sentiment, and policy expectations. Understanding the dynamics of bond yields is crucial for policymakers, investors, and economists alike. This paper aims to deepen the understanding of long-term sovereign bond yields by examining their determinants in both the short and long run, drawing on theoretical insights and empirical evidence, and accounting for structural breaks.

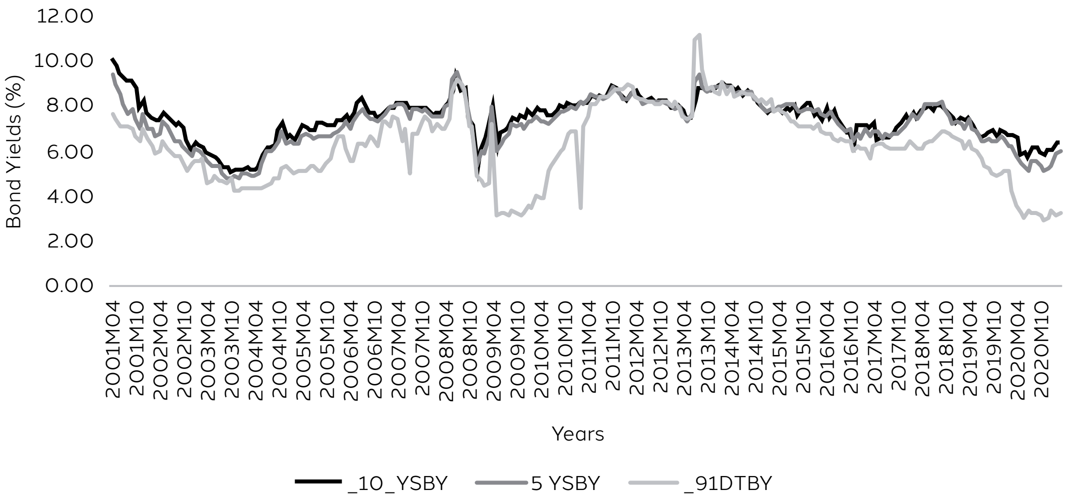
One key method for a government to raise capital is through the issuance of sovereign or government bonds in the market. The yields on these bonds have broader fiscal implications, as they represent the government's borrowing costs. Central banks can influence these interest rates by adopting various policies tailored to the economy's needs at different times. However, an important question arises: What factors determine government bond interest rates in the short and long term? The literature suggests that a government's borrowing costs depend on the macroeconomic conditions, the overall health of the economy, and external factors. According to **Keynes [1930]**, central banks play a crucial role in shaping long-term interest rates through short-term interest rates and other monetary policy tools. Keynes also argued that investor preferences for liquidity, shaped by social, psychological, and other expectations, can influence interest rates as well.

A country's growth heavily relies on a healthy bond market, which becomes even more important when fragile bank balance sheets and sluggish loan growth limit traditional financing. While the bond market might contribute to some economic expansion, sovereign bond yields represent a cost to the government, as higher bond yields translate into increased future payments. The shape of the bond yield curve also reflects the country's economic condition [**Akram, Li, 2017**; **Akram, Das, 2019**], making it crucial to understand the factors that determine sovereign bond yields, not only for scholarly reasons but also from a policy perspective.

Sovereign debt plays a vital role in filling the government's financial resource gaps, with the bond market serving as a primary means of raising funds. The yield on sovereign bonds carries broader fiscal implications because it directly affects the government's borrowing costs. Key policy moves, budgetary and financial data, and underlying economic fundamentals are the main factors that determine sovereign bond yields [**Poghosyan, 2014**].

India, like the United States, Japan, and other advanced economies, enjoys monetary sovereignty, issuing most of its sovereign debt in its own currency. However, while the capital markets in developed countries are almost entirely open, India's sovereign bond market is relatively closed. In contrast to developed economies, where debt is external in nature, India's sovereign debt is predominantly domestic, with the ownership structure also reflecting this. As of March 2020, commercial banks held the largest share of sovereign bonds at 40.41%, followed by insurance companies, with 25.09%, the Reserve Bank of India, with 15.13%, and provident funds, with 4.72%. India's rapid GDP growth makes it one of the fastest-growing major economies, underscoring the need to determine if the same fundamental factors that influence sovereign bond yields in developed markets apply to emerging economies. Therefore, studying the dynamics of India's sovereign bond market is essential for understanding the broader fiscal and economic factors that shape the global economy.

**Figure 1. Short- and long-term Indian sovereign bond yields of different maturities**

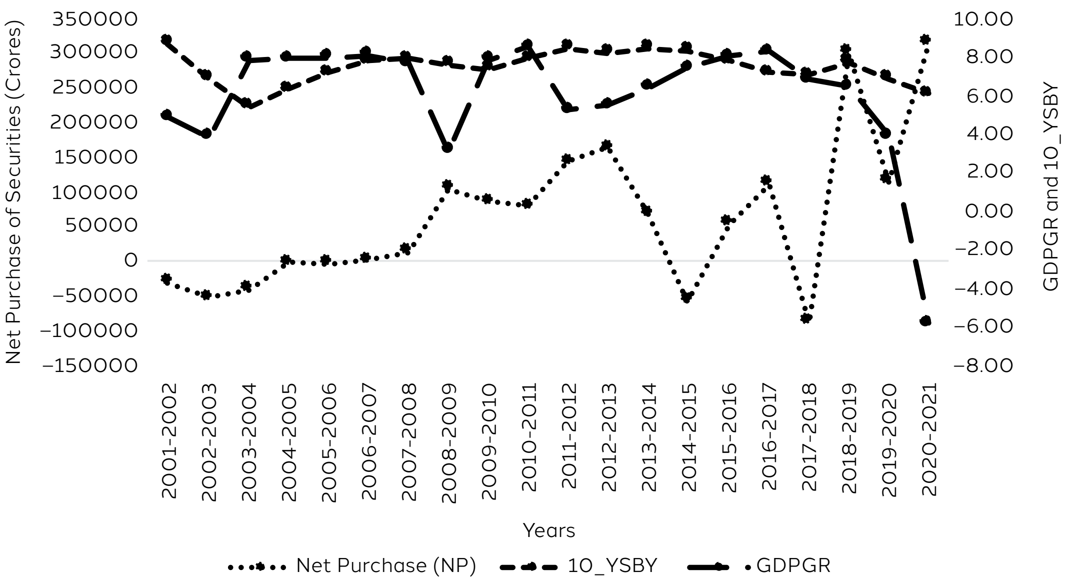



Source: Authors' own elaboration.

A discernible pattern in bond yield behaviour emerges from Figure 1, showing a clear influence of the short-term T-Bill rate on long-term interest rates. Both the nominal 5-year and 10-year government bond yields closely follow the 91-day Treasury bill yield, indicating a strong relationship between short-term and longer-term rates. Among various maturities, the 10-year government bond stands out as the most actively traded, with trading volumes predominantly concentrated in the 7- to 10-year range. The 5-year bond, within the 5- to 7-year maturity range, is the second-most traded. Moreover, there is a strong correlation of 0.93 between the yields of 10-year and 5-year bonds, highlighting the benchmark 10-year Indian Government Bond (IGB) yield as the optimal variable for capturing the dynamics of India's bond market.

From 2001 to 2006, rapid selling of securities led to an increase in bond yields, from 6.89% in the financial year 2002–2003 to 7.16% in 2005–2006 (see Figure 2). From 2006 onwards, the RBI primarily focused on purchasing government securities. The global financial crisis of 2008, despite varying levels of globalisation or domestic policy soundness, also impacted India. In 2008 and 2009, the RBI made significant purchases of government securities, causing bond yields to drop from 7.88% in 2007–2008 to 7.59% in 2008–2009, and further to 7.33% in 2009–2010. Several conventional measures were taken to counteract the crisis, including aggressive policy rate cuts. In late 2008, the US Federal Reserve implemented an unconventional monetary policy by keeping short-term rates near zero. During this time, interest rates in emerging economies ranged from 2% to 6% [**Naidu et al., 2016**]. Due to the interest rate differential, a significant capital flight occurred in the initial stages of the financial crisis from advanced to emerging economies. Consequently, India experienced an unprecedented exchange rate appreciation and a boom in the equity market through foreign institutional investors. Although the cost of borrowing decreased, bond yields rose due to increased demand for emerging market bonds, which offered higher yields than those in advanced economies. The cost of borrowing decreased while bond yields increased. Bond yields in emerging economies were in high demand as yields in the US and other advanced economies were lower than those in emerging economies.

**Figure 2. Trends in India's macroeconomic fundamentals (2001–2002 to 2020–2021)**




Source: Authors' own elaboration.

The first hint of US "tapering" in May 2013 triggered outflows from foreign institutional investors and caused a rise in bond yields. In response, the RBI increased interest rates and tightened liquidity to defend the currency. However, the higher interest rates failed to attract foreign investors back to the Indian bond market. As a result, the 10-year Indian government bond yields rose from 7.5% in mid-July to a peak of 9.23% by mid-August 2013. India's twin deficits increased, inflation spiked, and the GDP growth rate decreased from 8.5% in 2010 to 6.39% in the financial year 2013–14. The RBI reduced interest rates through monetary easing. In January 2014, the repo rate was reduced from 8.5% to 8%, followed by a reduction in the Cash Reserve Ratio (CRR) from 4.75% to 4.5% in June 2014, and a further cut to 4% in November 2014. These policy changes reduced long-term interest rates from 8.45% in 2013 to 8.30% in 2014–2015.

Starting in 2015, the RBI significantly increased its purchases of government securities. Between 2015 and 2020, the volume of securities purchased by the bank was double that of the 2010–2015 period. This surge in purchases was partly due to the economic disruptions caused by COVID-19 in 2019–20. The increased acquisition of government securities drove bond prices up, leading to a decline in bond yields. In 2019, the net purchase of government-dated securities amounted to ₹1.14 lakh crore, which increased to ₹3.13 lakh crore in 2021 and ₹2.14 lakh crore in 2021–22. The main reason behind this was COVID-19, which caused GDP growth to slow from 6.45% in 2018–19 to 3.87% in 2019–20, and further plummet to –5.83% in 2020–2021. To protect the economy and boost liquidity, the CRR was reduced by 100 basis points from 4% to 3% in April 2020, and the repo rate was cut from 5.15% to 4% in May 2020. Large amounts of government-dated securities were bought, leading to a fall in short-term interest rates and ultimately resulting in a decrease in 10-year sovereign bond yields from 7.71% in 2018–19 to 6.85% in 2019–2020 and 6.06% in 2020–2021 on average.

This paper addresses the long-standing debate on sovereign bond determinants, examining whether short-term interest rates are a key driver of long-term interest rates or if other macroeconomic factors – such as fiscal deficits, economic growth, and gold reserves – play a significant role [Baldacci, Kumar, 2010; Poghosyan, 2014]. There is relatively little literature explaining the factors that influence sovereign bond yields in emerging markets, especially in the case of India. This study seeks to analyse different macroeconomic fundamentals affecting government bond yields in India. Although some panel studies exist in the Indian context [Naidu et al., 2016], there is a dearth of country-specific time series studies. Therefore, this study's use of time series analysis will provide valuable insights for both academic research and policy-making.

The contribution of this paper is threefold. First, we use Autoregressive Distributed Lag (ARDL) models with structural breaks, a novel approach within the scope of the research. Second, we offer one of the most exhaustive compilations of variables employed to examine the determinants of Indian government bond yields, including some variables tested for the first time in the literature. The analysis considers three structural breaks and uses data from April 2001 to March 2021. Third, this investigation has substantial economic and financial implications, and its conclusions are relevant for investors and authorities facing the difficult task of fostering greater financial stability.

The rest of the paper is organised as follows. Section 2 reviews the theoretical and empirical literature on the determinants of sovereign bond yields, covering both advanced and emerging economies. Section 3 describes the dataset and econometric framework employed in the analysis. Section 4 reports the empirical findings and provides robustness and stability checks on the model. Finally, Section 5 concludes the findings with policy implications.

## Literature review

There have been many studies on bond yields, highlighting divided opinions. Some studies follow the Keynesian perspective, while others support loanable fund theory. Only a handful of studies have applied time series analysis to the case of India. This section reviews some of the relevant studies for both India and other countries.

Significant research has been conducted in the context of advanced economies. Elmendorf and Mankiw [1998] studied the macroeconomic effect of government debt for the United States and 18 other advanced countries. They concluded that fiscal deficits reduce national savings and increase aggregate demand. This subsequently impacts long-term interest rates due to an excess supply of government debt, leading to higher real interest rates. This study supports the conventional neoclassical loanable fund theory[1]. Gruber and Kamin [2012] explored the impact of the fiscal debt-to-GDP ratio on bond yields, analysing Organization for Economic Cooperation and Development (OECD) countries for the period 1988 to 2007. Their panel regression indicated that a one-percentage-point increase in the debt-to-GDP ratio is associated with an approximately seven-basis-point rise in the bond yield, implying a positive relationship. Poghosyan [2014] used the panel co-integration technique to study 22 advanced economies over the period from 1980 to 2010. The findings suggest that in the long run, an increase in the debt-to-GDP ratio and potential growth rate leads to higher government bond yields, while in the short run, yields are more influenced by inflation and short-term interest rates.

Cebula [2014] conducted a two-stage least square estimation by using yearly data from 1972 to 2012 and concluded that a one-percent increase in the budget deficit increases the yield on three-year and seven-year US Treasury bills between by 7–10 and 9–11 basis points respectively. Hsing [2015] employed the EGARCH model with quarterly data from Q1 1999 to Q2 2014, concluding that Spanish government bond yields increase with a rise in the debt-to-GDP ratio, Treasury bill rates, expected inflation, and US 10-year government bond yields, as well as during debt crises, while decreases in GDP growth and expected nominal exchange rates have the opposite effect. Alfonso et al. [2015] used data from January 1999 to December 2010 for a panel of 10 euro-area countries. They found that macro and fiscal fundamentals were largely insignificant in explaining bond spreads before the financial crisis, but became significant post-2007, in line with theoretical expectations. Naidu et al. [2016] investigated the proximate determinants of sovereign bond yields in emerging economies from 1980 to 2013 using panel co-integration analysis. They concluded that a one-percentage-point increase in US bond yields would raise emerging market bond yields by about 10 percent, highlighting the

1 The neo-classical loanable funds theory suggests that the supply and demand for loans in the market for loanable funds affect interest rates on loans.

significant impact of US market conditions on emerging economies. The study confirmed long-term relationships between domestic bond yields and factors such as US 10-year bond yields, the debt-to-GDP ratio, Federal Reserve rates, oil prices, real interest rates, and market volatility. Akram and Li [2017], analysing quarterly data from Q1 1960 to Q3 2014, identified short-term interest rates as the most significant determinants of long-term interest rates in the United States, particularly in the long term. Meanwhile, in the short run, higher government indebtedness positively affects long-term interest rates, according to their findings. Akram and Das [2014], using time series data from mid-1994 to the end of 2012 and applying the generalised method of moments (GMM), concluded that Japan's nominal government bond yields remained low due to policy-induced low short-term interest rates, low inflation, persistent deflationary pressures, tepid growth, and monetary sovereignty. Zhou [2021] examined the influence of government debt and macroeconomic factors on South Africa's long-term bond yield using ARDL technique. The analysis found that short-term interest rates significantly influence yields, with government debt and US bond yields exerting positive effects. The study also identified non-linear relationships, suggesting the need for coordinated monetary and fiscal policies, debt reduction, and structural reforms.

In the Indian contexts, few studies have examined the key determinants of sovereign bond yields. For example, [Chakraborty, 2012] analysed monthly data from April 2006 to April 2011 and concluded that an increase in the fiscal deficit does not necessarily lead to higher interest rates. Using an asymmetric vector autoregressive model, the study established that reserve currency, expected inflation, and capital flow volatility play significant roles in determining long-term interest rates. Krishna and Nag [2018] used quarterly data from March 2005 to June 2017 to identify long-term determinants of sovereign bond yields in India. They employed the Engle-Granger method to analyse co-integration among the variables. Their findings suggest that central bank actions, through monetary policy tools, influence short-term interest rates, which in turn drive long-term rates. Akram and Das [2019], using both monthly and quarterly data from 1999 to 2015, conducted an ARDL bound test to examine the factors determining the long-term bond yield. Their analysis reveals that the long-term interest rate is positively associated with the short-term rate. Goyal [2019], analysing monthly data from May 2002 to February 2018, concluded that, besides other variables, open market operations (OMO) plays a crucial role in determining government bond yields, as tightening long-run liquidity increases G-sec yields. The study emphasised that OMO is not just a liquidity management tool but also affects the interest rate spread, aiding monetary policy transmission.

This study differs from previous research [Chakraborty, 2012; Naidu et al., 2016; Akram, Das, 2019] in three ways. First, to the best of our knowledge, there is a dearth of country-specific time series studies for India, making the analysis of macroeconomic fundamentals' effects on long-term bond yields more relevant for policy-making. Second, earlier studies did not account for structural breaks in their models. This study employs the Bai-Perron structural break test to identify three break dates with unknown timing and incorporates them into the empirical models. Third, while previous research covered shorter periods, this study uses monthly data over the 20-year period from April 2001 to March 2021 for India.

## Data and methodology

### Data description

The time series data for all variables in this study were obtained from Reserve Bank of India-Database on Indian Economy (RBI–DBIE), the Central Statistical Organization (CSO), and the US Energy Information Administration. These data consist of monthly series from April 2001 to March 2021. To ensure consistency across the dataset, the series were converted to a common base year using a splicing method. The 91-Day Treasury Bill yield was used as a proxy for short-term interest rates. We calculated the Monetary Policy Index (MPI) based on the approach of Sahoo and Bhattacharya [2012] as we could not rely on just one policy variable from the RBI. All the variables, except for the various policy rates and the fiscal deficit growth rate, were converted to their natural logarithmic form. Table 1 provides detailed information on the variables, including their units, data frequency, and source.

**Table 1. Variables and data sources**

| Variables | Acronym | Units | Frequency | Source |
|---|---|---|---|---|
| Short-Term Treasury Bill Yields | 91DTBY | % Yields | 2001:04 to 2021:03 | RBI–DBIE |
| Monetary Policy Index | MPI | Index | 2001:04 to 2021:03 | Self-Calculated |
| Long-Term Sovereign Bond Yields | 10YSBY | % Yields | 2001:04 to 2021:03 | RBI–DBIE |
| Wholesale Price Index | WPI | Log (WPI) | 2001:04 to 2021:03 | CSO, RBI |
| Global Brent Crude Oil Price | BCOP | Log (GBCOP Dollar per Barrel) + | 2001:04 to 2021:03 | US Energy Information Administration |
| Gross Fiscal Deficit | GFD | Log (GFD in Million Dollar) | 2001:04 to 2021:03 | RBI–DBIE |
| Nominal Effective Exchange Rate | NEER | Log NEER | 2001:04 to 2021:03 | RBI–DBIE |
| Index of Industrial Production | IIP | Log IIP | 2001:04 to 2021:03 | CSO, RBI |
| Growth of Gold Reserves | GGR | % Change | 2001:04 to 2021:03 | RBI–DBIE |

Source: Authors' own elaboration.

## Model specification

The interplay between short-term and long-term interest rates in financial markets is influenced by multiple factors. According to the expectations theory of the term structure, long-term interest rates are determined by averaging current and anticipated short-term rates [**Akram, Das, 2019**]. Investors' expectations of future short-term rates, which are shaped by factors such as inflation and central bank policies, play a crucial role. If investors foresee an increase in short-term rates, long-term rates may rise to compensate for perceived risks. Central banks, closely linked to short-term rates, often adjust policies in response to inflationary pressures [**Friedman, Kuttner, 2010**]. This can lead to higher long-term rates as a strategy to counteract inflation's impact on future purchasing power. Foreign exchange reserves contribute to currency stability by lowering the risk premium associated with currency volatility, potentially boosting long-term interest rates [**Engel, 2016**]. Economic growth influences central bank policies, with rate hikes during expansionary periods [**Precious, Palesa, 2014**]. Government fiscal policies, including increased spending, may stimulate the economy but raise inflationary pressures, potentially leading to higher long-term interest rates. Forward guidance from central banks can impact expectations and, subsequently, long-term interest rates.

Changes in the price of Brent crude oil may influence inflation expectations, prompting adjustments in central bank policies and affecting long-term interest rates [**Novotný, 2012**]. Fluctuations in oil prices can alter risk perceptions, causing investors to reassess portfolios and influencing bond yields and long-term interest rates. A fiscal deficit often leads to increased government borrowing, impacting long-term interest rates. Rising deficits and debt levels can raise investor concerns, increasing perceived risk and leading to higher long-term interest rates [**Hoelscher, 1986**]. Changes in exchange rates affect global capital flows, with a stronger home currency potentially attracting international investors and influencing long-term interest rates. Central banks may respond to exchange rate fluctuations, adjusting interest rates and impacting long-term rates in the process [**Fornari et al., 2002**].

This study aims to examine the determinants of sovereign bond yield in India. To achieve this, we estimated the following models.

Model 1: $10YSBY = f(91DTBY, GGR, LFD, LGBCOP, LIIP, LNEER, LWPI, MPI)$

Model 2: $10YSBY = f(91DTBY, GGR, LFD, LGBCOP, LIIP, LNEER, LWPI, MPI, D1, D2, D3, D1{*}91DTBY)$

Model 3: $10YSBY = f(91DTBY, GGR, LFD, LGBCOP, LIIP, LNEER, LWPI, MPI, D1, D2, D3, D1{*}91DTBY, D2{*}91DTBY)$

Model 4: $10YSBY = f(91DTBY, GGR, LFD, LGBCOP, LIIP, LNEER, LWPI, MPI, D1, D2, D3, D1*91DTBY, D2*91DTBY, D3*91DTBY)$

Where,

10*YSBY*: 10-Year Bond Yield
91*DTBY*: 91-Day Treasury Bill Yields
*GGR*: Growth of Gold Reserves
*LFD*: Log of Fiscal Deficit (LFD)
*LGBCOP*: Global Brent Crude Oil Price
*LIIP*: Index of Industrial Production
*LNEER*: Nominal Effective Exchange
*LWPI*: Wholesale Price Index
*MPI*: Monetary Policy Index
*D*1: Dummy is used where '0' is assigned until 2004M07 and '1' thereafter.
*D*2: Dummy is used where '0' is assigned until 2009M09 and '1' thereafter.
*D*3: Dummy is used where '0' is assigned until 2013M10 and '1' thereafter.

## Econometric Methodology

### Unit Root Test

Since stationarity is of prime importance in time series analysis, we examined the stationarity properties of the time series variables using conventional unit root tests such as Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS). The ADF test [Dickey, Fuller, 1979] includes a parametric correction to account for higher-order correlation by adding lagged difference terms to the right-hand side of the regression equation. Given that the ADF test is often characterised by low statistical power, the unit root test was complemented with the PP test [Phillips and Perron, 1988], which uses a non-parametric method to control for higher-order serial correlation. The null hypothesis for both ADF and PP tests is that the series contains a unit root against the alternative hypothesis that the series is stationary, while the KPSS procedure [Syczewska, 2010] tests for the null hypothesis of stationarity. The ADF, PP and KPSS tests are combined to ensure robust results.

### Structural Break Points Test

Economic activities lead to changes in macroeconomic fundamentals, and the impact and adjustment of certain events can result in shifts in macroeconomic variables. Time series under such conditions are referred to as deterministic non-stationary. To promote economic restructuring and maintain macroeconomic stability, India has been continuously introducing new policies related to the variables considered in this study, which may result in structural breaks in these variables. Research on structural breaks began with the Chow test, which can only be applied when the structural break point is known and can detect just one structural break [Gregory, 1960]. Bai and Perron [1998] conducted an in-depth study on structural break and proposed the endogenous structural break test method. Bai [1999] demonstrated that this approach offers better testing accuracy and efficiency in small samples, making it a more accurate and objective method at present.

### ARDL Method

In time series analysis, most relationships are non-contemporaneous or lagged in nature, meaning that the dependent variable depends not only on the current time period but also on previous periods. After identifying the integration of I(0) and I(1) variables, we used the ARDL method to find long-run co-integration relationships. This model was proposed by Pesaran and Shin [1998] and further developed by Pesaran et al. [2001]. Under the ARDL framework, short-run and long-run coefficient of the independent variables can be obtained if all variables are co-integrated. The ARDL model is capable of solving the endogeneity and serial autocorrelation problem. The standard ARDL model is of the following form.

$$\Delta Y_t = \beta_0 + \varphi_1 y_{t-1} + \varphi_2 x_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Y_{t-i} + \sum_{i=0}^{n} \varphi_1 y_{t-1} + \mu_t \quad (1)$$

where $\beta_0$ is a constant, $\beta_i$ and $\delta_i$ are short-run coefficients, and $\varphi_1$ and $\varphi_2$ are long-run coefficients. The disturbance or white noise term is $\mu_t$.

As per the model specification, the following four equations are estimated using the ARDL model.

$$\begin{aligned}\Delta\_10\_YSBY_t &= \beta_0 + \varphi_1 10YSBY_{t-1} + \varphi_2 91DTBY_{t-1} + \varphi_3 GGR_{t-1} + \varphi_4 LFD_{t-1} + \\ &+ \varphi_5 LGBCOP_{t-1} + \varphi_6 LIIP_{t-1} + \varphi_7 LNEER_{t-1} + \varphi_8 LWPI_{t-1} + \varphi_9 MPI_{t-1} + \\ &+ \sum_{i=1}^{m} \beta_i \Delta 10YSBY_{t-i} + \sum_{i=0}^{n} \delta_{1i} \Delta 91DTBY_{t-i} + \sum_{i=0}^{q} \delta_{2i} \Delta GGR_{t-i} + \sum_{i=0}^{o} \delta_{3i} \Delta LFD_{t-i} + \\ &+ \sum_{i=0}^{p} \delta_{4i} \Delta LGBCOP_{t-i} + \sum_{i=0}^{r} \delta_{5i} \Delta LIIP_{t-i} + \sum_{i=0}^{s} \delta_{6i} \Delta LNEER_{t-i} + \sum_{i=0}^{t} \delta_{7i} \Delta LWPI_{t-i} + \\ &+ \sum_{i=0}^{u} \delta_{8i} \Delta MPI_{t-i} + \mu_{1t}\end{aligned} \quad (2)$$

$$\begin{aligned}\Delta\_10\_YSBY_t &= \beta_0 + \varphi_1 10YSBY_{t-1} + \varphi_2 91DTBY_{t-1} + \varphi_2 D1_{t-1} + \varphi_3 D1 * \\ &* 91DTBY_{t-1} + \varphi_4 D2_{t-1} + \varphi_5 D3_{t-1} + \varphi_6 GGR_{t-1} + \varphi_7 LFD_{t-1} + \varphi_8 LGBCOP_{t-1} + \\ &+ \varphi_9 LIIP_{t-1} + \varphi_{10} LNEER_{t-1} + \varphi_{11} LWPI_{t-1} + \varphi_{12} MPI_{t-1} + \sum_{i=1}^{m} \beta_i \Delta 10YSBY_{t-i} + \\ &+ \sum_{i=0}^{n} \delta_{1i} \Delta 91DTBY_{t-i} + \sum_{i=0}^{o} \delta_{2i} \Delta D1_{t-i} + \sum_{i=0}^{p} \delta_{3i} \Delta D1 * 91DTBY_{t-i} + \\ &+ \sum_{i=0}^{q} \delta_{4i} \Delta D2_{t-i} + \sum_{i=0}^{r} \delta_{5i} \Delta D3_{t-i} + \sum_{i=0}^{s} \delta_{6i} \Delta GGR_{t-i} + \sum_{i=0}^{t} \delta_{7i} \Delta LFD_{t-i} + \\ &+ \sum_{i=0}^{u} \delta_{8i} \Delta LGBCOP_{t-i} + \sum_{i=0}^{v} \delta_{9i} \Delta LIIP_{t-i} + \sum_{i=0}^{w} \delta_{10i} \Delta LNEER_{t-i} + \sum_{i=0}^{x} \delta_{11i} \Delta LWPI_{t-i} + \\ &+ \sum_{i=0}^{y} \delta_{12i} \Delta MPI_{t-i} + \mu_{2t}\end{aligned} \quad (3)$$

$$\begin{aligned}\Delta\_10\_YSBY_t &= \beta_0 + \varphi_1 10YSBY_{t-1} + \varphi_2 91DTBY_{t-1} + \varphi_3 D1_{t-1} + \varphi_4 D1 * 91DTBY_{t-1} + \\ &+ \varphi_5 D2_{t-1} + \varphi_6 D2 * 91DTBY_{t-1} + \varphi_7 D3_{t-1} + \varphi_8 GGR_{t-1} + \varphi_9 LFD_{t-1} + \\ &\varphi_{10} LBCOP_{t-1} + \varphi_{11} LIIP_{t-1} + \varphi_{12} LNEER_{t-1} + \varphi_{13} LWPI_{t-1} + \varphi_{14} MPI_{t-1} + \\ &+ \sum_{i=1}^{m} \beta_i \Delta 10YSBY_{t-i} + \sum_{i=0}^{n} \delta_{1i} \Delta 91DTBY_{t-i} + \sum_{i=0}^{o} \delta_{2i} \Delta D1_{t-i} + \\ &+ \sum_{i=0}^{p} \delta_{3i} \Delta D1 * 91DTBY_{t-i} + \sum_{i=0}^{q} \delta_{4i} \Delta D2_{t-i} + \sum_{i=0}^{r} \delta_{5i} \Delta D2 * 91DTBY_{t-i} + \sum_{i=0}^{s} \delta_{6i} \Delta D3_{t-i} + \\ &+ \sum_{i=0}^{t} \delta_{7i} \Delta GGR_{t-i} + \sum_{i=0}^{u} \delta_{8i} \Delta LFD_{t-i} + \sum_{i=0}^{v} \delta_{9i} \Delta LBCOP_{t-i} + \sum_{i=0}^{w} \delta_{10i} \Delta LIIP_{t-i} + \\ &+ \sum_{i=0}^{x} \delta_{11i} \Delta LNEER_{t-i} + \sum_{i=0}^{y} \delta_{12i} \Delta LWPI_{t-i} + \sum_{i=0}^{z} \delta_{13i} \Delta MPI_{t-i} + \mu_{3t}\end{aligned} \quad (4)$$

$$\begin{aligned}\Delta\_10\_YSBY_t &= \beta_0 + \varphi_1 10YSBY_{t-1} + \varphi_2 91DTBY_{t-1} + \varphi_3 D1_{t-1} + \varphi_4 D1*91DTBY_{t-1} + \\ &+ \varphi_5 D2_{t-1} + \varphi_6 D2*91DTBY_{t-1} + \varphi_7 D3_{t-1} + \varphi_8 D3*91DTBY_{t-1} + \varphi_9 GGR_{t-1} + \\ &+ \varphi_{10} LFD_{t-1} + \varphi_{11} LGBCOP_{t-1} + +\varphi_{12} LIIP_{t-1} + \varphi_{13} LNEER_{t-1} + \varphi_{14} LWPI_{t-1} + \\ &+ \varphi_{15} MPI_{t-1} + \sum_{i=1}^{m} \beta_i \Delta 10YSBY_{t-i} + \sum_{i=0}^{n} \delta_{1i} \Delta 1DTBY_{t-i} + \sum_{i=0}^{o} \delta_{2i} \Delta D1_{t-i} + \\ &+ \sum_{i=0}^{p} \delta_{3i} \Delta D1*91DTBY_{t-i} + \sum_{i=0}^{q} \delta_{4i} \Delta D2_{t-i} + \sum_{i=0}^{r} \delta_{5i} \Delta D2*91DTBY_{t-i} + \\ &+ \sum_{i=0}^{s} \delta_{6i} \Delta D3_{t-i} + \sum_{i=0}^{t} \delta_{7i} \Delta D3*91DTBY_{t-i} + \sum_{i=0}^{u} \delta_{8i} \Delta GGR_{t-i} + \sum_{i=0}^{v} \delta_{9i} \Delta LFD_{t-i} + \\ &+ \sum_{i=0}^{w} \delta_{10i} \Delta LGBCOP_{t-i} + \sum_{i=0}^{x} \delta_{11i} \Delta LIIP_{t-i} + \sum_{i=0}^{y} \delta_{12i} \Delta LNEER_{t-i} + \sum_{i=0}^{z} \delta_{13i} \Delta LWPI_{t-i} + \\ &+ \sum_{i=0}^{a} \delta_{14i} \Delta MPI_{t-i} + \mu_{4t} \end{aligned} \tag{5}$$

### *ARDL Bound Test*

The ARDL approach is applied regardless of whether the variables are I(0), I(1) or mutually integrated. This method is used to determine whether the independent variables significantly influence the dependent variable in the long run. The computed F-test results can be compared with the critical values provided by **Pesaran et al.** [**2001**] and **Narayan** [**2005**] for hypothesis testing. The F-statistic should be greater than I(1). If the F-statistic is less than I(0), no long-run co-integration relationship exists between the independent and dependent variables. If the F-statistic falls between I(0) and I(1), the results are inconclusive. The coefficients of the independent variables in the level equation indicate their long-term impact on the dependent variable.

### *ARDL ECM (Error Correction Mechanism)*

The ARDL Error Correction Mechanism (ECM) is used to find the convergence speed of independent variables in the long run. The coefficient of the co-integration equation should be negative and significant. The coefficient of the difference of independent variables tells us how significantly it affects the dependent variable in the short run.

$$\Delta Y_t = \beta_0 + \sum_{i=1}^{m} \beta_i \Delta y_{t-i} + \sum_{i=0}^{n} \delta_i \Delta x_{t-i} + \varphi ECM_{t-1} + \varepsilon_{it} \tag{6}$$

The benefit of using the ARDL model is that it solves the problem of the Johansen co-integration method, whose condition is that all the variables should be integrated of order 1. In the case of the ARDL method, the studied variable should be of order I(0) or I(1) but not I(2). It also allows different variables to take an optimal number of lags, which is not permitted in the Johansen co-integration approach. The optimal number of lags is calculated using Akaike or Schwartz or the Hannan-Quinn information criterion[2].

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[2] It is important to choose an appropriate number of lags in the model because including too many lagged variables can decrease the degrees of freedom, making the inference less reliable. The problem becomes worse if we have more explanatory variables. If we have large sample data the problem of the degree of freedom is solved, but the problem of multicollinearity arises. The coefficient of lagged variables can sometimes have unexpected signs, complicating the interpretation of results. After estimation, it is also important to perform residual diagnostic tests and stability diagnostic tests to ensure the model's validity.

The ARDL ECM for our study would be

$$\begin{aligned}\Delta\_10\_YSBY_t = \beta_0 + \sum_{i=1}^{m}\beta_i\Delta\_10\_YSBY_{t-i} + \sum_{i=0}^{n}\delta_{1i}\Delta\_91\_DTBY_{t-i} + \\ + \sum_{i=0}^{q}\delta_{2i}\Delta GGR_{t-i} + \sum_{i=0}^{o}\delta_{3i}\Delta LFD_{t-i} + \sum_{i=0}^{p}\delta_{4i}\Delta GBCOP_{t-i} + \sum_{i=0}^{r}\delta_{5i}\Delta LIIP_{t-i} + \\ + \sum_{i=0}^{s}\delta_{6i}\Delta LNEER_{t-i} + \sum_{i=0}^{t}\delta_{7i}\Delta LWPI_{t-i} + \sum_{i=0}^{u}\delta_{8i}\Delta MPI_{t-i} + \varphi ECM_{t-1} + \varepsilon_{1t}\end{aligned} \tag{7}$$

$$\begin{aligned}\Delta\_10\_YSBY_t = \beta_0 + \sum_{i=1}^{m}\beta_i\Delta 10YSBY_{t-i} + \sum_{i=0}^{n}\delta_{1i}\Delta 91DTBY_{t-i} + \sum_{i=0}^{o}\delta_{2i}\Delta D1_{t-i} + \\ + \sum_{i=0}^{p}\delta_{3i}\Delta D1*91DTBY_{t-i} + \sum_{i=0}^{q}\delta_{4i}\Delta D2_{t-i} + \sum_{i=0}^{r}\delta_{5i}\Delta D3_{t-i} + \sum_{i=0}^{s}\delta_{6i}\Delta GGR_{t-i} + \\ + \sum_{i=0}^{t}\delta_{7i}\Delta LFD_{t-i} + \sum_{i=0}^{u}\delta_{8i}\Delta LGBCOP_{t-i} + \sum_{i=0}^{v}\delta_{9i}\Delta LIIP_{t-i} + \sum_{i=0}^{w}\delta_{10i}\Delta LNEER_{t-i} + \\ + \sum_{i=0}^{x}\delta_{11i}\Delta LWPI_{t-i} + \sum_{i=0}^{y}\delta_{12i}\Delta MPI_{t-i} + \varphi ECM_{t-1} + \varepsilon_{2t}\end{aligned} \tag{8}$$

$$\begin{aligned}\Delta\_10\_YSBY_t = \beta_0 + \sum_{i=1}^{m}\beta_i\Delta 10YSBY_{t-i} + \sum_{i=0}^{n}\delta_{1i}\Delta 91DTBY_{t-i} + \sum_{i=0}^{o}\delta_{2i}\Delta D1_{t-i} + \\ + \sum_{i=0}^{p}\delta_{3i}\Delta D1*91DTBY_{t-i} + \sum_{i=0}^{q}\delta_{4i}\Delta D2_{t-i} + \sum_{i=0}^{r}\delta_{5i}\Delta D2*91DTBY_{t-i} + \\ + \sum_{i=0}^{s}\delta_{6i}\Delta D3_{t-i} + \sum_{i=0}^{t}\delta_{7i}\Delta GGR_{t-i} + \sum_{i=0}^{u}\delta_{8i}\Delta LFD_{t-i} + \sum_{i=0}^{v}\delta_{9i}\Delta LGBCOP_{t-i} + \\ + \sum_{i=0}^{w}\delta_{10i}\Delta LIIP_{t-i} + \sum_{i=0}^{x}\delta_{11i}\Delta LNEER_{t-i} + \sum_{i=0}^{y}\delta_{12i}\Delta LWPI_{t-i} + \\ + \sum_{i=0}^{z}\delta_{13i}\Delta MPI_{t-i} + \varphi ECM_{t-1} + \varepsilon_{3t}\end{aligned} \tag{9}$$

$$\begin{aligned}\Delta\_10\_YSBY_t = \beta_0 + \sum_{i=1}^{m}\beta_i\Delta 10YSBY_{t-i} + \sum_{i=0}^{n}\delta_{1i}\Delta 91DTBY_{t-i} + \sum_{i=0}^{o}\delta_{2i}\Delta D1_{t-i} + \\ + \sum_{i=0}^{p}\delta_{3i}\Delta D1*91DTBY_{t-i} + \sum_{i=0}^{q}\delta_{4i}\Delta D2_{t-i} + \sum_{i=0}^{r}\delta_{5i}\Delta D2*91DTBY_{t-i} + \\ + \sum_{i=0}^{s}\delta_{6i}\Delta D3_{t-i} + \sum_{i=0}^{t}\delta_{7i}\Delta D3*91DTBY_{t-i} + \sum_{i=0}^{u}\delta_{8i}\Delta GGR_{t-i} + \sum_{i=0}^{v}\delta_{9i}\Delta LFD_{t-i} + \\ + \sum_{i=0}^{w}\delta_{10i}\Delta LGBCOP_{t-i} + \sum_{i=0}^{x}\delta_{11i}\Delta LIIP_{t-i} + \sum_{i=0}^{y}\delta_{12i}\Delta LNEER_{t-i} + \\ + \sum_{i=0}^{z}\delta_{13i}\Delta LWPI_{t-i} + \sum_{i=0}^{a}\delta_{14i}\Delta MPI_{t-i} + \varphi ECM_{t-1} + \varepsilon_{4t}\end{aligned} \tag{10}$$

### *Stability and Residual Diagnostic Test*

The Bruce Godfrey Serial Correlation LM test is used to detect autocorrelation among the independent variables. If the probability value of the test statistic is greater than 0.05, the null hypothesis is rejected, indicating that there is no autocorrelation problem. The Autoregressive Conditional Heteroscedasticity (ARCH) test is a statistical method used in time series analysis to detect the presence of heteroscedasticity, where the variance of errors changes over time. In the ARCH heteroscedasticity test, the null hypothesis ($H_0$) is that there is no ARCH effect in the time series data, meaning that the variance of the errors is constant over time. The alternative hypothesis ($H_1$) is that there is an ARCH effect, indicating that the variance of errors changes over time. The null hypothesis is rejected if the p-value is less than or equal to the chosen significance level (commonly 0.05). The Cumulative Sum of Recursive Residuals (CUSUM) and Cumulative Sum of Squares of Recursive Residuals (CUSUM SQ) tests are used to check the stability of the model. If the estimated line lies within the 5% confidence interval level, the model is considered stable.

## Empirical estimation and results

Table 2 provides descriptive statistics for all variables over the entire sample period. The mean values of all the variables except for MPI, are positive. A negative MPI reflects the central bank's expansionary monetary policy on average throughout the sample period. In terms of risk, measured by standard deviation, the Growth of Gold Reserves shows the highest deviation, which is expected because gold reserves, part of the total exchange reserves, change on daily basis. Apart from GGR, the other variables exhibit lower standard deviations, likely due to the relatively closed nature of India's capital market. The government has been using both monetary and fiscal measures to stabilise the economy. The vast majority of the series exhibit negative skewness, which implies that they are skewed to the left compared to the normal distribution. In addition, the kurtosis statistic exceeds the reference value of the normal distribution (equal to 3) for the Growth of Gold Reserves (GGR) and Log of Gross Fiscal Deficit (LFD), indicating that these data are leptokurtic (more peaked around the mean and with fatter tails than the Gaussian distribution). The departure from normality is further confirmed by the Jarque–Bera statistics, which reject the null hypothesis of normal distribution for all variables except 91DTBY at the 1% significance level. The correlation matrix shown in Table 3 indicates that there is no evidence of high correlation among the explanatory variables.

**Table 2. Descriptive statistics**

| | _10_YSBY | _91DTBY | GGR | LFD | LGBCOP | LIIP | LNEER | LWPI | MPI |
|---|---|---|---|---|---|---|---|---|---|
| Mean | 7.44 | 6.28 | 1.20 | 12.32 | 4.09 | 4.49 | 4.78 | 4.49 | −0.06 |
| Median | 7.57 | 6.39 | 0.68 | 12.35 | 4.14 | 4.60 | 4.82 | 4.61 | 0.00 |
| Maximum | 9.71 | 11.14 | 68.35 | 13.33 | 4.89 | 4.98 | 5.05 | 4.87 | 3.00 |
| Minimum | 5.11 | 2.87 | −11.84 | 0.00 | 2.93 | 3.82 | 4.47 | 3.97 | −3.00 |
| Std. Dev. | 0.95 | 1.65 | 5.77 | 0.83 | 0.48 | 0.32 | 0.18 | 0.27 | 0.95 |
| Skewness | −0.47 | −0.07 | 6.58 | −13.75 | −0.38 | −0.64 | −0.15 | −0.40 | −0.69 |
| Kurtosis | 2.91 | 2.63 | 77.79 | 204.54 | 2.37 | 2.16 | 1.45 | 1.68 | 5.16 |
| Jarque-Bera | 8.83 | 1.59 | 57424.27 | 412010.02 | 9.87 | 23.18 | 24.83 | 23.77 | 65.31 |
| Probability | 0.01 | 0.45 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sum | 1777.14 | 1500.28 | 287.15 | 2943.97 | 977.16 | 1074.16 | 1141.67 | 1072.67 | −14.00 |
| Sum Sq.Dev. | 215.05 | 650.09 | 7937.03 | 164.03 | 53.73 | 24.95 | 7.75 | 17.63 | 213.18 |
| Observations | 239 | 239 | 239 | 239 | 239 | 239 | 239 | 239 | 239 |

Source: Authors' own elaboration.

**Table 3. Correlation matrix**

| Variables | _91DTBY | GGR | LFD | LGBCOP | LIIP | LNEER | LWPI | MPI |
|---|---|---|---|---|---|---|---|---|
| _91DTBY | 1 | | | | | | | |
| GGR | −0.20*** | 1.00 | | | | | | |
| LFD | −0.01 | 0.02 | 1.00 | | | | | |

| Variables | _91DTBY | GGR | LFD | LGBCOP | LIIP | LNEER | LWPI | MPI |
|---|---|---|---|---|---|---|---|---|
| LGBCOP | 0.51*** | −0.04 | 0.02 | 1.00 | | | | |
| LIIP | 0.21*** | −0.07 | −0.02 | 0.59*** | 1.00 | | | |
| LNEER | −0.10 | 0.10 | −0.03 | −0.24*** | −0.28*** | 1.00 | | |
| LWPI | 0.23*** | −0.09 | 0.03 | 0.54*** | 0.50*** | −0.19*** | 1.00 | |
| MPI | 0.09 | 0.00 | 0.01 | 0.33*** | 0.11 | 0.11 | 0.04 | 1.00 |

Note: *** denotes level of significance at 1%.

Source: Authors' own elaboration.

**Table 4. Results of ADF, PP and KPSS unit root test**

| Variables | ADF | | PP | | KPSS | | Decision |
|---|---|---|---|---|---|---|---|
| | Level | 1st Difference | Level | 1st Difference | Level | 1st Difference | |
| 10YSBY | −3.30** | - | −3.28** | - | 0.23 | 0.13*** | I(0) |
| 91DTBY | −2.12 | −19.36*** | −2.42 | −19.76*** | 0.25 | 0.10*** | I(0) |
| LFD | −15.96*** | - | −15.99*** | - | 0.05 | 0.17*** | I(0) |
| LGBCOP | −2.43 | −10.76*** | −2.14 | −10.17*** | 0.65*** | - | I(1) |
| GGR | −14.14*** | - | −14.15*** | - | 0.22 | 0.16*** | I(0) |
| LIIP | −2.49 | −4.98*** | −0.35 | −47.90*** | 1.95*** | - | I(1) |
| LNEER | −0.78 | −12.38*** | −0.65 | −12.28*** | 1.83*** | - | I(1) |
| LWPI | −1.47 | −3.23*** | −0.69 | −16.18*** | 1.88*** | - | I(1) |
| MPI | −6.11*** | - | −9.78*** | - | 0.12 | 0.06*** | I(0) |

Note: The superscripts '***' and '**' represent 1% and 5% level of significance respectively.

Source: Authors' own elaboration.

The first step before estimating any regression is to identify the order of integration of variables. We employed unit root tests such as ADF [Dickey and Fuller, 1981], PP [Phillips and Perron, 1988] and KPSS [Syczewska, 2010]. Table 4 shows that only the 10-year sovereign bond yield, 91DTBY, LFD, GGR and MPI are I(0), while other variables including LGBCOP, LIIP, LNEER and LWPI are I(1). All the decisions about the stationarity of the variables except 91DTBY align with the results of the ADF, PP and KPSS tests. As per the ADF and PP tests, 91DTBY is stationary at first difference while the KPSS test finds stationarity at level. As some of the variables are I(0) and some are I(1), the ARDL model was chosen to find out the long-run relationship between these variables.

**Table 5. Results of ADF unit root test with unknown break date**

| Variables | Level | 1st Difference | Decision | Break Date |
|---|---|---|---|---|
| 10YSBY | −4.0291 | −18.3497*** | I(1) | 2008M12 |
| 91DTBY | −2.8694 | −20.8999*** | I(1) | 2013M07 |
| GGR | −22.3892*** | −24.8956*** | I(0) | 2009M11 |
| LGBCOP | −3.5557 | −11.9791*** | I(1) | 2020M03 |
| LFD | −16.1285*** | −30.0269*** | I(0) | 2019M05 |
| LIIP | −3.0918 | −23.8688*** | I(1) | 2002M06 |
| LNEER | −3.8478 | −12.9002*** | I(1) | 2013M08 |
| LWPI | −2.6195 | −16.6214*** | I(1) | 2002M04 |
| MPI | −9.3197*** | −25.3805*** | I(0) | 2002M06 |

Note: The superscript *** represents 1% level of significance.

Source: Authors' own elaboration.

When considering a long time period in a study, there is a possibility of structural breaks in the data series. To account for this, the ADF unit root test with structural breaks was conducted, revealing breaks in different series at various time points, as shown in Table 5. The results confirm that some variables are stationary at I(0), while others are stationary at I(1), at a 1% level of significance. Comparing Tables 4 and Table 5, we conclude that both tables suggest that there are a mix of I(0) and I(1) variables in the model. Consequently, the ARDL approach is appropriate for assessing long-run co-integration among variables in this study.

**Table 6. Bai-Perron structural break**

| Break test | F-statistic | Break dates | | | | |
|---|---|---|---|---|---|---|
| 0 vs. 1 * | 40.795 | 2005M11 | | | | |
| 1 vs. 2 * | 9.86 | 2004M06 | 2013M12 | | | |
| 2 vs. 3 * | 4.31 | 2004M07 | 2009M09 | 2013M10 | | |
| 3 vs. 4 | 1.85 | 2004M06 | 2007M11 | 2010M11 | 2013M12 | |
| 4 vs. 5 | 2.06 | 2004M06 | 2007M11 | 2010M11 | 2013M12 | 2017M11 |

Note: * denotes level of significance at 0.05 percent.
Source: Authors' own elaboration.

After identifying the order of integration of the selected variables in using unit root accounting for structural breaks, we proceeded to check for potential structural breaks with unknown timing using Bai-Perron structural break test [Bai, Perron, 1998]. The Bai-Perron test identified the presence of three break dates: 2004M07, 2009M09 and 2013M10 after trimming the sample by 15% at a 5% significance level. For robustness, we performed the Breakpoint Regression (Least Squares Break Point Approach) at a 5% level of significance. We found no difference in break dates after incorporating Newey-West standard errors. The trimming percentage was set at 15%. We estimated the Least Square Break Point Regression with HAC (Newey-West) standard errors, using pre-whitening with maximum lags from SIC, Bartlett kernel, Newey-West automatic bandwidth, and NW automatic lag length.

Between the financial years 2004–05 and 2007–08, India experienced an economic boom marked by a substantial increase in foreign direct investment (FDI) and external commercial borrowing. The increase in FDI not only boosted the rate of capital formation in the country but also enabled many industries to advance technologically because of the infusion of new technology that accompanied investment. However, the period from 2008 to 2013 witnessed a global slowdown during the financial crisis. The structural break identified in 2013 may due to a sharp rise in the 10-year bond yield after May 2013. Just prior to this, bond yields had softened due to easing commodity prices. However, the US Federal Reserve's sudden announcement to taper bond purchases resulted in substantial FII outflows, leading to continued depreciation of the rupee. As the RBI tightened liquidity and raised rates to defend the currency, India's macroeconomic vulnerabilities became apparent, with high fiscal and current-account deficits, high inflation, and slow growth. The 10-year benchmark yield surged 168 basis points to 9.23% within a month, creating a statistically significant structural break [Krishna, Nag, 2018]. Although the Indian capital market is relatively closed, the consequences of the global crisis transmit through various macroeconomic variables as no economy is entirely isolated. A key factor influencing this transmission is the global Brent crude oil price. Exchange reserves, especially gold and foreign exchange reserves, play a crucial role in protecting the market from externalities during challenging times. Before applying the ARDL bounds test to check for co-integration among 10YSBY, 91DTBY, GGR, LGBCOP, LFD, LIIP, LNEER, LWPI and MPI, it is important to select an appropriate lag order for the variables. The study employed the optimal lag order of the vector auto-regression (VAR) model for the selection of the appropriate lag order. Table 7 suggests an optimal lag order of one, as recommended by selection criteria such as the Akaike Information Criterion (AIC), Schwarz Criterion (SC), and Hannan-Quinn (HQ) for employing the ARDL model. We followed SC criteria in estimating all models under the ARDL approach.

**Table 7. VAR optimal lag selection criteria**

| Lag | AIC | SC | HQ |
|---|---|---|---|
| 0 | 6.76 | 6.97 | 6.84 |
| 1 | −18.44* | −15.30* | −17.18* |
| 2 | −18.19 | −12.15 | −15.76 |
| 3 | −17.53 | −8.56 | −13.91 |
| 4 | −16.92 | −5.03 | −12.12 |
| 5 | −16.86 | −2.05 | −10.89 |
| 6 | −16.59 | 1.14 | −9.44 |
| 7 | −16.54 | 4.11 | −8.21 |
| 8 | −16.56 | 7.01 | −7.05 |

Note: * indicates lag order selected by the criterion.

Source: Authors' own elaboration.

The optimal lag structure for the ARDL Model is obtained using E-Views 13 based on Schwarz Criteria. The Model selection summary of the top 20 models based on Schwarz Criteria is shown in Figure 4 (See Appendix).

**Table 8. ARDL bound test result**

| Test Statistic | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| F-statistic | 3.81** | 6.17*** | 6.05*** | 6.06*** |
| Lower bound I (0) | 2.22 | 2.41 | 2.41 | 2.41 |
| Upper bound I (1) | 3.39 | 3.61 | 3.61 | 3.61 |

Note: The superscripts *** and ** represent 1% and 5% levels of significance respectively.

Source: Authors' own elaboration.

The ARDL bounds test determines whether there is long-term co-integration among the selected variables. The test results presented in Table 8 indicate co-integration across all models (Model 1–4). The F-statistics for each model exceed the lower and upper bounds of the ARDL model.

After identifying the long-run association between selected variables in all models, we proceed to estimate the long-run coefficients of the ARDL model. The results, shown in Table 9, reveal that the short-term interest rate (91DTBY) is positive and statistically significant in all the models, controlling for other variables. This confirms the Keynesian conjecture that the short-term interest rate positively influences the long-term interest rate in India. This finding is in line with previous studies [Akram and Das, 2019].

In Model 1, no structural break was considered and the estimated were obtained using the ARDL approach. The findings indicate that 91DTBY, along with LGBCOP and MPI, positively affect the long-term Indian sovereign bond yield.

Models 2–4 account for structural breaks identified by the Bai-Perron test. The ARDL long-run estimates of Model 2 show that the coefficients for 91DTBY, LGBCOP, MPI and D1 are positive and statistically significant at the 1 percent level of significance, while the coefficient for the interaction term D1*91DTBY is negative and statistically significant at the same level. This suggests that the short-term interest rate in the post-crisis period adversely affects the long-term interest rate. This finding is in line with the earlier finding of Krishna and Nag [2018].

In Model 3, the variables 91DTBY, LGBCOP, MPI, D1 and D1*91DTBY are found to be the drivers of the long-term interest rate. The interaction term D1*91DTBY is statistically significant and negative in the model, which suggests that the short-term interest rate in the post-crisis period adversely affects the long-term interest rate.

**Table 9. Long-run estimates of ARDL**

| Variables | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| 91DTBY(-1) | 0.25** | 1.36*** | 1.36*** | 1.41*** |
| GGR | 0.0002 | 0.002 | 0.002 | 0.002 |
| LFD | −0.09 | −0.03 | −0.01 | −0.01 |
| LGBCOP(-1) | 1.45** | | | |
| LGBCOP | | 1.44*** | 1.40*** | 1.06*** |
| LIIP(-1) | 1.20 | 0.27 | 0.83 | 0.34 |
| LNEER | −3.60 | −1.34 | −0.64 | −0.87 |
| LWPI | −4.11 | −2.43 | −2.07 | −0.23 |
| MPI | 0.32* | 0.18*** | 0.21*** | 0.20*** |
| D1 | | 6.29*** | 7.04*** | 6.91*** |
| D2(-1) | | | −1.09 | −0.13 |
| D2 | | 0.26 | | |
| D3 | | 0.24 | | −1.82*** |
| D1*91DTBY | | −1.18*** | −1.34*** | −1.32*** |
| D2*91DTBY(-1) | | | 0.20 | 0.01 |
| D3*91DTBY | | | 0.17 | 0.23*** |

Note: The superscripts *** and ** represent 1% and 5% levels of significance respectively.
Source: Authors' own elaboration.

Finally, Model 4 was estimated, accounting for all the structural break dates and their interaction term with the short-term interest rate. The ARDL long-term estimates of Model 4 indicate that 91DTBY, LGBCOP, MPI, D1, D3, D1*91DTBY and D3*91DTBY have a significant effect on the long-term interest rate. Variables including 91DTBY, LGBCOP, MPI, D1 and D3*91DTBY have a positive effect on the long-term interest rate, while D3 and D1*91DTBY exhibit a negative effect. In 2004, a 1-percent increase in the short-term interest rate resulted in a 1.32-percent decline in the long-term interest rate. Conversely, when the short-term interest rate changes by 1%, the long-term interest rate in 2013 will go down by the difference between the slope of the coefficient of D1*91DTBY and the coefficient of the D3*91DTBY by 1.09 percent. Additionally, a 1-percentage-point change in the 91-day T-bill yield led to a 1.41-percentage-point change in 10-year sovereign bond yields. Our finding that short-term interest rates determine long-term interest rates is consistent with earlier studies [**Akram, Das, 2019**; **Akram, Li, 2017**]. The MPI, which is a composite index of the Repo Rate, Reverse Repo Rate and Cash Reserve Ratio, is also statistically significant and its coefficient shows that a unit change in MPI significantly affects long-term bond yields by 0.20 units, demonstrating the favourable impact of monetary policy changes on long-term bond yields. Furthermore, the coefficient for the short-term interest rate increases as structural breaks are incorporated into the model.

**Table 10. Short-run estimates of ARDL model**

| Variables | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Δ91DTBY | 0.22*** | 0.71*** | 0.71*** | 0.78*** |
| ΔLGBCOP | 0.84*** | | | |
| ΔLIIP | 0.74*** | 0.45*** | 0.45*** | 0.46*** |
| ΔD2 | | 0.59** | 0.59** | 0.72*** |
| ΔD2*91DTBY | | −0.23*** | −0.23*** | −0.27*** |
| ECM | −0.13*** | −0.30*** | −0.30*** | −0.34*** |

Note: The superscripts *** and ** represent 1% and 5% levels of significance respectively.
Source: Authors' own elaboration.

ARDL ECM reveals short-run dynamics and the speed of adjustment towards long-run equilibrium after a short-run deviation. All models show negative and statistically significant coefficients of the ECM component at the 1% level, indicating that any disequilibrium can be quickly corrected in the long run if there is a shock to the explanatory variables from the previous year. Table 10 shows that as additional dummies and the interaction term from Model 2 are included in Model 4, the ECM values increase significantly, with the speed of adjustment ranging between 13% and 34% across all models.

The coefficients of the differenced variables show how these variables affect 10YSBY in the short run. The short-run ARDL coefficient estimates for all four models are presented in Table 10. The short-term interest rate (Δ91DTBY) is positive and significant in the model, indicating that short-term interest rates also influence long-term interest rates (10YSBY) in the short run. A 1-percentage-point change in 91DTBY raises 10YSBY by 0.22 percentage points in Model 1. However, the coefficient estimates for the short-term interest rate range from around 0.70 to 0.78 in Models 2–4, where structural breaks are considered. Global Brent Crude Oil prices are found to be positive and statistically significant only in Model 1 in the short run. In addition to 91DTBY, variables such as LIIP, D2 and D2*91DTBY are also statistically significant in Models 2–4. The coefficients for 91DTBY, LIIP and D2 are positive, while D2*91DTBY has a negative effect on the long-term interest rate across these models.

In a nutshell, the ARDL coefficient estimates for 91DTBY show a positive effect on the long-term interest rate in both the short and long run, supporting previous empirical findings [**Akram, Das, 2019**; **Akram, Li, 2017**] and confirming the Keynesian hypothesis.

**Table 11. Breusch-Godfrey Serial Correlation LM Test**

| Diagnostics | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Prob. $x^2$ | 0.14 | 0.16 | 0.24 | 0.41 |

Source: Authors' own elaboration.

**Table 12. ARCH Test of Heteroscedasticity**

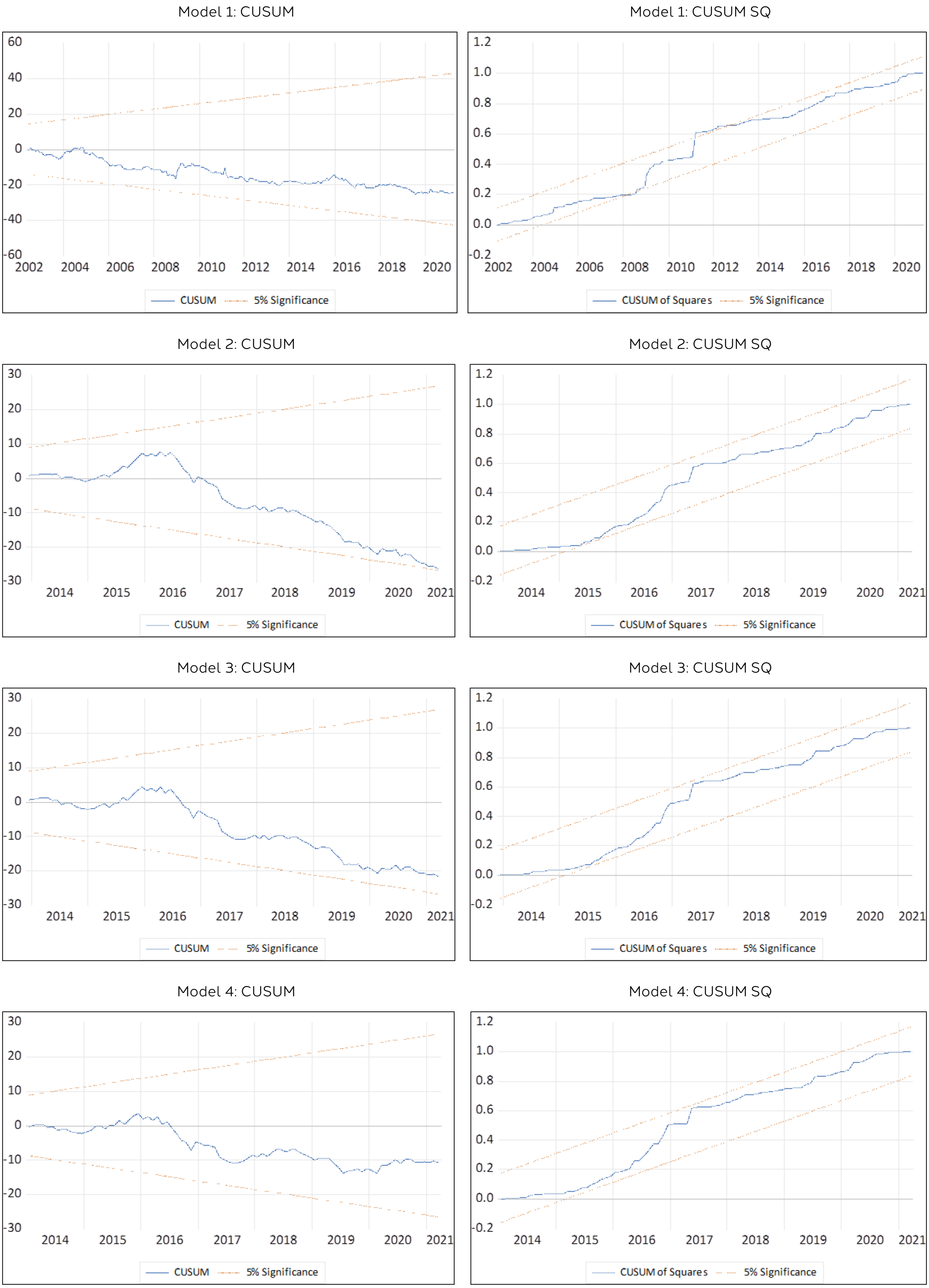
| Diagnostics | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Prob. $x^2$ | 0.0006 | 0.001 | 0.07 | 0.20 |

Source: Authors' own elaboration.

In time series analysis, autocorrelation is a serious problem, so the Breush-Godfrey Serial Correlation LM test was performed to check residual diagnostics (refer to Table 11). All the models pass the autocorrelation test as the null hypothesis of no autocorrelation is not rejected. To account for potential time-varying variance unrelated to any independent variables, the Autoregressive Conditional Heteroskedasticity (ARCH) test [**Engle, 1982**] was used to examine the dynamics of conditional variance. Table 12 shows that while the first two models do not pass the ARCH test, the third and fourth models did, at a 5 percent level of significance. Given the chi-squared probabilities of 0.07 and 0.20, the null hypothesis of homoscedasticity is accepted for Models 3 and 4, indicating that the final model is free from auto-correlation and heteroscedasticity.

Finally, the CUSUM and CUSUM Sq tests were performed to check the stability of the models. Both tests confirmed the stability of all estimated models. Figure 3 illustrates this stability, with results falling within the upper and lower confidence bands at the 5% significance level.

**Figure 3. Stability Diagnostic of ARDL Models: CUSUM Test and CUSUM Sq. Test**




Source: Authors' own elaboration.

## Conclusion and policy implications

The empirical results suggests that short-term interest rates have a positive and significant effect on long-term bond yields in both the short and long run. This finding confirms that Keynes' conjecture is valid for India for the period from April 2001 to March 2021. Given the importance of the short-term interest rate, more priority should be given to monetary sovereignty. This has been observed in Japan, where long-term yields remain low despite weak fundamentals, due to the country's strong monetary sovereignty [**Akram, Das, 2014**]. In addition to short-term interest rates, Brent crude oil prices also significantly and positively affect long-term bond yields, suggesting that the RBI should be vigilant and consider measures to mitigate global instability. The coefficient for the IIP is positive but not significant in the long run, while it is positive and statistically significant in the short run. As output increases, the demand for money rises, leading to higher interest rates.

The relationship between short-term interest rates and long-term sovereign bond yields underscores the pivotal role of monetary policy in shaping borrowing costs and financial markets. As long-term bond yields closely align with short-term interest rates, changes in central bank policies, such as interest rate adjustments, could significantly impact long-term borrowing costs for governments and businesses. This interconnection highlights the sensitivity of bond markets to monetary policy decisions.

Moreover, the inclusion of the Index of Industrial Production (IIP) suggests a strong correlation between bond yields and real economic activity. A positive relationship between the IIP and bond yields implies that bond investors closely monitor economic health. Higher industrial production may signal economic expansion, potentially leading to expectations of increased future inflation and, consequently, higher long-term bond yields.

Additionally, the influence of global Brent crude oil prices on long-term sovereign bond yields emphasises the importance of energy markets in shaping economic conditions. Fluctuations in oil prices can affect inflation expectations, production costs for businesses, and consumer spending patterns. Higher oil prices may prompt investors to anticipate inflationary pressures, leading to demands for higher yields on long-term bonds to offset potential purchasing power erosion.

The inclusion of a monetary policy index underscores the impact of central bank actions on bond market dynamics. Changes in key policy rates and ratios, such as the repo rate, reverse repo rate, and cash reserve ratio, can influence liquidity conditions, interest rate expectations, and overall market sentiment. As long-term bond yields are positively affected by the monetary policy index, market participants closely monitor and respond to central bank decisions and policy signals, highlighting the importance of understanding and interpreting such actions.

The results also suggest that, contrary to conventional wisdom, higher government indebtedness does not raise the nominal yields on Indian government bonds. Although the conventional view, based on the loanable funds perspective, is at odds with this finding, it is consistent with Keynes' theory and modern money theory. In summary, these factors collectively illustrate the intricate relationships that influence long-term sovereign bond yields. Monetary policy decisions, real economic activity, oil price volatility, and central bank actions all play significant roles in shaping bond market dynamics and investor behaviour. Understanding these interconnected influences is essential for policymakers, investors, and market participants to navigate bond markets effectively and anticipate economic trends.

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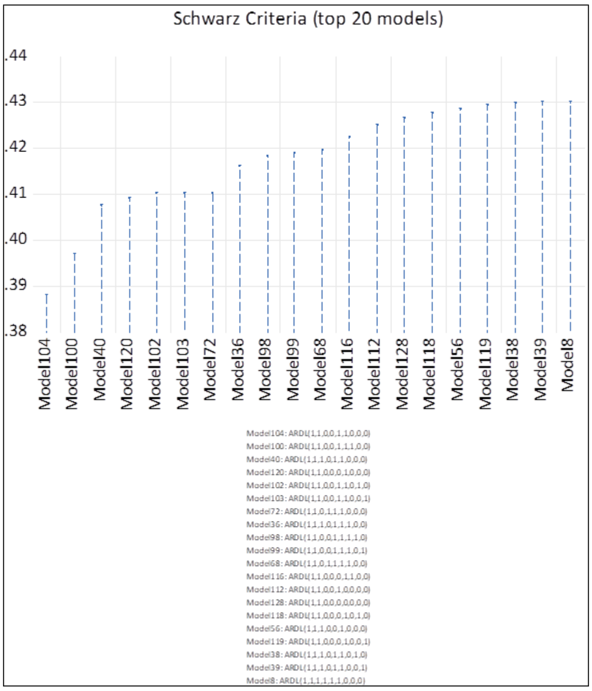
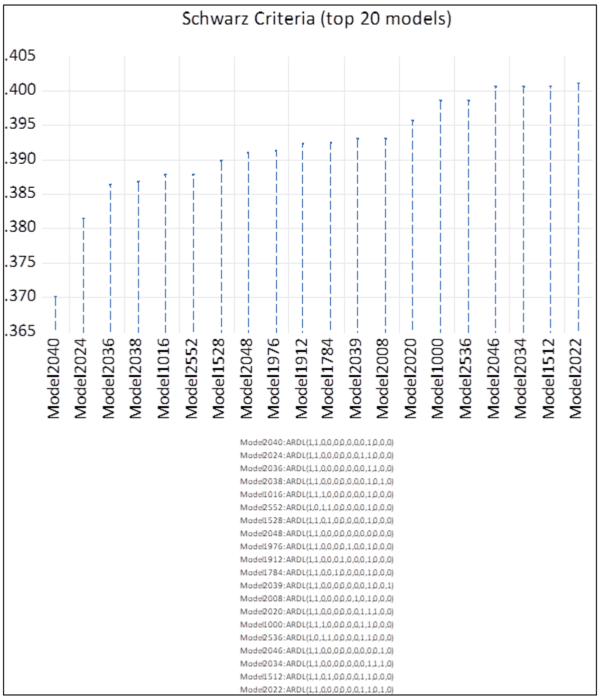
## Appendix

**Figure 4. Model Selection Summary: Lag Selection SC Criterion for ARDL Model**

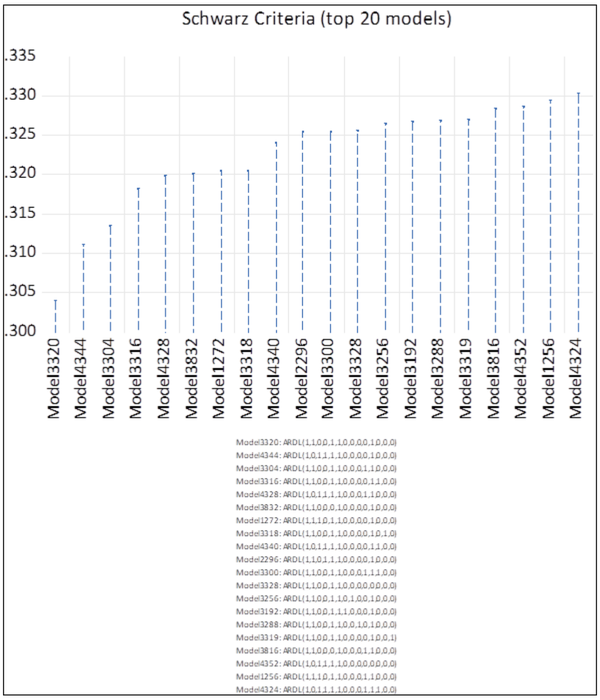
Model 1



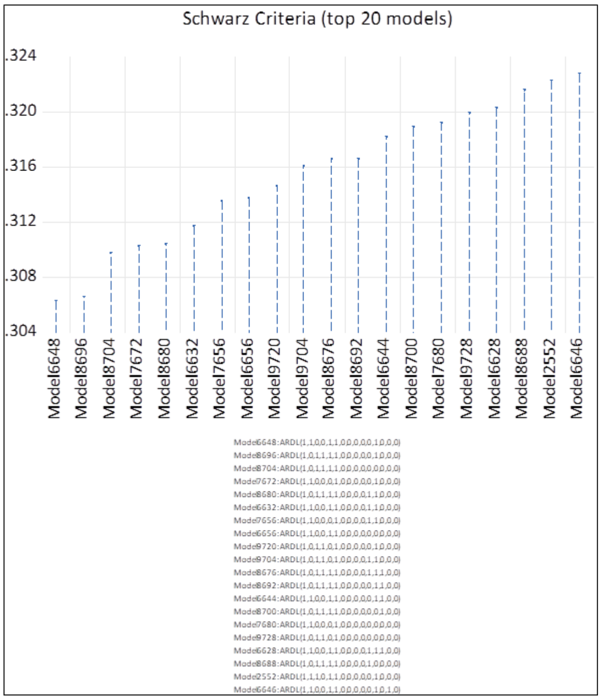

Model 2



Model 3




Model 4




Source: Authors' own elaboration.