Lower for Longer Monetary Policy and Economic Outcomes during COVID-19 Pandemic*

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Abstract

The Reserve Bank of India kept the monetary policy rate persistently low and unrevised between May 2020 and April 2022 to encourage economic activity in battling the COVID-19 pandemic shock. In this paper, I argue that this stance by the central bank, in contrast to the conventional flexible inflation targeting, is beneficial for the economy, especially in the recovery periods. I find that economic activity through increased capital demand and output by heterogeneous firms led to a slightly higher share of formal employment, hence a reduced share of informal labor. The differences in the magnitude of responses under the lower for longer stance versus the flexible inflation targeting are highest among firms with less volatile beliefs. Households, on the other hand, react quite similarly. Among heterogeneous households, households with formal employment are least impacted by the pandemic shocks and they respond first to the lower rate.

Keywords: Monetary policy; Heterogeneous firms; Informal labor; Sticky wage; Unemployment; COVID-19

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1 Introduction

The Reserve Bank of India (RBI) has undertaken a flexible inflation targeting to keep the headline consumer price inflation within a band of $4\% \pm 2\%$ since 2016. In the wake of the COVID-19 pandemic, the RBI relaxed its stance and kept the interest rate persistently low and unrevised for eight consecutive quarters between May 2020 and April 2022 (figure 1), while tolerating a moderate consumer price inflation (figure 2).

Figure 1: Monetary Policy

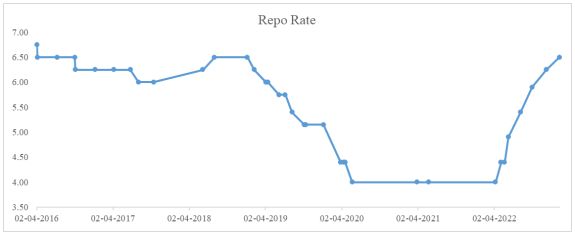
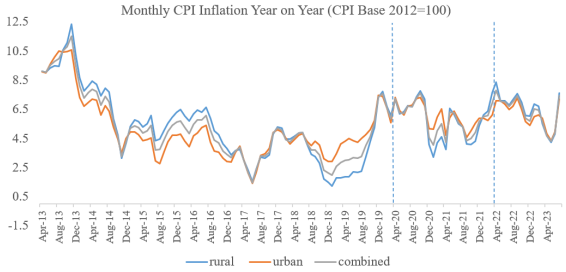


Figure 2: Year on Year CPI Inflation



Data source: Repo rate and CPI are obtained from the Reserve Bank of India's Database of Indian Economy. Inflation numbers are calculated year on year. The two vertical lines in the inflation figure indicate the period when the repo rate was kept unchanged.

In this paper, I evaluate the impact of this change in the monetary policy stance in view of the special scenario induced by the pandemic shocks on a handful of crucial economic indicators like the labor and capital demand, and output produced by firms, employment in formal-informal statuses, and consumer demands by households. Then I compare the magnitude of these effects with those under the conventional flexible inflation targeting as a counterfactual to examine if keeping the policy rate low for longer during recoveries is more stimulating for the economy.

To effectively answer these questions, there are a few complexities introduced to an otherwise standard heterogeneous agent New Keynesian model. The pandemic like scenario is created using a combination of demand shock on the utility from consumption, which in essence captures the reduction in utility due to the chances of getting infected, and a shock on the labor supply that imitates movement restrictions. On the firms' side, these are reflected in the lack of demand for their produce and the lack of factors of production. In addition, the firms feature heterogeneous beliefs about the interest rate, they form expectations about the policy rate using Bayesian update: some firms

believe interest rates may change abruptly, modeled with high prior variance and noisy signals and the rest believe interest rates will remain low for longer, modeled with low prior variance and precise signals. The proportion of these two types of firms varies over the recovery period. The rest of the model consists of traditional features like asset and productivity heterogeneity among households; while asset is contentious in state space, productivity takes high and low constantly calibrated values for formal and informal labor supply. Nominal wages are sticky due to a labor union, which leads to involuntary unemployment at equilibrium.

In order to calibrate model parameters, numerous sources of data have been used in this study. The transition rate matrix that features the movements among different statuses: formal employment, informal employment, unemployment, and non-participants, is created using extensive calculations of shares of these individuals in different periods in the Periodic Labor Force Survey and other government information. A rough estimate of the employment benefits received by the formal employees is obtained using data from the Ministry of Labour & Employment by the Government of India (GOI). The National Portal of India, by the GOI, provides a detailed estimate of government transfers for individuals of different employment statuses. This data is used to calibrate transfers. A rough estimate of the proportion of heterogeneous beliefs firms is obtained using RBI data on the survey of professional forecasters and the index of industrial production over the years. Household asset information is obtained from the All Indian Debt & Investment Surveys, and tax rates are calculated from the Ministry of Finance reports on income tax collections.

The findings suggest a clear advantage of keeping the monetary policy persistently low over the recovery period. A higher capital demand and an increased level of output stimulate the economy by higher employment and higher real wages, which translates into higher consumption demand. The magnitude of changes induced by LfL, in contrast to FIT is drastic in capital demand and output. The differences are highest around quarters 3 and 4. The difference in consumption demand and employment is far less distinguishable between these alternative policy rules. Therefore, the evidence suggests that the benefit of keeping the interest persistently low for longer during economic recoveries, instead of the conventional stance, is most enjoyed by the producers, and households remain largely indifferent between these alternative policies.

This paper makes three major contributions. For the very first time, it simulates the pandemic economy with realistic assumptions and evaluates how RBI's modified monetary policy stance in an emergency situation has impacted the economy. Second, it introduces behavioral complications in firms' decision making, especially after an unprecedented economy wide shock, and provided that a policy authority controls the interest rate with a feedback rule. Third, it compares the economic impact with that under the conventional policy stance of the RBI.

The remainder of this paper is organized as follows: Section 2 briefly presents the relevant literature, Section 3 lays down the model framework, Section 4 explains parameter calibrations and results, and concluding remarks are provided in Section 5.

2 Overview of Literature

A substantial body of research has examined the transmission of monetary policy in both advanced and emerging economies, highlighting the diverse channels through which policy rates influence real activity. Studies consistently document that interest rate changes affect credit conditions, investment decisions, household consumption, and asset prices, though the strength and timing of these pass-through mechanisms vary across institutional contexts and financial structures.

India-specific evidence provides a rich understanding of these dynamics. Contributions by Gabriel et al. (2016), Ghate et al. (2018), Dubey and Lohani (2022), Das and Mallick (2023), Lakdawala and Sengupta (2024) and others demonstrate that the adoption of inflation targeting has strengthened the monetary transmission mechanism, particularly through lending rates, credit flows, and exchange rate adjustments. These works also emphasize that the effects are uneven across sectors: transmission is notably weaker in agriculture and rural segments, while industrial and services sectors respond more strongly. The literature further highlights heterogeneous employment outcomes, suggesting that monetary policy shapes labor market dynamics in complex and sector dependent ways.

Parallel to this, a related empirical strand explores the relationship between output and employment, commonly framed through the lens of Okun's law following Okun (1973). While evidence from advanced economies—such as Conraria et al. (2020),

Mavrodi et al. (2023), and Alves and Violante (2024)—finds a robust and stable association between output fluctuations and changes in unemployment, the same is not true for many emerging and developing economies. Studies from Indonesia (Putri, 2024), China (Yin and Zhou, 2010), Latin America (Pizzo, 2019), and low-income countries (An et al., 2016) consistently report a weak or even absent link, underscoring structural and institutional differences that dampen the employment response to output movements.

3 Model

In this section, I lay out a simplistic general equilibrium model with wage rigidities. There are five agents in the economy: households, firms, a government, a monetary policy authority, and a union that sets the nominal wage. Households are heterogeneous in asset and labor market status. Competitive final goods producers aggregate a continuum of differentiated intermediate goods produced by monopolistically competitive firms to produce the final consumer good. The government operates through proportional income tax and lump sum transfer. Monetary policy authority sets the short-term nominal interest rate following alternative strategies.

3.1 Households

The economy is populated by a continuum of households (or individuals) of measure 1. Time t is continuous; at any instant of time individuals can be in one of four mutually exclusive labor market states s_t: employed in the formal sector, earning labor income, and receiving social security benefits ($s_t = F$), or employed in the informal sector, earning labor income only, no social security benefits ($s_t = I$), or unemployed and searching for a job ($s_t = U$), or non-participant, who are unable to accept any job offer, for various reasons, e.g., they are sick, or heavily involved in household care or outside the labor force ($s_t = N$). Households receive a flow of utility from consumption $c_t^i \geq 0$ and a flow of dis-utility from supplying labor $l_{i,t} \in [0, 1]$, i.e., total time endowment is normalized to 1. $l_{i,t}$ is the hours of work out of total time endowment. Households maximize expected lifetime utility at time 0 subject to the equation of motion,

$$\mathbb{E}_0 \int_0^\infty e^{-\rho t} \left[\frac{(c_{st}^i \xi_t)^{1-\sigma}}{1-\sigma} - \frac{(l_{st}^i A_{st})^{1+\psi}}{1+\psi} \right] dt \tag{1}$$

ρ is discount rate for future, $1/\sigma$ is intertemporal elasticity of substitution, $\sigma \geq 0$ and $1/\psi$ is Frisch elasticity of labor supply, $\psi \geq 0$. Households can save and borrow assets g_{st} at real interest rate r_{gt}, which can be invested in productive capital at a real return r_{kt} with a depreciation rate δ. Households can borrow assets up to an exogenous limit g. The evolution of household assets takes the form,

$$\dot{g}^i_{st} = (1-\tau)\, w^i_{st}\, A_{st}\, l^i_{st} + r_t\, g^i_{st} + T + b_s - \kappa_s - c^i_{st} \tag{2}$$

where $\dot{g}_{st}$ is the changes in the household asset holding over time, i.e., $\dot{g}_{st} = \frac{\partial g_{st}}{\partial t}$, τ is the rate of proportional tax on labor income of formal labor imposed by the government, w_{st} is real wage rate for labor type s, T is a lump-sum direct transfer from the government to the informal, unemployed and non-participant households, b_s is the employment benefits received by the formal labor, κ_s is the cost of job search, and c_{st} is real consumption expenditure. All the variables are expressed in real terms, where the numeraire is the final good in the economy.

To capture the COVID situation, I introduce two shocks: a negative shock on consumption demand and a negative supply shock on both types of labor. The demand shock can be interpreted as reduced consumption due to fear of infection, particularly for consumption of contact-intensive goods and services (e.g., dining out, travel). Lower consumption demand also stems from lower incomes and increased precautionary savings during uncertain times. The supply shock can be interpreted as movement restrictions, health risks, or quarantine measures that reduce labor supply, especially in contact-intensive sectors (e.g., hospitality, retail). This is modeled in this study as a negative shock to labor productivity or hours worked. Both shocks follow AR(1) processes.

Following Guerrieri et al. (2022)[1] the demand shock is modeled as a negative preference shock to utility. High MPC households (e.g., low-income or liquidity-constrained) reduce consumption more due to income losses, while wealthy households save more. The shock is specified as;

$$\log(\xi_t) = \rho_\xi \log(\xi_{t-1}) + \epsilon_{\xi,t}, \quad \epsilon_{\xi,t} \sim N(0, \sigma^2_\xi), \tag{3}$$

[1]They develop a theory of Keynesian supply shocks, where a supply shock in one sector (e.g., contact-intensive services) reduces output, leading to a demand shortage in other sectors. This is modeled as a sector-specific demand reduction due to income losses and incomplete markets. The shock indirectly affects consumption demand by reducing household income, resembling a negative preference shock to utility in affected sectors, as households cut spending on non-essential or contact-intensive goods (e.g., restaurants, tourism).

where ξ_t is a demand shock affecting consumption utility, ρ_ξ is the persistence parameter, and $\epsilon_{\xi,t}$ is a shock to consumption demand, reflecting reduced spending due to lock downs or fear of infection. In normal times $\xi_t = 1$, $A_{st} = 1$.

Following Silva and Duarte (2021)[2] the labor supply shock is modeled here as;

$$\log(A_{st}) = \rho_A \log(A_{st-1}) + \epsilon^s_{A,t}, \quad \epsilon^s_{A,t} \sim N(0, \sigma^2_{A,s}), \tag{4}$$

where $s \in \{F, I\}$ denotes the different magnitudes of shocks to formal and informal labor productivity, note, this is not the overall TFP of the firms, this is the productivity of each type of labor. A^s_t is productivity for labor type s, ρ_A is persistence parameter and $\epsilon^s_{A,t}$ is shock to productivity, with $\sigma^2_{A,c} > \sigma^2_{A,e}$ to reflect larger disruptions in the informal labor supply due to higher movement restrictions in contact-intensive sector where large proportion of informal labor are employed.

3.2 Firms

Final goods producers: Competitive final good producers aggregate a continuum of intermediate outputs from monopolistically competitive intermediate goods producers indexed by $j \in [0, 1]$. The aggregate output is a Dixit-Stiglitz index of the output from intermediate firms,

$$Y_t = \int_0^1 \left(y_{jt}^{\frac{\epsilon-1}{\epsilon}} \right)^{\frac{\epsilon}{\epsilon-1}} dj \tag{5}$$

where $\epsilon > 0$ is the elasticity between intermediate goods, cost minimization implies demand for intermediate good j is,

$$y_{jt} = \left(\frac{p_{jt}}{P_t} \right)^{-\epsilon} Y_t \tag{6}$$

where the price of the final good is an index of the prices of the intermediate goods,

$$P_t = \left[\int_0^1 (p_{jt})^{1-\epsilon} \, dj \right]^{\frac{1}{1-\epsilon}} \tag{7}$$

Intermediate goods producers: Intermediate goods producer j produces output y_{jt} of differentiated good j by hiring labor with formal and informal contracts as well as by hiring capital k_{jt}.

$$y_{jt} = A_t \left(A_{Ft} \, l^j_{Ft} \right)^\alpha \left(A_{It} \, l^j_{It} \right)^\gamma (k_{jt})^{1-\alpha-\gamma} \tag{8}$$

[2]They model a labor supply shock hitting non-essential sectors, reducing output and demand for non-essential goods in Portugal and the Euro Area.

α is the share of formal labor and γ is the share of informal labor.

One important addition to the baseline structure of the firm sector is heterogeneity in beliefs about future interest rates that affect their decisions on capital demand, output, and employment. Firms form expectations about the interest rate r_t using Bayesian updating. Firms are divided into two groups: Type 1 believes interest rates may change abruptly, modeled with high prior variance or noisy signals. Type 2 believes interest rates will remain low for longer, modeled with low prior variance or precise signals. Each firm $i \in \{1, 2\}$ updates its beliefs based on a private signal and a prior belief. Each firm i has a prior belief about the interest rate r_t, assumed to follow a normal distribution:

$$r_t \sim N(\mu_{i,t}, \sigma^2_{i,r}), \tag{9}$$

where $\mu_{i,t}$ is the prior mean and $\sigma^2_{i,r}$ is the prior variance, capturing uncertainty about r_t. To introduce heterogeneity, it is assumed that Type 1 is featured with high prior variance ($\sigma^2_{i,r} = \sigma^2_{\text{high}}$), reflecting belief in volatile rates and Type 2 with low prior variance ($\sigma^2_{i,r} = \sigma^2_{\text{low}}$), reflecting belief in persistently low rates.

Each firm i observes a private signal about the true interest rate r_t:

$$s_{i,t} = r_t + \eta_{i,t}, \quad \eta_{i,t} \sim N(0, \sigma^2_{i,\eta}), \tag{10}$$

where $s_{i,t}$ is firm i's signal at time t and $\eta_{i,t}$: Idiosyncratic noise, normally distributed with variance $\sigma^2_{i,\eta}$. Again, to incorporate heterogeneity it is assumed that Type 1 receives high signal noise ($\sigma^2_{i,\eta} = \sigma^2_{\eta,\text{high}}$), leading to volatile posterior beliefs and Type 2 receives a low signal noise ($\sigma^2_{i,\eta} = \sigma^2_{\eta,\text{low}}$), leading to stable posterior beliefs.

Using Bayes' rule, firm i computes the posterior belief about r_t given the signal $s_{i,t}$. The posterior expectation of r_t is a weighted average of the prior mean and the signal:

$$\mathbb{E}_i[r_t|s_{i,t}] = \frac{\sigma^2_{i,\eta}\mu_{i,t} + \sigma^2_{i,r}s_{i,t}}{\sigma^2_{i,r} + \sigma^2_{i,\eta}} \tag{11}$$

which can be rewritten as

$$\mathbb{E}_i[r_t|s_{i,t}] = (1 - \kappa^*_i)\mu_{i,t} + \kappa^*_i s_{i,t}, \tag{12}$$

where the weight on the signal is

$$\kappa^*_i = \frac{\sigma^2_{i,r}}{\sigma^2_{i,r} + \sigma^2_{i,\eta}}. \tag{13}$$

Due to heterogeneity, Type 1 features high $\sigma^2_{i,r}$ or high $\sigma^2_{i,\eta}$ implies κ^*_i is large, so beliefs are sensitive to signals, reflecting volatility and Type 2 features low $\sigma^2_{i,r}$ or low $\sigma^2_{i,\eta}$ implies κ^*_i is small, so beliefs are anchored to $\mu_{i,t} \approx r_{\text{low}}$. The posterior variance of r_t is

$$\text{Var}_i(r_t|s_{i,t}) = \frac{\sigma^2_{i,r}\sigma^2_{i,\eta}}{\sigma^2_{i,r} + \sigma^2_{i,\eta}}. \tag{14}$$

Due to heterogeneity Type 1 features high $\sigma^2_{i,r}$ or $\sigma^2_{i,\eta}$ results in higher posterior variance, indicating persistent uncertainty and Type 2 features low $\sigma^2_{i,r}$ or $\sigma^2_{i,\eta}$ results in lower posterior variance, indicating confidence in stable rates.

Therefore, the economy consists of a continuum of firms $i \in [0, 1]$, with a fraction ϕ in Type 1 and $1 - \phi$ in Type 2. The distribution of beliefs is:

$$\mathbb{E}_i[r_t|s_{i,t}] \sim \begin{cases} N\left(\mathbb{E}_i[r_t|s_{i,t}], \frac{\sigma^2_{\text{high}}\sigma^2_{\eta,\text{high}}}{\sigma^2_{\text{high}}+\sigma^2_{\eta,\text{high}}}\right) & \text{for Type 1,} \\ N\left(\mathbb{E}_i[r_t|s_{i,t}], \frac{\sigma^2_{\text{low}}\sigma^2_{\eta,\text{low}}}{\sigma^2_{\text{low}}+\sigma^2_{\eta,\text{low}}}\right) & \text{for Type 2.} \end{cases} \tag{15}$$

This dispersion in $\mathbb{E}_i[r_t|s_{i,t}]$ drives heterogeneous pricing, investment, and hiring decisions, affecting aggregate outcomes like output and inflation. Last but not least, the proportion of type 1 firms in the economy, denoted by $\phi \in [0.20, 0.80]$, varies over time, leading to an added dynamics in the aggregate capital demand, output, and employment.

3.3 Wage Setting

I adopt the wage-setting mechanism by Erceg et al. (2000) that is commonly used in the standard New Keynesian sticky wage models to a heterogeneous-agent economy. Union sets firm-specific (therefore goods-specific) nominal wages. At time t, the union sets the nominal wage in order to maximize the welfare of its current members (all individuals employed at time t) subject to a Rotemberg-style quadratic costs of adjusting the nominal wage, in utility terms, with scaling parameter θ. This cost is expressed in terms of deviations of nominal wage growth from the central bank's inflation target, the deterministic steady-state inflation rate π^*. It is assumed that the contractual hours worked required by the union from all workers must satisfy firm's demand for effective labor. The union maximizes

$$\int_0^\infty e^{-\rho t}\left[\int u^F_t(c^F_t, l^F_{jt})d\mu_t - \frac{\theta}{2}\left(\frac{\dot{W}^F_{jt}}{W^F_{jt}} - \pi^*_t\right)^2\right]dt \tag{16}$$

subject to

$$\dot{g}_{Ft} + c_{Ft} = (1-\tau)\, w_{Ft}\, l_{Ft} + r_t\, g_{Ft} + T + b_{Ft} \tag{17}$$

where W is the nominal wage.

Lemma 1: The solution to this optimization problem provides the New Keynesian wage Phillips curve (*proof* in Appendix 6.2) for formal labor,

$$\rho(\pi_w^F - \pi_t^*) = \dot{\pi}_w^F + \frac{W_t^F}{\theta}(1-\tau)\int (c_t^F)^{1-\sigma} l_{jt}^F d\mu_t - \frac{\psi}{\theta}\frac{(1-\alpha)^2}{\alpha}\frac{y_{jt}}{A_t}\int (l_{jt}^F)^{\psi-\alpha} d\mu_t\ . \tag{18}$$

Symmetrically, I obtain the wage Philips curve for informal employment. Since the utility and the budget constraints for formal and informal employees differ, the nominal wage contract also differs, even within the same firm.

3.4 Monetary Authority

The monetary authority sets the nominal interest rate according to a flexible inflation targeting (FIT) rule that reacts to deviations of inflation and unemployment rate from their targets with some inertia. If I let m denote the shadow policy instrument not subject to the ZLB, then the FIT rule is defined as,

$$\frac{dm}{dt} = -\beta_i\left(i_t - i^* - \beta_\pi(\pi_t - \pi^*) - \beta_u(u_t - u^*)\right) \tag{19}$$

$$i_t = max\{0, m_t\}$$

where i^* denotes the steady-state nominal interest rate, and u^* is the steady-state unemployment rate. On the other hand, the low for longer rule takes the form

$$\frac{dm}{dt} = -\beta_i\left(i_t - i^* - \beta_{\pi 1}(\pi_t^A - \pi^*)^- - \beta_{u1}(u_t - u^*)^+\right) \tag{20}$$

$$i_t = max\{0, m_t\}$$

where π_t^A is the average past inflation, x^+ is the shorthand for $max\{x, 0\}$, and x^- is the shorthand for $min\{x, 0\}$. Intuitively, they mean policy adjustments take into account the minimum of $\{(\pi_t^A - \pi^*), 0\}$ and the maximum of $\{(u_t - u^*), 0\}$.

3.5 Fiscal Authority

$$\dot{G}_t + T = \sum_{i=F,I}\left[\tau\, A_{st}\int w_{i,t}\, l_{i,t}(g_{st}, s_t)\, d\mu_t + r_t\int g_{st}^i\, d\mu_t\right] \tag{21}$$

where $\dot{G}_t$ is government debt. Outside of steady state, the fiscal instrument that adjusts to balance the budget can be either T to τ. There is no optimization by govt. it simply uses one of its instruments to balance the budget. Also, a balanced budget does not mean no deficit.

3.6 Equilibrium

Given the stochastic process of productivity shocks, the equilibrium of the economy is characterized by a sequence of consumption, hours worked, asset holding, and the prices of goods, wage rates, return on asset, return on capital, and measure μ_t such that households and firms objective functions are satisfied, the decisions satisfy aggregate consistency condition, govt budget balances and all markets clear.
The asset market clears when,

$$\sum_s \int g_{st}\, d\mu_t = \int k_t^j\, dj \tag{22}$$

The final goods market clears when the aggregate demand for final goods matches the aggregate supply

$$Y_t = C_t\ . \tag{23}$$

There is involuntary unemployment at the steady state; however, formal and informal labor demand is met while the union sets wages[3].

4 Taking the Model to Data

4.1 Calibration

I calibrate most of the parameters using data on the Indian economy; the empirical strategies are discussed below. I obtain a few parameters from studies specific to the Indian economy and from the standard literature in this area. Parameter values, their descriptions, and sources are in the table 1. The detailed estimations of these parameters are reported in the Appendix 6.1. For the calibration of the shock parameters in utility and labor supply, parameters in Bayesian updates and ϕ, please refer to Appendix 6.1.

[3]Union maximizes the welfare of existing employees while setting the nominal wage, at the set wage, it is guaranteed that firms meet their factor demand, however, there are always excess supply of labor that do not get absorbed. And wages not adjusting immediately (being sticky), this involuntary employment persists.

Table 1: Parameter Values, Description and Sources

Parameter	Value	Description	Source
Households			
ρ	0.98	Discount factor	Standard
σ	1.99	Inverse of IES	Standard
ψ	3	Inverse of Frisch elasticity of labor supply	Standard
b_F	0.31	Benefits	Calculated by Author
g	-0.08	Borrowing limit	Calculated by Author
κ	0.0527	Cost of job search	Alves and Violante (2024)
Government			
τ	0.11	Rate of tax on labor income	Calculated by Author
T	0.25, 0.31, 0.413	Lump-sum transfer during pandemic	Calculated by Author
Firms			
δ	0.069	Rate of depreciation of capital	Standard
ϵ	10	Elasticity of substitution between goods	Standard
α	0.33	Share of formal labor in production	Calculated by Author
γ	0.33	Share of informal labor in production	Calculated by Author
θ	100	Cost of adjustment parameter	Standard
Monetary Policy			
β_i	0.07	Taylor rule coefficient	Alves and Violante (2024)
$\beta_\pi, \beta_{\pi 1}$	2.25, 5	Inflation adjustment coefficient	Alves and Violante (2024)
β_u, β_{u1}	-0.15	Unemployment adjustment coefficient	Alves and Violante (2024)

4.2 Findings

This section presents the main results from the calibrated model and evaluates its ability to replicate key features of the households in India. I begin by comparing the model generated aggregates with official data to establish the baseline credibility of the framework. This mode –data reconciliation is essential, as it ensures that subsequent counterfactual exercises and policy experiments are grounded in a realistic representation of household consumption, savings behavior, and financial portfolio choices.

Table 2 compares key aggregate moments from the model with their empirical counterparts, focusing on household consumption and financial asset holdings. The model aggregates reflect the combined behavior of formal, informal, unemployed, and non-participant households, allowing the simulated economy to capture the full distribution

of balance sheet heterogeneity. All variables are expressed relative to GDP to ensure comparability across data sources and time. Overall, the model closely reproduces the empirical magnitudes of consumption and financial assets, aligning well with estimates from the National Accounts Statistics and Quarterly GDP Press Notes (MoSPI, 2020–2022) as well as the Handbook of Statistics on the Indian Economy (RBI, 2023). This correspondence provides confidence that the calibrated model captures the salient macroeconomic features of household behavior. **Notes:** Model aggregates combine formal,

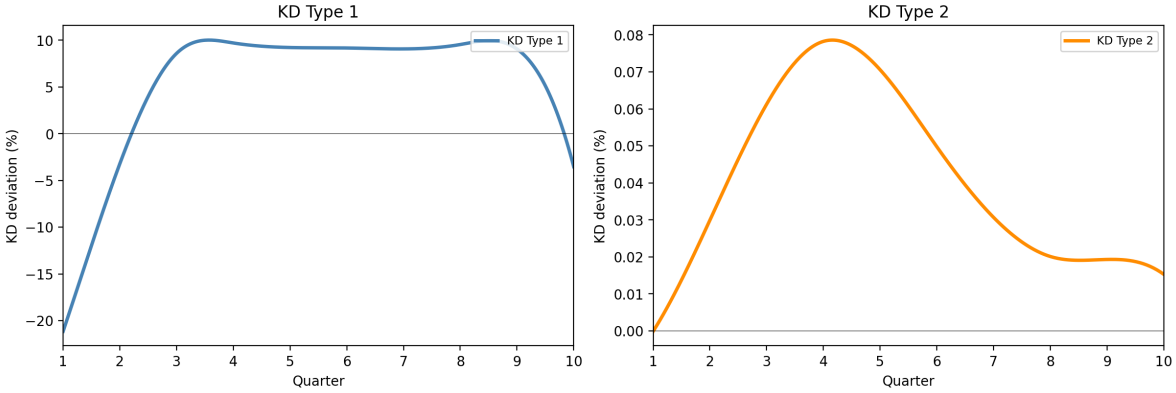
Table 2: Model and data comparison of household consumption and financial assets

	Mean	10th pctl	25th pctl	50th pctl	75th pctl	90th pctl
Household Consumption Expenditure (% of GDP)						
Model	56.2	39.8	45.6	52.1	58.4	60.7
Data[a]	55.0	45.0	49.0	55.0	60.0	66.0
Household Financial Assets (% of GDP)						
Model	15.1	9.2	11.6	14.8	18.9	20.5
Data[b]	16.0	10.0	12.5	15.5	19.0	22.0

informal, unemployed and nonparticipant households. All values expressed as ratios to GDP.
[a] Source: MoSPI, *National Accounts Statistics* and *Quarterly GDP Press Notes* (2020 - 2022).
[b] Source: RBI, *Handbook of Statistics on the Indian Economy*,(2023).

With the model reproducing the key consumption and asset distribution moments, let us look at its implications for firms' investment behavior. In particular, the heterogeneous beliefs structure embedded in the production sector becomes central for understanding how firms adjust capital demand when the policy rate remains low for an extended period. The persistently low interest rate during the pandemic leads to an increase in capital demand by firms. The initial dip occures from the pandemic shocks and uncertainties. The heterogeneity among firms in their beliefs about the expected path of the interest rate induces heterogeneity in their capital demand as well. Figure 3 shows that type 1 firms with volatile beliefs respond by increasing their capital demand over the first three quarters, and then keep the demand constant till quarter 9. When the interest rate is revised at a higher rate, they quickly respond with a lower capital demand. Type 2 firms with more stable beliefs, on the other hand, keep their capital demand stable and mostly unchanged. The proportion of these two types of firms $(0 < \phi < 1)$ in the economy varies over time, and the aggregate demand for capital is a ϕ weighted average of the demands.

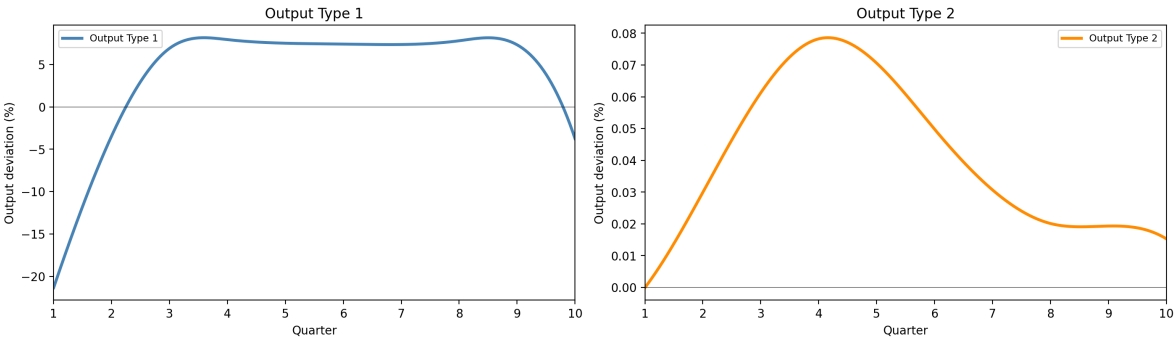
Figure 3: Capital Demand by the Two Types of Firms under the Low for Longer Policy Stance



Note: Vertical axis presents the percentage deviation from the steady state values. Type 1 firms are designed with more volatile beliefs and Type 2 firms are designed with more stable beliefs.

Higher capital demand translates into higher output for both types of firms, though the magnitude and persistence of these responses differ according to their belief structures. As shown in Figure 9, Type 1 firms with more volatile expectations exhibit a sharper increase in output, mirroring their immediate rise in capital demand. In contrast, Type 2 firms maintain a slower increase in output, consistent with their more stable belief formation. These heterogeneous output dynamics highlight how differences in expectation updating can amplify or dampen the real effects of an extended low interest rate environment. The sharp decline in first few quarters captures the initial response to the unprecedented economic wide lockdown.

Figure 4: Output from the Two Types of Firms under the Low for Longer Policy Stance



Note: Vertical axis presents the percentage deviation from the steady state values.

While the drastic initial decline in capital demand and output seems reasonable from the

pandemic features included in the model, it is important to examine if the data shows the same. Table 3 summarizes the quarterly evolution of Gross Domestic Product (GDP) and Gross Fixed Capital Formation (GFCF) during the pandemic, providing empirical grounding for the model's capital and output dynamics. Year on year growth in GDP and GFCF exhibit sharp dips in the early quarters of 2020–21, reflecting the abrupt contraction during the nationwide lockdown followed by a rapid rebound as restrictions eased. This is well reflected in the model generated values of the variables, and the magnitudes of responses over different quarters match closely.

Table 3: Quarterly Changes in Key Macroeconomic Indicators during the Pandemic

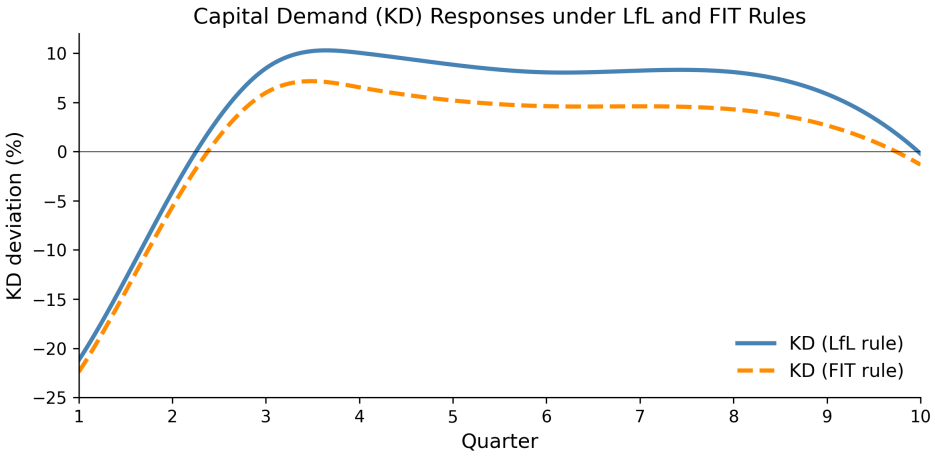
Quarter	**GDP**	**GFCF**
	(YoY, %)	(YoY, %)
Apr-Jun 2020	−23.9	−24.5
Jul-Sep 2020	−7.3	−8.0
Oct-Dec 2020	0.5	1.0
Jan-Mar 2021	1.6	3.0
Apr-Jun 2021	5.6	7.0
Jul-Sep 2021	8.4	10.0
Oct-Dec 2021	5.4	8.5
Jan-Mar 2022	4.7	9.0
Apr-Jun 2022	6.3	8.5
Jul-Sep 2022	6.4	9.0

Notes: Data obtained from MoSPI (Quarterly GDP & Expenditure Releases, 2020–2022) and RBI (Flow of Funds).

Figure 5 compares aggregate capital demand under the Lower for Longer (LfL) policy stance with that under a standard Flexible Inflation Targeting (FIT) framework. The contrast illustrates how prolonged policy rate accommodation amplifies firms' investment incentives at the aggregate level. Under LfL, capital demand rises sharply and remains elevated for several periods, reflecting both the lower borrowing cost and the heterogeneous, belief driven responses of firms documented earlier. In contrast, under FIT where interest rates adjust more quickly in response to inflation dynamics the increase in capital demand is lower. These patterns highlight the significance of extended monetary accommodation, by shaping expectations and reducing financing constraints, the LfL stance delivers a stronger and more persistent surge in aggregate investment relative to a conventional policy framework.

Figure 11 depicts that both types of firms replace informal labor with formal labor as long

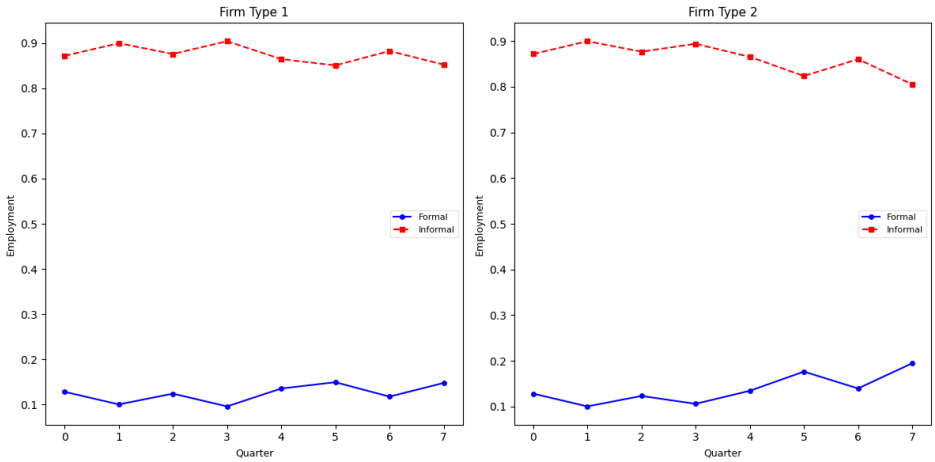
Figure 5: Aggregate Capital Demand under the Lower for Longer and Flexible Inflation Targeting



Note: Values are aggregate for the economy. Vertical axis presents the percentage deviation from the steady state values.

as the interest remains unrevised at a low level. The increase in formalization, although it seems small, given the size of the informal labor market, in absolute terms, is a sizable impact. For instance, if in the $2022-23$ quarter 1, around 56.3 crore (563 million) individuals were employed, an increase in the share of formal labor from 0.22 to 0.28 would mean an additional 28.15 million individuals getting formalized. The formal-informal share in different quarters roughly matches the survey data.

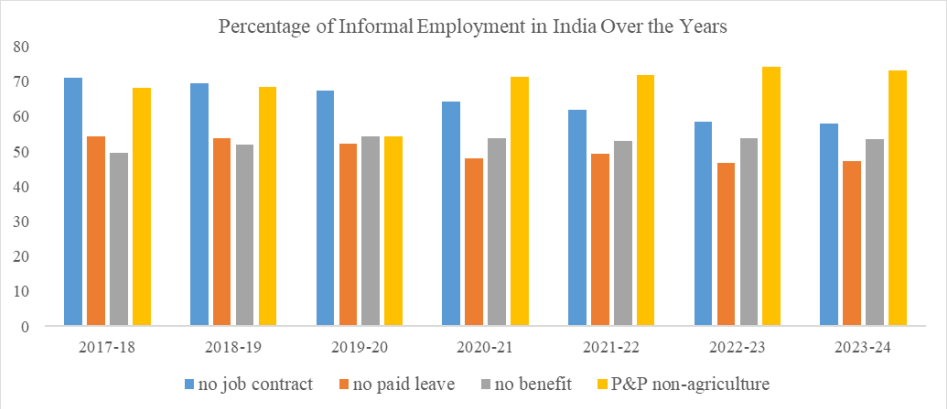
Figure 6: Proportion of Formal and Informal Employment under Low for Longer Stance



Note: Vertical axis presents the proportion of formal and informal employment in total employment for Type 1 and Type 2 firms.

The average share of formal employment for different quarters for pre-pandemic years 2017-18 to 2019-20 in total employment was 11.08%, 12.31%, and 12.36%, respectively. These are calculated from the Economic Survey Report $2021-22$ published by the government of India. These numbers did not change drastically in the peak of pandemic years $2020-21$ and $2021-22$. A calculation based on reports of the Periodic Labor Force Survey and other fragmented government reports suggests the average share of formal employment during this quarter was around 10.87 and 10.23, respectively. Figure 7 provides a further decomposition into different components of informal employment over the pre-pandemic and pandemic years using data from the PLFS surveys. It emphasizes the fact that all the components within informal employment have remained broadly unchanged.

Figure 7: % of Employed Individuals Reporting Different Indicators of Informal Employment in Recent Years



Note: Data source: PLFS. No job contract: percentage of regular wage/salaried employees who had no written job contract, no paid leave: percentage of regular wage/salaried employees not eligible for paid leave, no benefit: percentage of regular wage/salaried employees not eligible for any specified social security benefit, P&P non-agriculture: percentage of workers engaged in proprietary and partnership (P & P) enterprises among workers engaged in non-agriculture sector.

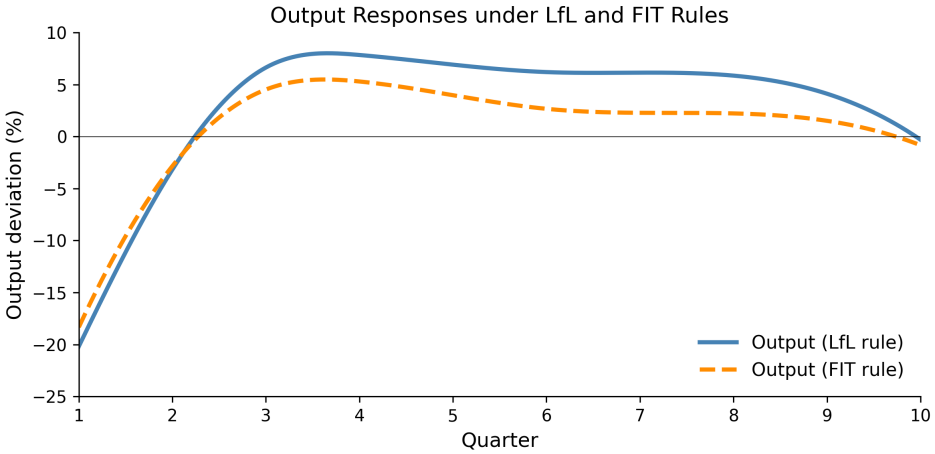
To further look at the changes in the share of different statuses 7 plots the model generated shares over different quarters. It shows that the slight decrease in non-participant and informal share has been compensated by the slight increase in the share of formal employment.

Note: Values are aggregate for the economy. Vertical axis presents the percentage deviation from the steady state values. The output under LfL closely follows the path of capital demand. And so does output under the FIT rule (figure 9).

Figure 8: Proportion of Households in Different Status of Employment Over Different Quarters

Note: All numbers are aggregate over the two types of firms.

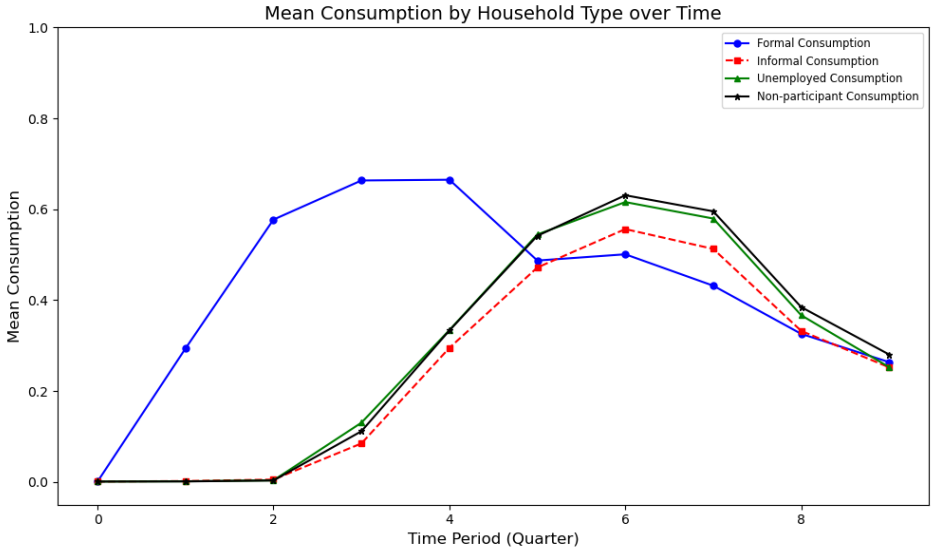
Figure 9: Aggregate Output Responses under the Lower for Longer and Flexible Inflation Targeting



The consumption responses of households in different statuses, with steady state normalized to 0, are depicted in Figure 10. Households do not react immediately to the lowering of the interest rate, as the initial negative shock to consumption demand due to the heightened probability of getting infected remains prevalent. Formal households, due to a higher safety cushion (e.g., medical and life insurance, other added benefits), start showing heightened consumption demand from the second period onwards. However, the rest of the households react to lower rates only after four quarters. This again highlights the fact that formally employed households are generally the ones who have the ability and resources to navigate a crisis situation with the least effect, therefore reiterating the need for more formalization in the economy. Demand falls sharply for all households when the interest rate is revised upwards.

Beyond the timing, the relative magnitudes across groups are also informative. The peak responses of formal households are noticeably larger than those of informal, unemployed, and non-participant households, suggesting that the marginal propensity to consume out of interest rate driven income and wealth effects is higher for those with more secure and predictable earnings. In contrast, more vulnerable households remain cautious even when rates are low, reflecting liquidity constraints and precautionary motives that dampen their reaction. Thus, the same accommodative monetary policy generates an uneven boost to consumption across the employment distribution, amplifying the advantage of formal workers during the recovery phase.

Figure 10: Consumption Responses of Households in Different Employments Status under the Low for Longer Stance



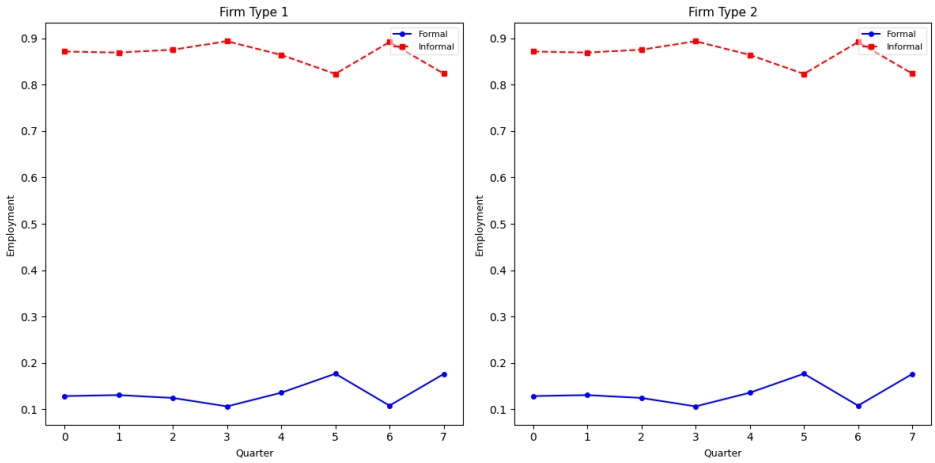
Note: Numbers on vertical axis are the average consumption responses of households.

Figure 11 depicts that the formal and informal shares under FIT react similarly to those under LfL, however, the magnitudes differ. LfL leads to higher formalization than FIT for most of the quarters. This indicates that a prolonged period of low interest rates not only supports aggregate activity but also gradually changes the composition of employment in favour of formal jobs. Under FIT, by contrast, the faster normalization of the policy rate limits the extent of reallocation towards formal employment, even though the qualitative direction of change is the same.

The evolution of employment shares also helps to interpret the distributional implications of the two policy regimes. Since formal jobs are typically associated with better social protection, higher wages, and more stable working conditions, the stronger rise in the formal share

under LfL implies that this policy disproportionately benefits workers who manage to transition into or remain within the formal sector. Informal workers, on the other hand, experience more modest gains, reinforcing the idea that institutional and structural constraints in the labour market shape how monetary policy translates into employment outcomes.

Figure 11: Proportion of Formal and Informal Employment under Flexible Inflation Targeting



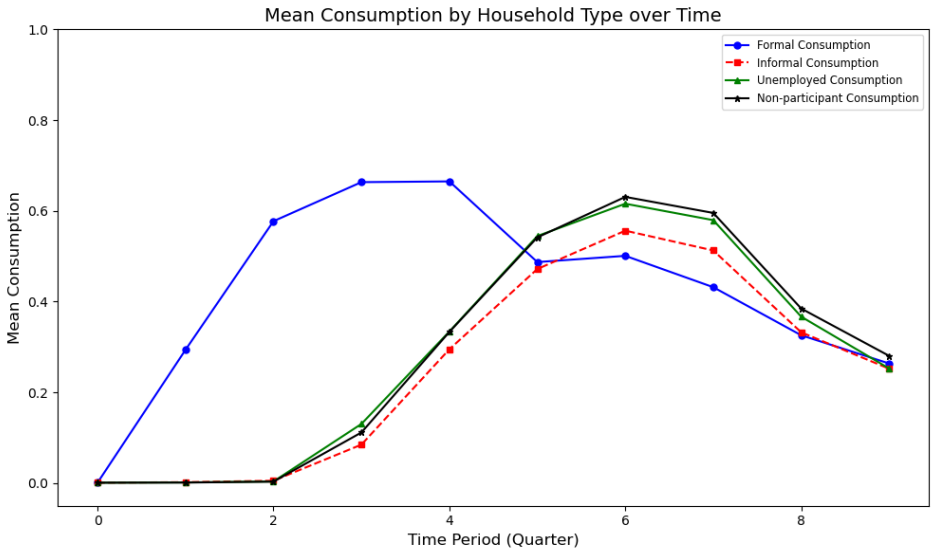
Note: Vertical axis presents the proportion of formal and informal employment in total employment for Type 1 and Type 2 firms.

Figure 12 also illustrates similar consumption responses of households. The magnitudes of consumption increase, again, are lower than those under LfL. Under FIT, households benefit from the initial easing, but the relatively quicker reversal of the policy rate limits the duration and strength of the consumption boost. Formal households still respond more than others, but the difference between groups is narrower compared to the LfL scenario, as the window of very low rates is shorter.

Taken together, the comparison of Figures 10 and 12 suggests that the choice of policy regime matters more for the intensity and persistence of consumption responses than for their qualitative pattern. In both cases, formal households lead the recovery in demand, but only under LfL is the response strong and long lived enough to generate substantial aggregate effects. This underscores the idea that the duration of monetary accommodation is a key determinant of how much additional spending is ultimately unlocked from different segments of the household distribution.

To derive a concrete understanding of the magnitude difference for some of the crucial variables, let us look at Table 4. Δs are the difference in magnitude of responses in the respective variables under the LfL and FIT rule, where $\Delta x = x_{LfL} - x_{FIT}$. Higher differences

Figure 12: Consumption Responses of Households in Different Employments Status under the Flexible Inflation Targeting



Note: Numbers on vertical axis are the average consumption responses of households.

Table 4: Comparison of Responses under Lower for Longer and Flexible Inflation Targeting

Quarter	Δr	ΔKD	ΔY	ΔC	ΔL
Q1	-0.0075	1.2121	0.1622	0.0000	0.0000
Q2	-0.0107	1.5065	0.1783	0.0000	0.0003
Q3	-0.0100	2.4611	1.1764	0.0025	0.0004
Q4	-0.0093	3.4013	2.1737	0.0028	0.0006
Q5	-0.0087	3.3281	2.1702	0.0019	0.0005
Q6	-0.0081	3.2422	3.1660	0.0014	0.0001
Q7	-0.0076	3.1446	3.1612	0.0004	0.0000
Q8	-0.0070	3.0362	3.1557	0.0004	0.0000
Q9	-0.0066	2.9178	2.1497	0.0003	0.0000
Q10	-0.0021	1.8166	1.0923	0.0000	0.0000

Note: Column 1: Δr is the difference in interest rates between LfL and FIT. Column 2: ΔKD is capital demand difference: LfL minus FIT. Similarly column 3: ΔY is output difference, column 4: ΔC is consumption difference, and column 5: ΔL is total formal + informal employment difference: LfL minus FIT.

in responses for capital demand and output than on aggregate employment and consumption indicate that while keeping the interest lower for longer is beneficial for all sections in the economy, it is most encouraging to the firms; households, on the other hand, are mostly indifferent between FIT and LfL.

More precisely, the table shows that the gap in capital demand and output responses is both quantitatively large and persistent, confirming that the investment channel is the primary margin through which LfL outperforms FIT. By contrast, the differences in total employment and aggregate consumption are relatively modest, suggesting that the additional stimulus from LfL does not translate one for one into stronger labour market or household spending outcomes. This pattern is consistent with the model's heterogeneous-agent structure: firms with more optimistic or stable beliefs take greater advantage of the prolonged low rates to expand their capital stock, while many households, especially those outside the formal sector, remain constrained or cautious. In policy terms, the results imply that LfL can be an effective tool to boost production capacity and formal employment, but complementary measures such as social insurance, credit access, and labour market reforms are likely needed to ensure that the gains from such a policy are more evenly transmitted to household welfare.

5 Conclusion

Keeping interest rates low for longer was one of the prominent strategies by the central bank to encourage economic activity during the recovery from the COVID-19 pandemic. With the help of a heterogeneous agent New Keynesian model tailored to Indian economy I investigate if this policy stance by the central bank was beneficial for the economy, how different sections of the economy responded to persistently lower interest rates, and what is the magnitude of differences in responses under this low for longer rule in contrast to the flexible inflation targeting.

I observe that the firms increase their capital demand and output in response to lowered rates. Firms with stable beliefs respond the most. Formal employment shares increase slightly. Households react by increasing consumption demand. However, households other than the formally employed take around five quarters to react. Comparing the magnitude difference in alternative policy rules shows that a lower for longer rule is mostly advantageous for the firms, while households remain mostly indifferent.

One of the major limitations of this study is how the pandemic has been captured in the model. Due to the computational complexities, the number of shocks that could be introduced

is limited, and the nature of the shocks is simplistic. This leaves it open to experimentation in extended works. Additionally, calibration of parameters need more attention, data availability is the challenge.

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6 Online Appendix

6.1 Calibration Details:

In this section, I discuss the calibration strategies, data sources, and other details about the model parameters.

6.1.1 Benefits for formal employment

Data on social security schemes: the mandatory provident fund, a pension scheme, and disability and life insurance. Taking only the contribution of the employer and the government, the total benefit roughly amounts to 30.66%, i.e., $12\% + 1.16\% + (70/4)\%$.

6.1.2 Transition Rates

Data on the changing shares of formal-informal employment, unemployment, and non-participants over different years are used to obtain the transition rates among these statuses over different quarters.

Informal Employment: The PLFS report mentions, according to the 15th International Conference of Labour Statisticians (ICLS) conceptual framework, unincorporated enterprises owned by households (i.e., proprietary and partnership enterprises, including the informal producers' cooperatives) are largely considered as informal sector enterprises. In PLFS, proprietary and partnership enterprises are considered as informal sector enterprises. In this survey, from the employees (regular wage/salaried persons and casual labour) in usual status, information on the following conditions of employment was collected:

- whether there was any written job contract in the employment,
- whether employees were eligible for the paid leave
- whether employees were covered under any specified social security benefits.

These numbers are also presented in the reports. I make a rough estimate of the percentage of informal workers out of total employment if an individual is working in proprietary and partnership enterprises or does not possess any of the above three criteria. There are also several reports by the government that provide the informal employment numbers right away.

The average share of formal employment for different quarters for pre-pandemic years 2017-18 to 2019-20 in total employment was 11.08%, 12.31%, and 12.36%, respectively. These are calculated from the Economic Survey Report $2021-22$ published by the government of

India. These numbers did not change drastically in the peak of pandemic years $2020-21$ and $2021-22$. A calculation based on reports of the Periodic Labor Force Survey and other fragmented government reports suggests the average share of formal employment during this quarter was around 10.87 and 10.23, respectively. Although the pre-pandemic years' numbers are useful for comparison, the transition matrix is only calculated for the pandemic years.

6.1.3 Household Assets

The National Sample Survey Office (NSSO), under the Ministry of Statistics and Programme Implementation, Government of India, conducts national-level surveys on various socioeconomic variables for households in India. I use their latest All India Debt & Investment Survey (AIDS) conducted between Jan-Dec 2019 to obtain the data on the borrowing limit of the households. This survey reports the financial assets of households which include all household deposits in financial institutions (checking, saving, call, and money market accounts), government bonds, and corporate bonds net of revolving consumer credit, etc., and all household debts.

According to this data source, 84.4% of the rural population and 85.2% of the urban population aged 18 years and above have some financial assets in banks, and 35% households in rural India and 22.4% households in urban India hold some kind of financial debt, indicating decent access to financial markets in both rural and urban areas. On average, the amount of debt in rural households is Rs. $59,748$, and it is Rs. $1,20,336$ in urban households. The net (asset minus debt) household assets as a proportion of per capita GDP varies roughly between -2.98 and 3.26. Ignoring the extreme values beyond 10^{th} and 90^{th} percentile, net asset holding varies between -0.32 and 0.60. I calibrate the quarterly borrowing limit at -0.08, corresponding to the yearly borrowing limit of -0.32. I only target the mean while deriving the steady state distribution of net assets. Comparing the steady state moments with moments from survey data concludes that my model produces realistic values of this distribution.

6.1.4 Transfers

A rough estimate of the proportion of heterogeneous beliefs firms is obtained using RBI data on the survey of professional forecasters and the index of industrial production over the years. Household asset information is obtained from the All Indian Debt & Investment Surveys, and tax rates are calculated from the Ministry of Finance reports on income tax collections.

press release reports data on government direct benefit transfers to the households, and The National Portal of India, by the GOI, provides a detailed estimate of government transfers for individuals of different employment statuses. This data is used to calibrate transfers. The quarterly average of total direct benefit transfers from the state government and the central government to households divided by the number of beneficiaries in the COVID-19 pandemic years in proportion to average per-capita GDP in these years is obtained to be 0.25, 0.31 and 0.413 on average, for informally employed, unemployed and non-participants respectively.

6.1.5 Tax

The income tax rates vary widely depending on income slabs, age, and occupation. Therefore, I use the average income tax collection as a percentage of total taxable income for the last three years. The data is obtained from the RBI bulletin on the Union budget 2020-21 and 2022-23. The three-year average income tax rate is around 11% leading to a quarterly rate of 2.75%.

6.1.6 Mean Reversion Rate of the Monetary Policy Shock

I calibrate the mean reversion rate of the monetary policy shock η using historical data on the weighted average call money rate (WACR). WACR is a short-term interest rate that is used as the operating target by the Central Bank of India (RBI). An operating target is an anchor that is kept as close as possible to the target policy rate (the repo rate) so as to minimize any internal lag within the monetary policy framework by controlling liquidity in the overnight interbank call money market. I obtain quarterly data on WACR from April 1991 to December 2023 that is available in the *Handbook of Statistics on Indian Economy* published by the RBI. I de-seasonalize the log WACR and test for the presence of unit roots. Then I fit an ARIMA model with appropriate AR and MA specifications along with the order of integration as 1. The quarterly mean revision rate is obtained as 0.45, leading to $\eta = 0.64$. I introduce a one-time expansionary shock to the monetary policy of 50 basis points, i.e., $\zeta_0 = -0.5\%$ points, and the shock dies at the rate $e^{-\eta t}$.

Note that this mean reversion rate only applies to the FIT rule; for the low for the longer rule, the mean reversion is close to zero.

6.1.7 Shock parameters in labor supply

Income losses persisted for 6-12 months. $\rho_A = 0.85 - 0.9$, reflecting gradual recovery post-2020. Volatility (σ_A): Informal workers and unemployed faced severe income shocks (50–80%

income loss in Q1 2020). Formal workers experienced milder shocks (around 10–20% income reduction). The standard deviation of labor income shocks during COVID-19 was estimated at around 0.1–0.15 for informal workers by the RBI Annual Report 2020-21.

To reflect heterogeneity: Formal (F): Lower volatility (0.03) due to job security. Informal (I): Higher volatility (0.12) due to income losses. Unemployed (U): High volatility (0.10) due to job search disruptions. Non-participants (N): Moderate volatility (0.05) due to indirect effects (e.g., reduced remittances).

6.1.8 Shock parameters in utility

Persistence (ρ_ξ): Consumption shocks were less persistent than labor shocks, as government transfers (e.g., Rs. 500 per month to PM Jan Dhan accounts) and pent-up demand aided recovery by mid-2021. However, high MPC households (informal, unemployed) faced prolonged constraints. $\rho_\xi = 0.75$–0.8.

Volatility (σ_ξ): Consumption fell sharply in 2020 (9.1% aggregate, 20–30% for informal households per NSSO). High MPC households faced larger shocks due to income losses and limited savings. Standard deviation of consumption shocks: 0.05–0.1 for informal/unemployed, 0.02 for formal workers. Formal (F): Low volatility (0.02) due to stable incomes. Informal (I): High volatility (0.08) due to income and credit constraints. Unemployed (U): High volatility (0.07) due to no income. Non-participants (N): Moderate volatility (0.04) due to reliance on transfers/remittances.

6.1.9 Bayesian update

Signal noise reflects uncertainty in observing true TFP, driven by market volatility, data quality, and economic shocks. During COVID-19, Indian firms faced high uncertainty due to lockdowns, supply chain issues, and policy changes. RBI's Industrial Outlook Survey (2020) reported increased forecast dispersion (0.2–0.3 standard deviation). Post-COVID, noise declined but remained higher for informal firms due to limited data access. Studies (e.g., Rawat and Sharma (2021)) estimate TFP growth at 0.4–0.6 for Indian firms between 1999-2018.

Data Limitations: Firm-level TFP beliefs are not directly surveyed in India. Calibration relies on aggregate TFP estimates and RBI forecast dispersion, which may not capture micro-level heterogeneity. The calibrated parameters are therefore, $\sigma 2_signal = 0.12, firm1_\mu = 1.15, firm1_{\sigma^2} = 0.05, firm2_\mu = 0.95, firm2_{\sigma^2} = 0.18$.

6.1.10 Others

For the rest of the parameters, I stay as close as possible to the parameterizations that are well-accepted in the New Keynesian literature.

6.2 Derivation of Wage Phillips Curve:

The derivation of the wage Phillips curve for formal labor in a heterogeneous-agent economy, adapting Erceg et al. (2000). The union sets firm-specific nominal wages W_{jt}^F and W_{jt}^I to maximize:

$$\int_0^\infty e^{-\rho t}\left[\int\left(\frac{(c_t^F)^{1-\sigma}}{1-\sigma}-\psi(l_{jt}^F)^{\psi-\alpha}\right)d\mu_t-\frac{\theta}{2}(\pi_w^F-\pi_t^*)^2\right]dt$$

subject to:

$$\dot{g}_t^F+c_t^F=(1-\tau)w_t^F l_t^F+r_t g_t^F+T+b_t^F,\quad l_{jt}^F=\left(\frac{\alpha A_t}{w_t^F}\right)^{\frac{1}{1-\alpha}}$$

Hamiltonian:

$$\mathcal{H}=\int\left(\frac{(c_t^F)^{1-\sigma}}{1-\sigma}-\psi(l_{jt}^F)^{\psi-\alpha}\right)d\mu_t-\frac{\theta}{2}(\pi_w^F-\pi_t^*)^2+\lambda_t\pi_w^F W_{jt}^F$$

First-Order Conditions Control:

$$-\theta(\pi_w^F-\pi_t^*)+\lambda_t W_{jt}^F=0\implies\lambda_t=\theta\frac{\pi_w^F-\pi_t^*}{W_{jt}^F}$$

State:

$$\dot{\lambda}_t=\rho\lambda_t-\int\left((c_t^F)^{-\sigma}\frac{\partial c_t^F}{\partial w_t^F}-\psi(\psi-\alpha)(l_{jt}^F)^{\psi-\alpha-1}\frac{\partial l_{jt}^F}{\partial w_t^F}\right)\frac{1}{P_t}d\mu_t$$

where:

$$\frac{\partial c_t^F}{\partial w_t^F}\approx(1-\tau)l_{jt}^F\frac{\alpha}{1-\alpha},\quad\frac{\partial l_{jt}^F}{\partial w_t^F}=-\frac{l_{jt}^F}{(1-\alpha)w_t^F}$$

Co-State Dynamics

$$\dot{\lambda}_t=\theta\frac{\dot{\pi}_w^F-(\pi_w^F-\pi_t^*)\pi_w^F}{W_{jt}^F}$$

Substitute and simplify:

$$\dot{\pi}_w^F=\rho(\pi_w^F-\pi_t^*)-\frac{w_t^F}{\theta}\int\left((c_t^F)^{-\sigma}(1-\tau)l_{jt}^F\frac{\alpha}{1-\alpha}+\frac{\psi(\psi-\alpha)(l_{jt}^F)^{\psi-\alpha}}{(1-\alpha)w_t^F}\right)d\mu_t$$

Final Form: Rearrange, adjust exponents, and use

$$y_{jt}/A_t=(l_{jt}^F)^\alpha$$

and obtain the New Keynesian Wage Phillips curve.