Macroeconomic, Monetary Policy Risk and Bond Premia::Indian Market Perspective

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Abstract.
The paper documents the term premium dynamics in the Indian central government debt market. The term premium which averages approximately 198 bps in Q32005- Q42021 for the 10-year maturity central government securities,is highly persistent and has hardly changed after the implementation of Inflation Targeting Bill in 2015. Three channels are identified towards such persistence in the premium component a)Long history of passive monetary policy b)High risk of encountering countercyclical inflation c)Presence of an aggregate asset market with aggregate negative real dividend growth [1].
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1. Introduction

The paper primarily identifies the principal factor behind a persistent term premium in the Indian central government debt market. The research question is predominant in the current scenario as the Central Bank has struggled to control the yields of 10 Year Government securities (G-Secs) below 6 % while the short-term rates have reduced below 4 %. The size of the Central Government Debt Market, as of 2021, is worth USD 1.63 trillion (approxi-

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mately 60 % of GDP as of March 2021), demanding the yields be confined below 6 % to reduce the burden of interest payment. The difference between the short-term and long-term interest rates is not a recent phenomenon; in fact, the trends are similar to what was prevalent before the period of Inflation Targeting(IT) Bill implementation in 2015 (see figure 1). The term premium and expected nominal rates are two components of this difference. The expected nominal rate is the average short-term rate expected to prevail over the maturity of the bond (the expectation hypothesis channel), and the term premium is the risk compensation sought by the investors for holding the log term bonds(Kim & Orphanides,2007). While the expected nominal rates have gradually decreased post IT (see figure 2), the term premium component has hardly moderated and persistently varies between 125 bps to 250 bps.

The term premium depends on both amount of risk and price of risk, both can vary over time due to variable fundamentals.The price of risk, or the degree of systemic risk, can change with varying perception of inflation uncertainty, real activity, monetary policy uncertainty.The amount of risk varies with business cycles, as investors become more risk averse during recessions.Further, if the perception of price of risk doesn't change in the economy, the benefits of lower short term rates will not transcend to longer segment due to sticky premium component.In the face of low inflation post IT, few working papers identified the premium/spread primarily to foreign spillovers post IT[2] (Patra , 2020 2021 ; Dilip, 2019).The central bank under-

[2] The foreign holding in the Indian central government debt market is limited to average holding of 5%-6% of the total outstanding for the sample period considered.

took liquidity management in form of aggressive cuts of the repo rates from 2019 onwards, long-term repo operations to infuse liquidity for a maturity greater than three years, and simultaneous buy-sell of the central government bonds to flatten the yield curve Vardhan &| Sengupta(2020). However, the premium has hardly been under control. Thus, an obstinate premium for more than a decade warrants further analysis. In the first part of the paper, we document unstable/uncertain inflation expectations in the economy due to passive monetary policy followed in India.The long- run expectations declined post IT, but are unstable due to the long history of passive monetary policy. A persistent premium in nominal bonds over a decade indicates constant pricing of risk towards systemic, unstable inflation expectations. India doesn't have a vibrant TIPS market like developed markets; thus, direct observation of inflation risk premium is not possible. To circumvent the same, I adapt the learning framework of Carvalho, Eusepi, Moench & Preston (2021) in the Indian context to see how long-run inflation expectations are generated in the economy, especially after IT. Such a learning framework tries to identify how the low-frequency movement in the long run expectations are being generated, whether by considering historical evidence (backward-looking) or the expectations are purely forward-looking. Latter, suggest a more anchored expectation and inflation uncertainty will be low in such case. The long-run inflation expectations are conditional on current short-run inflation surprises. Similar to Bullard & Mitra (2003), if these current deviations are within a narrow bound for the large period, the long-run expectations are stable and become forward-looking. In terms of Bullard Mitra(2003), the long-run expectations are E-stable, and dynamics are similar to predictions of forward-looking ration expectation models found in McCallum & Nelson (1999), Woodford(1999), Taylor(1999 a). These frameworks only take into cognizance expectations arising out of surprises and do not account for expectations driven by sunspot shocks.

In the learning framework of Carvalho, Eusepi, Moench & Preston (2021), a series of bounded deviations lead to stable expectations. The framework incorporates a weight (gain) function on past deviations. If the expectations are stable, then the weight function gradually converges to zero, and the expectations converge to the desired central bank target. However, when deviations are beyond a certain threshold, the long-run expectations are continuously updated by giving constant weights to past deviations. In India, the gain function is constant both in pre and post-IT regimes. Such weight function indicates that backward-looking components are still prevalent while forming long-run expectations. This is primarily due to the continuation of the passive monetary policy regime in spite of officially adopting IT in 2015 (Eichengreen, Gupta, & Choudhary, 2020). A gradual decrease in long-run inflation expectation post IT is primarily due to a series of negative forecast errors/deviations (see figure 3), and in turn, these negative deviations were driving downward revisions of long-run expectations. As in Bullard & Mitra(2003), the long-run expectations are unstable in India due to passive monetary policy and are sensitive to short-run errors. The framework clearly captures recent episodes where there have been upward revisions in low-frequency movements of long-run inflation expectations. The framework also estimates a target band of 3.8 % to 5 % for the formation of stable expectations.The framework captures the underline low frequency movement in inflation expectation to a large extent, considering the fact that likelihood of the Indian data is scaled down extensively in order to stick to the posteriors estimated in the original framework. The estimates clearly show upward revisions in inflation expectations between 2019-2020 and again in late half of 2021.

In the subsequent section of this paper, I show the economic mechanism behind the risk premium levels observed in the Indian bond market. Following Song(2017) the consumption asset pricing model of Bansal and Yaron (2004) is augmented with :a) monetary policy rule with passive response to inflation gap, b) time-varying inflation target in the monetary policy rule, c)incorporating regime switching in the covariance between real consumption growth shock and inflation target shocks in the inflation target path. The model combines the real side long run consumption risk with nominal side factors. The first clause introduce endogenous inflation and the assets inherits nominal properties. The second clause introduces with what strength the central bank counters rising inflation. The third clause induce cyclical properties of inflation, necessary for generating the risk premiums. A risk averse agent who favors early resolution of uncertainty is aware about possibility of countercyclical inflation in the future, and passiveness of the central bank towards rising inflation in such states, will always command a risk compensation for holding nominal bonds. The long run consumption side also helps to introduce equity aspect in the model.Incorporating the joint aspect of bond and equity mimics a representative agent who have a portfolio of bonds and equity with a target return.The joint aspect helps to capture the bond premiums associated with states when consumption growth is low and aggregate return(includes dividend growth) from equity market is not sufficient to hedge against such states. The aspect is important in Indian market perspective as the aggregate real dividend growth is negative (average around -3%) and the real consumption growth is positive (average 1.4%) for our sample period Q32005 to Q42021.As the real returns of an aggregate portfolio are not sufficient to hedge against such low growth states, an extra premium will be commanded in anticipation of such countercyclical states in both equities and bonds.Both aggregate equities and bonds are risky in anticipation of the aggregate consumption risk associated with such low states.

The model features two distinct economic regimes: a) CP regime occurs when conditional covariance between real consumption growth and inflation target is negative. The macroeconomic shocks are countercyclical, and the central bank raises interest rate less than one to one rising inflation. The central bank accommodates inflation by rising the inflation target. b) PP regime occurs when conditional covariance between real consumption growth and inflation target is positive, procyclical macroeconomic shocks and passive monetary policy. The CP form is version of the economy defined in (Piazzesi & Schnieder 2006 ;Wacther 2008 ; Chernov & Mueller 2012 ; Rudebusch & Swanson 2012) where agents command a high premium for inflationary risk in the countercyclical states.To capture the risk with each of the regime, I do a Bayesian estimate of the defined state space model. The a priori risk with counter-cyclical inflation is significant in Indian economy as the unconditional probability of such scenario is 53% and the economy undergoes frequent regime switches. The model closely matches the moments observed in the Indian macro data. Further, the model predicts an average premium of 180 bps for the sample period Q3 - Q4 2021 and an average market return of $\approx 12\%$. The smoothed probability clearly shows the heightened risk of countercyclical inflation in recent times.The upward revisions in inflation expectation, heightened risk of countercyclical inflation, clearly overlaps with episodes of increase in nominal term premium.

2. Empirical evidence on changes in expected nominal rates, premiums,inflation expectation and anchoring

In this section, I empirically document the changes in inflation expectations, the changes in expected nominal rates, and the term premium. Following ACM methodology to measure the risk associated with the government bonds, the ZCYC yield components expected nominal rates and the term premium are estimated. As observed, the expected nominal rates started decreasing post-2015 in sync with the decrease in inflation expectation and realized inflation.Both long-term (10 years ahead) and short-term inflation gradually declined and converged within the central bank's target band post IT, but the bond premium showed minor improvement on the asset side. Ascertaining changes in inflationary risk premium or anchoring of inflation expectation in the Indian market is difficult due to the absence of TIPS market. To investigate the issue of improvement in anchoring, we estimate the state - space model illustrated in Carvalho, Eusepi, and Moench's (2021) to identify low-frequency movement in long-run inflation expectations. The framework is an intuitive model of inflation and inflation expectation based on learning. When forecasting, the agents use the following price setting model(Perceived Law of motion)

$$PLM :: \hat{E}_{t-1}\pi_t = (1-\gamma_p)\bar{\pi}_t + \gamma_p \pi_{t-1} + \phi_t, \tag{1}$$

where π_t is inflation , $\bar{\pi}_t$ is the long run inflation prevailing in the economy and ϕ_t is zero-mean stationary component, comprising of shocks to marginal cost (s_t) and cost push shocks (μ_t), as observed in a New Keynesian model.

$$\phi_t = s_t + \mu_t, \tag{2}$$

$$s_t = \rho_s s_{t-1} + \epsilon_t, \tag{3}$$

μ_t and ϵ_t are i.i.d. disturbances , normally distributed with mean zero and std σ_μ , σ_ϵ

The price setting agents assumes the perceived long run inflation to be constant while forecasting inflation at any time.

Now while setting a price at time t, by virtue of strategic complementary, the agents will set price contingent on the perceived prevailing future expected inflation, as prices remains fixed for few periods. The dependence of the perceived expected inflation on the actual inflation is captured through Actual law of motion(ALM)

$$ALM :: \{E_{t-1}\pi_t = (1-\gamma_p)\tau\bar{\pi}_t + \gamma_p \pi_{t-1} + \phi_t, \tag{4}$$

where $\tau 1$ controls the feedback from expected inflation to Realized inflation. The difference between the ALM and PLM is contingent on the feedback parameter. When the difference is large, the firms will put less weight on the perceived long run inflation expectation ($\tau \ll 1$) and put more weight on the transient short run shocks.

In the setup, the agents update their long run inflation expectation following Marcet and Nicolini (2003) technology. In such setup, the agents put constant weight(constant gain) on the forecast errors, if the errors continue to be beyond certain bound for a certain period or on continuous basis. When the errors are within certain bound for a long period, the agents decrease their weight(decreasing gain) on the forecast error, and the inflation forecast is close to the prevailing long run inflation expectations. The setup clearly highlights the specifications mentioned in Bullard & Mitra (2003) for the stability of expectations in recursive learning models.Both, this framework clearly suggests the expectations will be purely forward-looking when the current short run deviations are within certain bounds. Such bounds are only possible with aggessive monetary policies where the central bank is aware about the limits eyon which agents again switch to constant gain.

$$\bar{\pi}_t = \bar{\pi}_{t-1} + k_{t-1}^{-1} f_{t-1} \tag{5}$$

where $\mathrm{f}_t = \pi_t - \underbrace{(1-\gamma_p)\bar{\pi}_t + \gamma_p \pi_{t-1} + \rho_s s_{t-1}}_{\hat{E}_{t-1}\pi_t}$

The f_t is the forecast error and k_t is the weight/gain function associated with the forecast error. The gain function is determined as

$$k_t = k_{t-1} + 1, if \mid \hat{E}_{t-1}\pi_t - E_{t-1}\pi_t \mid \leq v * \sqrt{MSE} \tag{6}$$

else $\mathrm{k}_t = \bar{g}^{-1}$

where $\bar{g}$, $v > 0$ are parameters,$\hat{E}_{t-1}\pi_t$ is the agent's one period ahead forecast and $E_{t-1}\pi_t$ is the forecast from ALM; and $\mathrm{MSE} = \mathrm{E}[\pi_t - E_{t-1}\pi_t]^2$

The parameter v determines how much the agents are aware about the economy. It defines the bound for a stationary environment, where agents are able to identify the low frequency movements and the weights on transient short run shocks are low. One can think from regime switching perspective, in a non-stationary environment the shocks to long run inflation expectations are higher as compared to a stable stationary environment, an assumption prevalent in DSGE literature (Schorfheide, 2005 ; Smets and Wouters 2007)

2.1 Data

Inflation is measured by the CPI.The CPI series is available in OECD database from September 1958 on monthly basis. The inflation is measured every quarter, year over year(YoY).Such frequency is selected, as the central bank in India measures inflation YoY every quarter, since the price series are more volatile as compared to the developed nations. Similarly, in SPF the inflation forecasts for one, two,three quarters ahead are also estimates at YoY frequency. One, two and three quarters ahead inflation expectations along with realized inflation are included in the model to predict 10 year inflation expectations. The SPF data series are available from September 2007 on a quarterly basis. The 10-year expectations are available till June 2018, as the central bank discontinued the long run survey and continues with short run survey hereafter. The sample ends in December 2021.

2.2 Estimation & Results

Summarizing the equations in section. 2, following are the system of latent equations:

$$\pi_t = (1 - \gamma_p)\tau\bar{\pi}_t + s_t + \mu_t$$

$$\bar{\pi}_t = \bar{\pi}_{t-1} + k_{t-1}^{-1} f_{t-1}$$

$$f_t = (1 - \gamma_p)(\tau - 1)\bar{\pi}_t + \mu_t + \epsilon_t$$

$$k_t = k_{t-1} + 1, if, \mid \hat{E}_{t-1}\pi_t - E_{t-1}\pi_t \mid \leq v * \sqrt{MSE}$$

$$\bar{g}^{-1}, otherwise$$

$$s_t = \rho_s s_{t-1} + \epsilon_t$$

$$\mathcal{E}_t = (\pi_t, \bar{\pi}_t, f_t, s_t)$$

where $\mathcal{E}_t$ are the latent states and the structural parameters are

$$\bar{\Delta} = (\pi^*, v, \bar{g}, \gamma_p, \tau, \rho_s, \sigma_s^2, \sigma_\mu^2)$$

.

The measurement equation is linked with the system of latent states in the following manner .

$$\begin{pmatrix} \pi_t \\ E_t^{SPF}\pi_{t+1} \\ E_t^{SPF}\pi_{t+2} \\ E_t^{SPF}\pi_{t+3} \end{pmatrix} = \pi^* + A_t^{'}\mathcal{E}_t + B_t e_t$$

where π^* is the long run inflation target. The vector e_t are the observation errors for all the variables. The observation errors are included to filter the shocks driving short run inflation expectations.

The SPF forecast are mapped to model forecast in the following manner::

$$E_t^{SPF}\pi_t = \hat{E}_t\pi_t = (1-\gamma_p)\bar{pi}_t + \gamma_p\pi_{t-1} + \rho_s s_{t-1} \tag{7}$$

As the availability of the survey data is limited, the US posterior distribution is taken as prior for all parameters, except for the average inflation, exogenous shocks and the observation errors. Further, the likelihood is scaled by a parameter λ in order to keep the model parameter as close to US posteriors and gaining sample specific information simultaneously. The scaling parameter is taken as 0.02. The inflation target π^* is set to the central bank's target of 4% .

$$\mathrm{P}^{In}(\bar{\Delta}^{In}|Y_t^{In}, Y^{US}, \bar{\Delta}^{US}) = L(Y_t^{In}|\bar{\Delta}^{US}, \bar{\Delta}^{In})^{\lambda} L(Y_t^{US}|\bar{\Delta}^{US}) p(\bar{\Delta}^{US}) p(\bar{\Delta}^{In})$$

In order to capture the non-linearity in the data, the reduced form of the system of equations are solved using Bayesian techniques involving marginal particle filters.

Table 1 Priors and the Posterior distribution of the learning model. CPI data is considered for estimating Realized inflation for the period September 1958 to December 2021. SPF data are available from September 2007.

	Prior			**Posterior**		
Parmeters	Distr	Mean	Std	Mean	5 percent	95 percent
π^*	Normal	4	0.4	4.2	3.83	4.66
v	Gamma	0.022	0.006	0.022	0.0128	0.0295
g	Gamma	0.126	0.028	0.165	0.102	0.208
τ	Beta	0.906	0.041	0.92	0.85	0.96
ρ_s	Beta	0.879	0.028	0.91	0.87	0.96
γ_p	Beta	0.140	0.029	0.14	0.095	0.191
σ_s	IGamma	0.5	2	0.32	0.16	0.53
σ_μ	IGamma	0.5	2	0.81	0.44	1.2

The measurement errors are in the range of 0.83 standard deviations to 2.36 standard deviations. The model forecast of the 10-year expectations (figure 4) tracks the SPF estimates to a large extent. The model clearly shows the underline low frequency movements are being captured, despite giving extremely low weight to likelihood obtained on Indian data[3].

The gain function (figure 5) is constant, which implies the agents are deriving their expectations conditional on the recent short run forecast errors. As seen from the realized inflation and short run expectations (figure 3), it is evident that agents have been putting constant weight on the negative surprises post 2015, while deriving their long run expectations. Such phe-

[3] A subsequent version with λ=0.20 is under evaluation, the results shows much better fit, the gain function is constant like the earlier case, see figure 5

nomenon is generally associated with passive monetary policy, where agents are backward looking while forming their long run expectations. In terms of DSGE literature the backward looking solution for long-run expectation is one of the Minimum State Variable arising out of passive monetary policy Farmer, Waggoner & Zha (2008). The results are also in line with Bullard and Mitra(2003) where the author shows the expectation becomes purely forward-looking in an active monetary policy regime, where the central bank is able to maintain the current deviations within certain bounds.
The long run inflation expectation graph clearly shows upward deviations in forecasted expectations for the periods when realized inflation increased as compared to short run forecasts.Such revisions can be observed in recent second half of 2021.
The model parameter also suggests that as $\bar{\pi}_t$ drifts outside the interval $3.9\% < (\pi^* + \bar{\pi}_t) < 5.1\%$ for an elongated period of time, the agents switch to constant-gain regime while updating their expectations.

3. Empirical evidence on asset moments

3.1 Brief Overview

In this part of the paper, I estimate a state space model to estimate asset premiums associated with long-term consumption risk, as illustrated in Bansal and Yaron(2004). Further, to consider the consumption risk arising out of central bank monetary policy response as in Song(2017), the long-run consumption risk model is augmented with a Taylor rule having passive monetary policy coefficients. Pure consumption risk models like Bansal and Yaron (2004) capture consumption risk by tracking changes in the price of the real dividend claims and the price of the real consumption claims. By embedding a monetary policy, the assets inherit the nominal risks arising from the central bank's monetary stance. In India, the real dividend growth is negative, approximately -3 % and the real consumption growth is positive 1 % for the sample period 1996 to 2021. In such a scenario, the consumption claims are valued more than the dividend claims as the latter is not sufficient to hedge in the low consumption states.

The model also captures counter-cyclical inflation risk by incorporating regime-switching parameters in the covariance between shocks to inflation targets and shocks to consumption processes. [4] Generally, in a low-growth state, the bonds are risky as the real marginal utility with fixed streams of cash flows increases. Typically, agents dislike such states as large shocks to inflation come with low consumption growth, and the central bank does not respond aggressively. Such a setting is similar to the extreme version of the economy defined in (Wacther 2008 ; Chernov and Mueller 2012 ; Rudebusch and Swanson 2012). The a priori risk with counter-cyclical inflation is significant in Indian economy, as the unconditional probability of such scenario is 53%.

[4] The same is also verified from a Uhlig(2007) style Sign restricted VAR, a positive shock to gdp results in a negative impulse response for inflation, results are available on request

Preferences :: The representative agents has a recursive preference like in Bansal and Yaron(2004) and maximizes their lifetime utility

$$V_t = max(((1-\delta)C_t^{\frac{1-\gamma}{\theta}} + \delta(E_t(V_{t+1}^{1-\gamma}))^{\frac{1}{\theta}})^{\frac{\theta}{1-\gamma}}$$

subject to budget constraint $W_{t+1} = (W_t - C_t)R_{c,t+1}$
where W is the invested wealth and $R_c$is the return on the consumption stream/all invested wealth . $\gamma > 1$ is the risk aversion and ψ >1 is the inter temporal elasticity of the substitution. The log real stochastic discount factor is $m_{t+1} = \theta log\delta - \frac{\theta}{\psi}\delta c_{t+1} + (\theta - 1)r_{c,t+1}$ where $\theta = \frac{1-\gamma}{1-1/\psi}$.
Following Campbell and Shiller(1988) we have a log linearised version $r_{c,t+1} = k_0 + k_1 z_{t+1} - z_t + g_{t+1}$ where $r_{c,t+1} = log(R_{c,t+1})$ and $z_t = log(P_t/C_t)$ $k_1 = exp(\bar{z})/(1+exp(\bar{z}))$ $k_0 = log(1+exp(\bar{z})) - k_1\bar{z}$
Similarly for log market return $r_{m,t+1} = k_0 + k_1 z_{m,t+1} - z_t + g_{m,t+1}$ where $z_{m,t+1} = log(P_t/D_t)$
. $log(P_t/C_t)$ is the price to consumption of the universal asset where the total wealth W is invested. Such assets are generally unobservable and C_t , the consumption stream is assumed to be the dividend associated with such unobservable assets. g_{t+1} is the growth in consumption stream. Similarly, $log(P_t/D_t)$ is the log price to dividend of the observed aggregate market assets.

Consumption process and Inflation Target Rule:: As in Bansal and Yaron(2004) the consumption growth is decomposed δc_{t+1} into a (persistent) long - run growth component $x_{c,t}$ and a transitory component $\sigma_c \eta_{c,t+1}$. In addition to the consumption process,an autoregressive process for inflation target is introduced, as changes in inflation happens with permanent changes in inflation target Schorfheide (2005). An autoregressive process for the monetary policy shocks are also introduced in the model. The covariance between the real growth shock and the inflation target shock is captured by $\beta(S_t)\sigma_{xc}^2(S_t)$, where β is regime switching, not zero and the sign changes as per state.β is negative during countercyclical states and captures supply shock in the economy.

The dividend stream Δd_{t+1} has levered exposure ϕ to $x_{c,t}$. ϕ <1 is assumed for Indian market, as real dividend growth is negative. The state space representation for consumption growth and dividend process can be shown as $G_t = (\Delta c_t, \Delta d_t)'$

$G_{t+1} = \mu + \varphi X_t + \Sigma \epsilon_{t+1}$ Measurement Equation

$X_{t+1} = \Phi X_t + \Omega(S_t)\Sigma \epsilon_{x,t+1}$ Latent States

$\mu = (\mu_c, \mu_d), \epsilon_{t+1} = (\epsilon_{c,t+1}, \epsilon_{d,t+1})$

$$\varphi = \begin{bmatrix} 1 \; 0 \; 0 \\ \phi \; 0 \; 0 \end{bmatrix}, \Sigma = \begin{bmatrix} \sigma_c & 0 \\ 0 & \sigma_d \end{bmatrix}$$

$$\Phi = \begin{bmatrix} \rho_c & 0 & 0 \\ 0 & \rho_{pi} & 0 \\ 0 & 0 & \rho_i \end{bmatrix}, \Omega = \begin{bmatrix} 1 & 0 & 0 \\ \beta(S_t) & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}, \Sigma_x = \begin{bmatrix} \sigma_{xc} & 0 & 0 \\ 0 & \sigma_{x\pi}(S_t) & 0 \\ 0 & 0 & \sigma_{xi} \end{bmatrix}$$

Regime switching in conditional variances is only considered. The latent states are $X_t = (x_{c,t}, x_{\pi,t}, x_{i,t})$ $x_{i,t}$ is monetary policy shock and $x_{\pi,t}$ is the inflation target , both following auto regressive process.

Monetary Policy Rule The monetary policy rule follows a simple Taylor series rule and is contingent on the system of the latent variables. $i_t = \tau_0 + \tau_c x_{c,t} + \tau_\pi(\pi_t - \Gamma_0 - x_{\pi,t}) + x_{\pi,t} + x_{1,t}$.
From the asset-pricing equation, $i_t = -E_t(m_{t+1} - \pi_{t+1}) - \frac{1}{2}Var_t(m_{t+1} - \pi_{t+1})$ combining the asset pricing equation and the monetary policy rule, one gets the solution for $\pi_t = \Gamma_0 + \Gamma_1 X_t$ where Γ_0 and Γ_1 are the function of the model parameters. As inflation is contingent on the system of latent states, and not part of the latent system and is included in the measurement equation, one can avoid the issue of indeterminacy conveniently in this setup. The expected inflation can be obtained by solving forward in the following manner :: $E_t\pi_{t+T} = \Gamma_0 + \Gamma_1 E_t(X_{t+T})$.

Unlike developed market, the policy of the central bank in India is passive despite adoption of IT, no regime switching is considered in the policy response path.

Monetary neutrality and Expectation formations The real consumption growth process and the inflation process is arranged in the following manner.

$$\begin{bmatrix} \Delta c_{t+1} \\ \pi_{t+1} \end{bmatrix} = \begin{bmatrix} \mu_c \\ \Gamma_0(S_{t+1}) \end{bmatrix} +. \begin{bmatrix} e_1 \\ \Gamma_1 \Phi \end{bmatrix} + \begin{bmatrix} \sigma_c \eta_{c,t+1} \\ \Gamma_1 \Omega(S_{t1}) \Sigma_x(S_{t+1}) \eta_{x,t+1} \end{bmatrix}$$

where $e_1 = (1, 0, 0)$. In the setup, the monetary policy is assumed to be neutral. The assumption enables to capture inflation expectation in a reduced form without considering the structural aspects influencing changes in the correlation between inflation and consumption growth. The passive monetary is the absorbing state in our setting. The agents naively believe the regime is permanent and accordingly form their expectations.

Markov chain The model parameters evolve according to a two-state Markov chain, $S_t \in (1, 2)$

a). Countercyclical Macroeconomic shocks and Passive Monetary Policy (CP) : $\beta < 0$ and,$\tau_\pi < 1$

b) Procyclical Macroeconomic shocks and Passive Monetary Policy (PP) : $\beta > 0$ and,$\tau_\pi < 1$

The Markov transition probability matrix Π is 2 * 2 dimension matrix where each row sums to one.

Asset Prices:: The solution to log price-consumption is assumed of the form

$z_{c,t} = A_0(S_t) + A_1 X_t$

similarly, the solution to log price-dividend is assumed to be of the form

$z_{m,t} = A_{0,m}(S_t) + A_{1,m} X_t$

The log nominal pricing kernel is

$m^{\$}_{t+1} = m_{t+1} - \pi_{t+1}$

and the nominal n maturity log bond price satisfies

$p^{\$}_{n,t}(S_t) = .C^{\$}_{n,0}(S_t) + C^{\$}_{n,1} X_t$

The bond loading follows the recursion

$C^{\$}_{n,1} = C^{\$}_{n-1,1} - \Gamma_1 \Phi - \frac{1}{\psi} e_1$

$C^{\$}_{n,0}(S_{t+1}) = \Pi(S_t = k,)(C^{\$}_{n-1,0}(S_t) - \Gamma_0(S_t) + (\theta - 1)\kappa_1 A_0(S_t) +$

$\frac{1}{2}\Psi_{n-1,c}(S_t)\Psi_{n-1,c}(S_t)^{'}) + \Xi(S_t)$

where $\Xi(S_t) = \theta log\delta + (\theta - 1)(\kappa_0 - A_0(S_t) - \gamma\mu_c + \frac{1}{2}\gamma^2 e_1 \Sigma\Sigma^{'} e_1^{'}$

and $\Psi_{n-1,c}(S_t) = (C^{\$}_{n,1} + (\theta - 1)\kappa_1 A_1 - \Gamma_1)\Omega(S_t)\Sigma_x(S_t)$

Following boundary condition is assumed $\mathrm{C}_{0,1} = C_{0,0} = 0$

κ_0 and κ_1 are solved endogenously in the following manner::

Let $\bar{p}_j = \Sigma_{i\in 2}\bar{p}_i \Pi_{ij}$. Then for any asset

$\bar{z}_i = \Sigma_{j\in 1,2}\bar{p}_j A_{0,i}(j)$

$\kappa_{1,i} = \frac{exp(\bar{z}_i)}{1+exp(\bar{z}_i)}$

$\kappa_{0,i} = log1 + exp(\bar{z}_i) - \kappa_{1,i} z_i$ The solution is numerically determined until attaining convergence.

The term premium is obtained by averaging the expected one period future risk premium of declining maturity.

The one period future risk premium conditional on the regime is expressed approximately as $-\Pi(k,:) * \begin{bmatrix} \Lambda(k,1) \\ \Lambda(k,2) \end{bmatrix}$

where $\Lambda(k,j) = ((\theta-1)\kappa_1 A_1 - \tau_1)\Omega(j)\Sigma_x(j)\Sigma_x(j^{'}\Omega(j)^{'}C^{\$}_{1,n-1}$

3.3 Data and Parameters

Growth in real private final consumption expenditure[5] is estimated every quarter at rolling window frequency of twelve months time frame . consumption expenditure on non durable and services are not available on quarterly basis for India[6]. Inflation is computed as defined in section 2. Aggregate stock market data consist of twelve months rolling window returns , dividends and prices of the value weighted portfolio of stocks traded on BSE and NSE. Market related data are sourced from Prowess dx. Filtering techniques for the stocks are followed using the methodology defined in the data library for Fama French and Momentum Factors in India[7]. Growth rate of consumption and dividend are first difference of the log series. ZCYC yields with one year, two year ,five year and ten years maturity are estimated using the NSS parameters obtained from CCIL)[8] . The time series

[5] Per-capita data available only on annual basis

[6] We do a estimation where the percentage of non durable goods and service consumption every quarter is fixed to annual value in each calendar year. The results are similar. Average percentage consumption of Non durable goods and service is approximately 89% for the sample period considered

[7] https://faculty.iima.ac.in/ iffm/Indian-Fama-French-Momentum/

[8] Clearing Corporation of India Ltd (CCIL) disseminates Nelson - Seigel- Svensson(NSS) parameters on daily basis, available on their website Securities Segment - ZCYC (ccilin-

spans from 2005:Q3 to 2021:Q4 [9]. The sequence of observations is as follows
$Y_t = (\Delta c_t, \pi_t, pd_t, y_{1,t}, y_{2,t}, y_{5,t}, y_{10,t})$
$S_{1:T}$ be the sequence of the hidden states and the parameters are $\Delta =$
$(\Delta, \gamma, \psi, \mu_c, \mu_d, \rho_c, \rho_d, \sigma_{xc}, \sigma_{x\pi}, \sigma_{xi}, \sigma_c, \sigma_d, \beta(-), \beta(+), \tau_0, \tau_c, \tau_\pi)$
$TP = (\Pi_{i,j})_{i,j=1,2}$
The model is solved using Metropolis within Gibbs iteratively sampling from two conditional posterior distribution. $\sigma_{x\pi CP} > \sigma_{x\pi PP}$ is assumed for proper identification of the regimes.

3.4 Parameter Estimates and regime probabilities

The posterior estimates in Table 2 indicates a significant probability with counter-cyclical inflation risk in Indian market. The unconditional probability associated with counter-cyclical inflation is approximately 53 %. The macroeconomic moments and asset pricing moments in Table 3 match the observed moments to a large extent. The log price to dividend estimates clearly underlines the importance of negative real dividend growth. The market return estimates also indicates part of the non-linearity in the data is being captured through regime switching in conditional variances. Further,the observed correlation between consumption growth and inflation fails to reject the null hypothesis of zero correlation. The model prediction of negative correlation clearly signifies the counter cyclical risk in the economy. The same is verified through the plot of smoothed probability

dia.com) from Sept 2009 onwards. We are thankful to CCIL for providing us the NSS parameters from July 2005 to August 2009.

[9] We also estimate from 1996: Q3 to 2021:Q4.Yield data starts from 2005:Q3. The results are similar

Table 2 Priors and the Posterior distribution for parameters and transition probability. The preference parameters are fixed based on Schorfheide,Song and Yaron(2016), ratio of σ_c to σ_d , μ_c, μ_d fixed from the sample estimates.σ_c is 1% of the sampe estimate .

	Prior				Posterior		
Parameters	Distr	fixed	5 percent	95 percent	Median	5 percent	95 percent
δ		0.999		-	-	-	-
ψ	-	2	-	-	-	-	-
γ	-	8	-	-	-	-	-
μ_c	-	0.014	-	-	-	-	-
μ_d	-	-0.03	-	-	-	-	-
$\rho_{c,\pi,i}$	-	0.99	-	-	-	-	-
σ_c	-	0.0001	-	-	-	-	-
σ_d	-	8.34*σ_c	-	-	-	-	-
$\beta(+)$	U	-	0.5	9.5	1.05	0.05	2.24
$\beta(-)$	U	-	-0.5	-9.5	-2.5	-1.077	-3.61
τ_0	-	0.064	-	-	-	-	-
τ_π	U	-	0.05	0.95	0.845	0.75	0.95
τ_c	U	-	0.05	0.95	0.53	0.48	0.62
σ_{xc}	IG	-	0.001	0.10	0.024	0.01	0.043
$\sigma_{xpi}PP$	IG	-	0.001	0.10	0.020	0.013	0.036
$\sigma_{xpi}CP$	IG	-	0.001	0.10	0.047	0.010	0.083
$p11$	Beta	-	0.85	0.95	0.90	0.80	0.97
$p22$	Beta	-	0.85	0.95	0.91	0.80	0.97

associated with counter cyclical states (figure 6). Both the smoothed probability and inflation expectation plots clearly identifies heightened inflationary risk in recent times.

Table 3 Macro data moments and asset pricing moments

	Data			Model		
Variable	Mean	Std Dev	AC 1 lag	Mean	Std Dev	AC 1 lag
$Ln(P/D_t)$	4.94	0.23	0.7	4.82	0.177	0.47
π_t	0.0686	0.0267	0.784	0.064	0.011	0.683
Δc_t	0.0162	0.12	0.47	0.0163	0.12	. 0.47
$corr(\delta c_t, \pi_t)$	0.07*	0	0	-0.28	0	0
$y_{1,t}$	6.56	1.44	0.869	7.03	1.02	0.830
$y_{2,t}$	6.8	1.21	0.846	7.11	1.007	0.823
$y_{5,t}$	7.26	0.88	0.788	7.23	1.02	0.783
$y_{10,t}$	7.63	0.72	0.6686	7.44	1.06	0.730
r_m	13.6%	0	0	11.6%	0	0
$Termpremium$	198bps	0	0	180bps	0	0

4. conclusion

The paper identifies the potential factors behind the persistent premium in Indian government bond market.In the first section of the analysis, the stability of inflation expectations are verified, especially post IT.The stability of the inflation expectation determines the systemic risk with the inflation uncertainty. For the purpose we use recursive learning methodology of Carvalho, Eusepi, Moench & Preston (2021).The analysis clearly shows the inflation expectations are driven by backward forecast errors/deviations even in the post-IT regime. The expectations are highly sensitive to transient forecast errors, and such sensitivity is arising out of long history of passive monetary policy in India. In the subsequent section,the economic channel behind the persistence in the term premium is explored. For the purpose we use long run consumption risk model of Bansal and Yaron(2004) augmented with Taylor rule as in Song(2017).The

Taylor path incorporates the passive monetary policy prevalent in India. The analysis clearly shows significant risk associated with counter-cyclical inflation. Further, the persistence is also driven by aggregate negative real dividend growth in the economy.As real returns of a aggregate portfolio are not sufficient to hedge against low growth states, an extra premium will be commanded in anticipation of such states in both equities and bonds.Both aggregate equities and bonds are risky in anticipation of the aggregate consumption risk associated with such low states. In short three channels are identified towards such persistence in the premium component, a)Long history of passive monetary policy b)High risk of encountering countercyclical inflation c)Presence of an aggregate asset market with aggregate negative real dividend growth.

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6. Figures

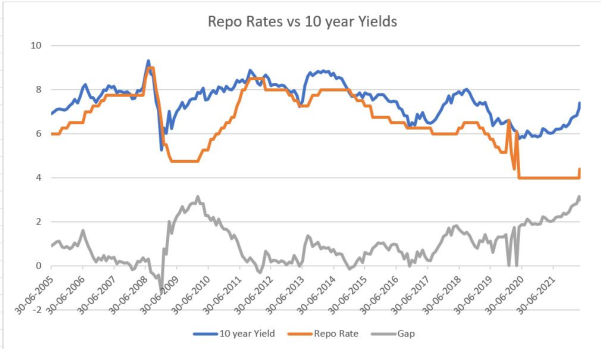

Fig. 1. Repo-rate,10 Year Yields and Gap/credit spread between 10 years and Repo-rate

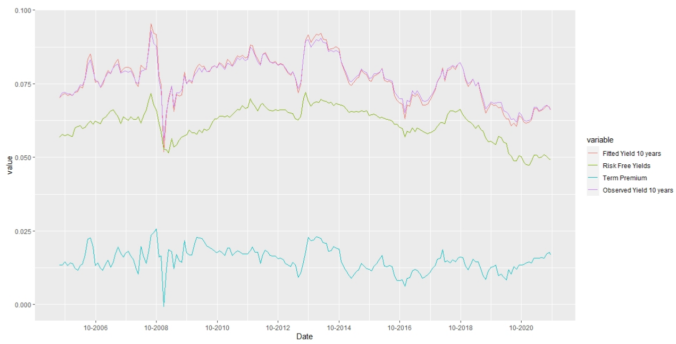

Fig. 2. Observed 10 Year ZCYC Yields, Expected Nominal Rates and Term/Risk Premium for the period July 2005 to December 2021 at monthly frequency.The expected nominal rates and term premium are estimated using ACM(2015) methodology.

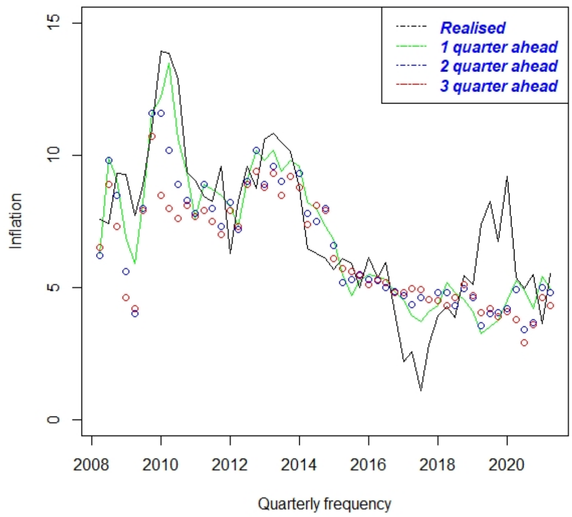

Fig. 3. Realized inflation,Short run inflation expectations from Survey of Professional forecasters.Observations are shown in quarterly frequency from September 2007 to December 2021

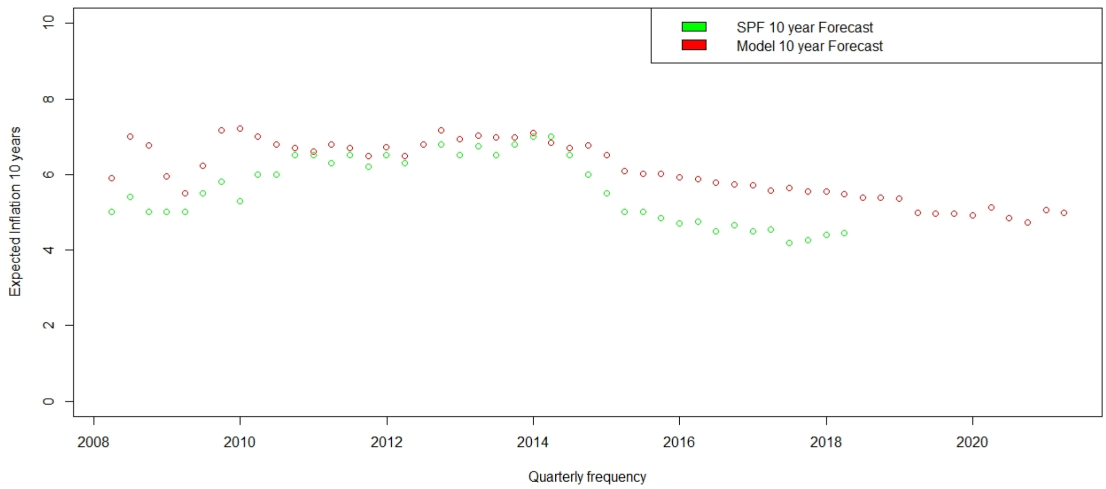

Fig. 4. SPF forecast and model forecast of 10 year Inflation expectations. SPF forecasts of 10 year inflation expectations are available until June 2018. Model forecast done up to December 2021. The likelihood is scaled by the parameter λ =0.02. The parameters other than inflation target and standard deviations are restricted to US estimates.The parameter π^* is set to the central bank target of 4%

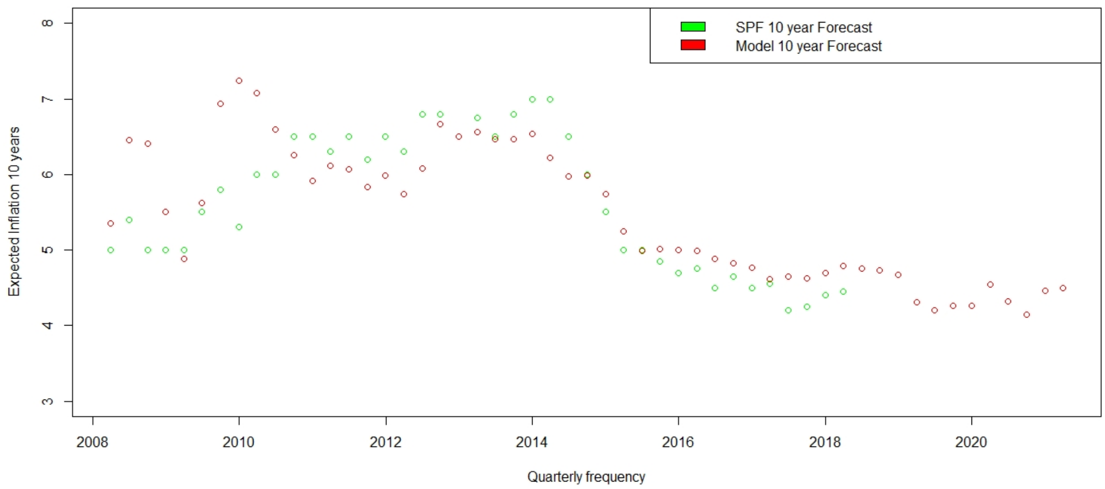

Fig. 5. SPF forecast and model forecast of 10 year Inflation expectations. SPF forecasts of 10 year inflation expectations are available until June 2018. Model forecast done up to December 2021. The likelihood is scaled by the parameter λ =0.2. The parameters other than inflation target and standard deviations are restricted to US estimates.The parameter π^* is set to the central bank target of 4%. The gain function is constant like the earlier case

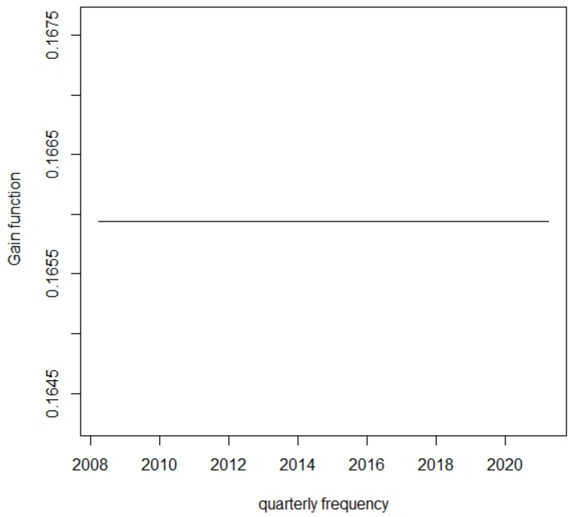

Fig. 6. The Gain function

Fig. 7. Recession bars and smoothed probability of counter cyclical inflation. The shaded areas represents the periods of recession. The observations are in quarterly frequency from July 2005 to December 2021