Financial Market Imperfections, Informality and Government Spending Multipliers

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Abstract

Developing countries are characterized by underdeveloped financial markets and a large share of informal sector in economic activity. Evidence suggests that countries with less developed financial sector have lower government spending multipliers. This paper quantifies government spending multipliers in India using an estimated new-Keynesian DSGE model with two types of entrepreneurs: formal and informal and imperfect financial market. In the model, informal entrepreneurs are financially-excluded and the banking sector is monopolistically competitive featuring collateral constraint and sticky interest rates. Results show that the government consumption multiplier is significantly less than one at all horizons. The government investment multiplier is also significantly less than one at shorter horizons, but becomes approximately one at longer horizons.

Keywords: Government Investment; Government Consumption; Financial Market Imperfections; Government Spending Multipliers; Informal Sector; Financially-Excluded Entrepreneurs

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1 Introduction

There is a large empirical literature which has tried to quantify government spending multipliers for various countries. This literature finds that government spending multipliers in developing countries are in general smaller than in developed countries (IMF 2008, Illzetzki et. al. 2013, Hory 2016). Stijn and Tims (2014) and Hory (2016) also find that countries with less developed financial sector have lower government spending multipliers. These later findings suggest that imperfections in financial sector may be important in shaping the fiscal transmission mechanism.

Most developing countries are characterized by two important and interrelated features: a large share of informal sector in economic activity and a limited development of financial markets. In a typical developing country, informal sector employs 70% of labor force and accounts for 1/3rd of GDP (Loayza 2016, World Bank 2022). This sector mainly consists of lower-skilled and lower-paid workers, with less access to finance and social safety nets, small farmers and firms mainly engaged in production of non-traded goods and services using labor-intensive technologies (La Porta and Shleifer 2014, ILO 2018, World Bank 2022). It largely operates outside the purview of government rules and regulations. Most of the informal firms have limited access to capital markets and have to rely on internal funds to meet their expenditure (Farazi 2014, La Porta and Shleifer 2014).

Financial markets in developing countries are also characterized by limited competition in the banking sector and collateral requirements due to the problem of contract enforcement and asymmetric information. Evidence from the World Enterprise Surveys of World Bank suggests that the collateral requirement acts as a major barrier for firms to raise resources in developing countries (Dabla-Norris *et. al.* 2015, Fan *et. al.* 2020). Additionally, in many developing countries domestic banking sector is subject to financial repression which creates captive domestic market for government debt and imposes significant implicit tax on financial sector (Giovanini and de Melo 1993, Reinhart and Sbrancia 2015).

The main goal of this paper is to analyze and quantify government consumption and investment multipliers in the context of a developing country characterized by a large informal sector and less developed financial markets. For my analysis, I develop and estimate a new-Keynesian DSGE model with two-sectors: formal and informal featuring a rich set of financial frictions commonly prevalent in developing countries.

In the model, there are two types of entrepreneurs: formal and informal. Formal entrepreneurs produce formal goods and hire workers in formal labor markets. Informal entrepreneurs produce informal goods and hire workers in informal labor markets. Consistent with the evidence, only formal entrepreneurs have access to the banking sector. The banking sector is monopolistically competitive with sticky interest rates and is subject to collateral constraint *'a la* Kiyotaki and Moore (1997). Borrowing by formal entrepreneurs cannot exceed a given fraction of the value of their physical capital. Formal goods and labor markets are monopolistically competitive and are subject to nominal rigidities (Calvo pricing). Informal goods and labor markets are competitive. The government capital is productive and may have differential effect on the productivity of formal and informal sectors. Government finances its expenditure through distortionary taxes and borrowing.

I first analyze and estimate a model (Benchmark model henceforth) in which all (worker) households have access to banking sector (Ricardian) and they supply labor to both formal and informal sectors. Then, I analyze a model with heterogeniety among households in which a fraction of households are financially-excluded (non-Ricardian). As discussed below, estimation results show that data prefers the Benchmark model over models with a large share of non-Ricardian households. I also analyze models with financial-repression and competitive banking to understand the role of financial-repression and imperfect competition in banking in explaining business cycle dynamics and their effects on government spending multipliers.

Models are estimated using annual data for India for the period 1970-2016.[1] India is chosen for a variety of reasons. Apart for being a major emerging market, the informal sector in India is large employing 86% of the workforce and contributing 50% of GDP (NCEUS 2007a, GOI 2012). The banking sector is characterized by limited coverage, accessibility and use of formal banking sector (Demigruc-Kunt and Klapper 2013, RBI 2014, Badrinza et. al. 2017). Vast majority of informal enterprises do not have access to banking sector (NCEUS 2007b). Data from the World Bank shows that around 85% of loans to private sector by banks is collaterized in India.[2]

[1]The quarterly GDP data and its components are available from 1996:1 onwards for India. However, this data reports total investment and does not provide its break-up between private and government investment. The break-up between these two components is available only at the annual frequency. Thus I use annual data for observables.

[2]Global Financial Development Series : Loans Requiring Collateral available at *https* :

Financial repression is extensively used and it has been an important source of revenue for the government. Kletzer and Kohli (2001) estimate that revenues from financial repression in India averaged 6% of GDP in 80's and around 2.9% in 90's.

Based on the comparison of log marginal data densities (Kass and Raftery 1995), I find that data very strongly favors the Benchmark model over a model with a high share of non-Ricardian households. The log marginal data density of the model with 65% of households being non-Ricardian is estimated to be 413.89 compared to 707.47 for the Benchmark model.[3] The log marginal data densities with the fraction of non-Ricardian households being 0.50 and 0.10 are 592.99 and 707.86 respectively. These results suggest that within the class of models (for the given set of observables) analyzed in this paper, the inclusion of financially-excluded entrepreneurs obviates the need to include the financially-excluded households.

Data strongly favors the Benchmark model over the model with competitive banking (log marginal data density= 698.36), which highlights the importance of incorporating monopolistic competition in the banking sector with sticky interest rates in the model. Data also favors the Benchmark model over the model with financial repression, but not strongly (log marginal data density=704.73).

Based on estimation results, I use the posterior distribution of parameters of the Benchmark model and the model with low fraction of non-Ricardian households (0.10) to quantify government spending multipliers. Also since data does not strongly favor the Benchmark model over the model with financial repression, I also quantify government spending multipliers for the model with financial repression for the comparison purpose.

Results from the Benchmark model show that the short-run mean output multipliers of both government consumption and investment are significantly lower than unity. The output multiplier of government consumption falls over

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//databank.worldbank.org/reports.aspx?source = global − financial − development. Similar is the case for other developing countries. Fan *et. al.* (2020) using the data from the World Enterprise Surveys from 131 countries find that on average 77% of bank loans are collaterized.

[3]Taking model X as null and Y as alternative, based on $2\ln(\text{Bayes Factor})$ statistics Kass and Raftery (1995) suggest following criteria: if $2\ln(\text{Bayes Factor}) > 10$, there is a very strong evidence against the null, if it is between $6-10$ a strong evidence against the null, and if it is between $2-6$ a positive evidence against the null. If it is between $0-2$, it is not worth mentioning.

time with mean impact and 25-years present value multiplier being 0.72 and 0.60 respectively. The mean value of impact output multiplier of government investment at 0.61 is smaller than the impact output multiplier of government consumption. However, it increases over time and over longer term it becomes approximately one. The size and pattern of output multipliers of government consumption and investment based on the model with low fraction of non-Ricardian households and the model with financial repression are very similar to that of the Benchmark model.

In 1991 major structural reforms took place in India which were focused on deregulating and opening of the Indian economy. To examine whether government spending multipliers have changed in the post-reform period, I reestimate the Benchmark model using data from 1992-2016 and calculate the multipliers based on posterior estimates. Results show that the size and pattern of output multiplier of government investment remain similar to output multiplier based on the full sample. However, longer term output multiplier of government consumption is significantly smaller, with the present value of 10-years and 25-years government consumption multipliers being not significantly different from zero.

To the best of my knowledge, this is the first paper which develops and estimates a two-sector new-Keynesian model with two types of entrepreneurs: with and without access to credit market to quantify government spending multipliers. The other novel feature is the analysis of effects of different types of financial market imperfections on government spending multipliers in a unified framework. While the model is estimated for India, the analytical framework developed is likely to be applicable to developing countries in general.

My paper closely relates to four branches of the literature. First, it relates to monetary DSGE models which study the effects of financial market imperfections on government spending multipliers. One branch of this literature has examined the effects of collateral constraint on government consumption multiplier. These studies have mainly focussed on the interaction between collateral constraint and liquidity trap in the context of developed countries. They find that the collateral constraint significantly enhances the government consumption multiplier and it may become greater than one even outside liquidity trap. (e.g. Fernández-Villaverde 2010, Carrillo and Poilly 2013).

The other branch of this literature has examined the effects of non-Ricardian households on government consumption multipliers (e.g. Gali et. al. 2007, Leeper et. al. 2017). These studies show that the presence of financially-excluded households weakens the negative wealth effect on private consumption and it can significantly enhance government consumption multiplier. Unlike these studies, I consider a much richer set of financial imperfections including differential access to banking sector by entrepreneurs. Also my results show that the output multiplier of government consumption remains significantly below one despite collateral constraint and non-Ricardian households.

Secondly, this paper relates to studies analyzing the effects of imperfect competition in the banking sector on economic dynamics in the DSGE framework (e.g. Gerali et. al. 2010, Mandelman 2010, Andres and Arce 2012). These studies focus on the role of imperfect competition in banking sector in accounting for business cycle. My paper adds to this literature by examining interactions among informality, imperfect competition in banking sector and fiscal shocks.

Thirdly, there is a growing literature which has examined the role of informal sector in propagating and amplifying business cycle in the two-sector DSGE framework (e.g. Shapiro 2015, Fernández and Meza 2015, Coskun 2022). Another strand of this literature studies macro-economic effects of monetary policy (Castillo and Montoro 2010) and product and labor market regulations (Anand and Khera 2015, Levya and Urrutia 2020). My paper contributes to this literature by analyzing interactions among informal sector, financial frictions and fiscal shocks.

Finally, this paper contributes to the DSGE literature examining the macro-economic effects of financial repression. The focus of these studies is on the effects of financial repression on the monetary transmission mechanism (e.g. Lahiri and Patel 2017, Banerjee et. al. 2020). In contrast, this paper examines the effects of financial repression on the fiscal transmission mechanism.

Rest of the paper is organized as follows. Section 2 presents the Benchmark model. Section 3 describes the empirical approach. Section 4 discusses estimation results. Section 5 examines the models with non-Ricardian households, financial repression and competitive banking. Section 6 quantifies and analyzes government spending multipliers using the Benchmark model and models with financial repression and high share of Ricardian households. Section 7 discusses robustness of results. This is followed by conclusion. For brevity, I only present main equations in the text. All equilibrium equations are listed in Appendix 1.

2 Model

This paper develops a New-Kenyensian model with two types of labor markets: formal (f) and informal (n) and two types of entrepreneurs (unit measures) : formal (Ef) and informal (En). Formal entrepreneurs operate in the formal sector and informal entrepreneurs operate in the informal sector. Formal goods are used for private and public consumption and investment, export and import. But informal goods are used only for domestic private consumption. Households (workers) and entrepreneurs consume both formal and informal goods. The general model incorporates key characteristics of formal and informal sectors identified in the literature and features a rich set of financial frictions commonly prevalent in developing countries.

Formal entrepreneurs produce domestic intermediate goods used in the production of formal final goods employing private and government capital, labor and imported intermediate good. They hire workers in the formal labor market. Informal entrepreneurs produce informal goods using private and government capital and labor. They hire workers in the informal labor market. Similar to Baxter and King (1993) and Leeper et. al. (2010), I assume that government capital is a public good and the production function in both sectors has constant returns to scale in private inputs.

Consistent with the evidence, I assume that the production technology in informal sector has a lower productivity (TFP) and a smaller elasticity of production with respect to private capital compared to the production technology in formal sector. Evidence from India also shows that public infrastructure has a larger impact on the output of bigger firms compared to smaller firms (Chatterjee et. al. 2021). Additionally, registered manufacturing sector (larger firms) is much more import-intensive and is more reliant on foreign technology compared to unregistered manufacturing firms (smaller firms) and enterprises engaged in agriculture and services sector (Paul 2014 and Paul and Kumar 2021). To capture these aspects, I assume that the informal sector has a smaller elasticity of production with respect to government capital compared to the production technology in formal sector. Also the private capital stock in formal sector and government capital consists of both domestic and imported goods. But the private capital stock in informal sector consists of only domestic goods.

Formal goods and labor markets are monopolistically competitive and are subject to nominal rigidities (Calvo pricing) similar to a standard New-Kenyensian model. Transactions in formal goods market are intermediated through final good producers and retailers. Similarly, transactions in formal labor market are intermediated through labor packers and unions. Informal goods and labor markets are competitive. The government imposes tax on the sales of formal final goods, profits of formal entrepreneurs and formal wage earnings. Workers and entrepreneurs in the informal sector do not pay taxes. In addition, there is no sales tax on informal goods.[4] These assumptions reflect the fact that the formal sector in India is subject to a variety of labor, fiscal and product market regulations, while the informal sector is largely unregulated.

As discussed earlier, empirical evidence shows that only a small fraction of firms have access to the banking sector in India. According to a Government of India report on unorganized sector only 3% of unregistered units had access to institutional finance in 2001-02 (Chapter 4, NCEUS 2007b). Similarly a survey by the International Finance Corporation, World Bank shows that more than 90% of small and very small enterprises did not have bank account in 2010 in India.[5] To capture this I assume that only formal entrepreneurs have access to banking sector. They can borrow from banks to finance their expenditure. Informal entrepreneurs do not have access to the banking sector and must finance their expenditure using their own resources.

The banking sector is modeled similar to Gerali et. al. (2010). Each bank consists of three branches: retail deposit branch, retail loan branch, and wholesale branch. Retail deposit branch creates a continuum of differentiated (one-period) deposit contracts at no cost and sells them to households. It loans collected deposits to the wholesale branch at the competitive rate. Retail loan branch obtains loans from wholesale branch at the competitive rate, creates a continuum of differentiated (one-period) loans at no cost and sells them to formal entrepreneurs. Similar to Kiyotaki and Moore (1997), due to limited enforcement of contracts formal entrepreneurs face a collateral constraint. The amount of loan obtained by a formal entrepreneur cannot exceed a given fraction of future value of its physical capital.

Due to imperfect substitutability, retail branches enjoy market power and set their deposit and loan interest rates. Empirical evidence from India shows that market interest rates particularly loan rates respond sluggishly

[4]Since informal goods market is competitive, there is no distinction between final (consumed by households) and intermediate (produced by informal entrepreneurs) informal goods. Similarly, there is no distinction between informal labor supplied by households and labor employed by informal entrepreneurs.

[5]Data available at $https://data.world/finance/ifc-enterprise-finance-gap$.

to changes in the policy interest rate (Das 2015). To capture their sluggish response in a simple way, as in Gerali et. al. (2010) I assume that retail branches face quadratic adjustment cost in changing their interest rates over time.

The economy is subject to capital control. Households and entrepreneurs in the economy do not have access to international financial markets. International lending and borrowing are done by the government. This is consistent with the Indian experience.[6]

To ease the exposition, I first present and discuss the Benchmark model with only one type of (Ricardian) households with no financial repression. As discussed earlier, data also prefers the Benchmark model over models with high proportion of non-Ricardian (NR) households and financial repression. The analysis of models with both types of households and financial repression is undertaken in Section 5.

In the Benchmark model, all households have access to banking sector and save in terms of one-period deposits. They supply labor to both formal and informal sectors similar to Fernández and Meza (2015). They own all the final and retail good firms, banks and labor agencies (packers and unions).

One key difference between households and entrepreneurs is in the degree of impatience. The discount factor of households, β_R, is higher than the discount factor of formal entrepreneurs, β_{Ef}, and informal entrepreneurs, β_{En}. Thus, in equilibrium households save and entrepreneurs would like to borrow.

The utility of *ith* type of agents depends on the CES aggregator of consumption of both formal and informal final goods, c_{it}, given by

$$c_{it} = [\chi_c^{1/\zeta_c} {c_{ift}}^{\zeta_c - 1/\zeta_c} + (1-\chi_c)^{1/\zeta_c} c_{int}^{\zeta_c - 1/\zeta_c}]^{\zeta_c/\zeta_c - 1}$$

$$\text{with } \ 0 < \chi_c < 1 \ \forall \ i = R, \ Ef \ \& \ En \tag{2.1}$$

where c_{ift} and c_{int} are consumption of formal and informal final goods by the *ith* type of agent respectively at time t. χ_c and ζ_c are weight of formal

[6]The capital account was completely regulated in India till the end of 1992. Starting November 1992 Indian currency was made convertible on current account, but not on capital account. Since then there has been a progressive opening of capital account particularly in terms of inward capital flows. But Indian residents and firms are still heavily regulated in terms of accessing foreign debt market (Mohan and Ray 2017). Even after liberalizing of capital account since 1992, India remains one of the most heavily regulated country among developing countries (Fernández et. al. 2015).

goods in the composite consumption good and the elasticity of substitution between formal and informal goods in consumption respectively.

The price of composite consumption good, P_t, is used as numeraire and the inflation rate, π_t, is defined as $\frac{P_t}{P_{t-1}}$. All prices are expressed relative to the price of composite consumption good. Let p_{ft} and p_{nt} be the (relative) price of formal and informal final goods respectively, then the optimal intra-temporal allocation implies that

$$1 = \chi_c((1 + tc_t)p_{ft})^{1-\zeta_c} + (1 - \chi_c)p_{nt}^{1-\zeta_c} \tag{2.2}$$

where tc_t is the sales tax on formal goods.

The demand functions of formal and informal goods by the *ith* type of agent are given by

$$c_{ift} = \chi_c c_{it}((1 + tc_t)p_{ft})^{-\zeta_c} \text{ \&} \tag{2.3}$$

$$c_{int} = (1 - \chi_c)c_{it}p_{nt}^{-\zeta_c} \tag{2.4}$$

for $i = R, Ef$ & En.

2.1 Households

The utility of a household, i, depends on its consumption, $c_{Rt}(i)$, and the labor supply index, $l_{Rt}(i)$. The labor supply index is defined as

$$l_{Rt}(i) = \phi_{lf} l_{Rft}(i) + l_{Rnt}(i) \tag{2.5}$$

where $l_{Rft}(i)$ and $l_{Rnt}(i)$ are labor supplied to formal and informal sectors respectively. ϕ_{lf} captures the relative disutility of working in formal sector and helps in matching the wage-differential between formal and informal sectors observed in India.

The period utility of *ith* household is given by

$$\ln c_{Rt}(i) - \frac{\mu_R}{1+\tau} l_{Rt}(i)^{1+\tau} \tag{2.6}$$

where μ_R is the relative weight of labor supply in the utility function of household and τ is the inverse of *Frisch elasticity*.

The *ith* household enters time period, t, with nominal one-period deposit, $D_t(i)$. At the beginning of period t, it chooses its consumption, $c_{Rt}(i)$, labor supply, $l_{Rht}(i)$, and its sectoral composition, $l_{Rft}(i)$ and $l_{Rnt}(i)$, and amount of deposits, $D_{t+1}(i)$, which matures next period. While making its decisions, it takes prices of formal final goods, p_{ft}, and informal goods, p_{nt}, real wages received by households in the formal sector, w_{hft}, and informal sector, w_{nt}, and (gross) nominal rate of interest on deposit, $R_{ht+1}(i)$, between periods t and $t+1$ as given.

The total unit of deposit contracts bought by *ith* Ricardian household, $D_{t+1}(i)$, is a composite constant elasticity of substitution basket of differentiated deposit contracts, $D_{t+1}(i,j)$, bought from retail deposit branches indexed $j \in (0,1)$ at the interest rate, $R_{ht+1}(i,j)$, and is given by

$$D_{t+1}(i) = \Big(\int_0^1 D_{t+1}(i,j)^{\xi_d - 1/\xi_d} dj \Big)^{\xi_d/\xi_d - 1} \tag{2.7}$$

where $\xi_d < -1$ is the elasticity of substitution among deposit contracts. The demand function of deposits is given by the solution of optimization problem

$$\max_{D_{t+1}(i,j), D_t(i)} \int_0^1 R_{ht+1}(i,j) D_{t+1}(i,j) dj$$

subject to (2.7), which yields

$$D_{t+1}(i,j) = D_{t+1}(i) \left(\frac{R_{ht+1}(i,j)}{R_{ht+1}(i)} \right)^{-\xi_d} \tag{2.8}$$

where the deposit interest rate index

$$R_{ht+1}(i) = \Big(\int_0^1 R_{ht+1}(i,j)^{1-\xi_d} dj \Big)^{1/1-\xi_d}. \tag{2.9}$$

The *ith* household maximizes its expected utility

$$E_0 \sum_{t=0}^{\infty} \beta_R^t \nu_t \left[\ln c_{Rt}(i) - \frac{\mu_R}{1+\tau} l_{Rt}(i)^{1+\tau} \right]$$

subject to its budget constraint

$$(1 - tw_t) w_{hft} l_{Rft}(i) + w_{nt} l_{Rft}(i) + \frac{R_{ht}(i)}{P_t} D_t(i) + \hat{d}iv_t = c_{Rt}(i) + \frac{D_{t+1}(i)}{P_t} + \hat{t}o_t \; \forall \, t \geq 0 \tag{2.10}$$

(2.3), (2.4), (2.5) and (2.7) given prices, taxes and laws of motion for exogenous stochastic processes. ν_t, tw_t, $\hat{to}_t$ and $\hat{div}_t$ are preference shock, tax rate on formal wage earnings, real lump-sum tax and total real dividend received from final good producers, banks, unions and labor packers by the ith household respectively at time t. Throughout the paper, variables with ˆ refer to aggregate quantity variables which private agents take as given while making their decisions.

2.2 Production

Informal Entrepreneurs

Informal entrepreneurs produce informal goods at time t, y_{Ent}, using their own private capital, kp_{nt}, government capital, kg_t, and labor, l_{nt}. The informal sector production function is given by

$$y_{Ent} = \kappa A_t \hat{k}g_t^{\alpha_{gn}} kp_{nt}^{\alpha_n} l_{nt}^{1-\alpha_n} \text{ with } \alpha_n \ \& \ \kappa \in (0,1) \ \& \ \alpha_{gn} \geq 0 \tag{2.11}$$

where A_t is an exogenous stochastic total factor productivity (TFP). Parameter κ captures the lower productivity in the informal sector.

The utility of an informal entrepreneur depends on its consumption, c_{Ent}. At the beginning of time period t, an ith informal entrepreneur enters with $kp_{nt}(i)$ amount of private capital stock and maximizes its inter-temporal utility function

$$E_0 \sum_{t=0}^{\infty} \beta_{En}^t \ln c_{Ent}(i)$$

by choosing its consumption, amount of labor to hire, $l_{nt}(i)$, private capital investment, $Ip_{nt}(i)$, and next period private capital stock, $kp_{nt+1}(i)$, subject to its budget constraint

$$c_{Ent}(i) = p_{nt} y_{Ent}(i) - w_{nt} l_{nt}(i) - (1 + tc_t) p_{ft} Ip_{nt}(i) \tag{2.12}$$

and the law of motion of private capital stock

$$kp_{nt+1}(i) = Ip_{nt}(i) + (1-\delta) kp_{nt}(i). \tag{2.13}$$

As discussed earlier, informal entrepreneurs do not have access to the banking sector and must finance their purchases using their income.

Formal Entrepreneurs

Formal entrepreneurs produce domestic intermediate good at time t, y_{Eft}, using their own private capital, kp_{ft}, government capital, $\hat{k}g_t$, labor, l_{ft}, and imported intermediate good, v_t. They hire labor from labor packers and purchase imported intermediate goods and sell their goods to retailers in a perfectly competitive market.

The formal sector production function is given by:

$$y_{Eft} = A_t \hat{k}g_t^{\alpha_{gf}} kp_{ft}^{\alpha_{f1}} v_t^{\alpha_{f2}} l_{ft}^{1-\alpha_{f1}-\alpha_{f2}} \text{ with } 0 < \alpha_{f1} \ \& \ \alpha_{f2} < 1 \ \& \ \alpha_{gf} \geq 0. \tag{2.14}$$

The utility of a formal entrepreneur depends on its consumption, c_{Eft}. At the beginning of time period t, the ith formal entrepreneur enters with $kp_{ft}(i)$ amount of physical capital stock and $B_{Et}(i)$ amount of one-period nominal borrowing maturing in time period t. It maximizes its inter-temporal utility function

$$E_0 \sum_{t=0}^{\infty} \beta_{Ef}^t \ln c_{Et}(i)$$

by choosing its consumption, total amount of one-period nominal borrowing, $B_{Et+1}(i)$, amount of labor to hire, $l_{ft}(i)$, private capital stock, $kp_{ft+1}(i)$, and private physical investment, $Ip_{ft}(i)$, and its domestic, $Ip_{fht}(i)$, and imported component, $Ip_{zt}(i)$, subject to its budget constraint

$$c_{Eft}(i) + RE_{t-1}\frac{B_{Et}(i)}{P_t} + s_t Ip_{ft}(i) =$$

$$\frac{B_{Et+1}(i)}{P_t} + (1-tk)[p_{Eft} y_{Eft(i)} - w_{ft} l_{ft}(i) - p_{zt}(1+tz_t)v_t(i)] \tag{2.15}$$

where p_{Eft}, s_t, w_{ft}, p_{zt} and $R_{Et}(i)$ are relative price of domestic intermediate good, relative price of composite investment good, real formal wage, relative price of imported good and the nominal rate of interest on loan between periods $t-1$ and t respectively. The term in the bracket of right hand side is the real profit of formal entrepreneur and tk_t and tz_t are the tax rate on profits and custom duty respectively.

As discussed before, formal entrepreneurs face a collateral constraint: the borrowing amount of a formal entrepreneur inclusive of repayment cannot exceed a given fraction of expected future value of its private physical capital,

$$\frac{B_{Et+1}(i)}{P_t} R_{Et+1}(i) \leq \psi_t k p_{t+1}(i) E_t q_{t+1} \pi_{t+1} \tag{2.16}$$

where $R_{Et+1}(i)$, ψ_t, and $q_t \equiv \frac{Q_t}{P_t}$ are nominal interest rate on loan, stochastic loan to value of capital (LTV) ratio and the equilibrium real price of capital/Tobin's Q at time t respectively.

The law of motion for private capital accumulation of ith formal entrepreneur is given by

$$kp_{ft+1}(i) = Ip_{ft}(i) + (1-\delta) kp_{ft}(i) - \frac{\phi_k}{2} \left(\frac{kp_{ft+1}(i)}{kp_{ft}(i)} - 1 \right)^2 kp_{ft}(i) \text{ with } 0 < \delta < 1. \tag{2.17}$$

Formal entrepreneurs face quadratic cost in changing capital stock outside the steady state, where ϕ_k is the adjustment cost parameter. The total private investment, Ip_{ft}, is given by the CES aggregator

$$Ip_{ft}(i) = [\chi_k^{1/\zeta_k} Ip_{fht}(i)^{\zeta_k - 1/\zeta_k} + (1-\chi_k)^{1/\zeta_k} Ip_{zt}(i)^{\zeta_k - 1/\zeta_k}]^{\zeta_k/\zeta_k - 1} \text{ with } 0 < \chi_k < 1 \tag{2.18}$$

where χ_k and ζ_k are weight of domestic investment good in the composite investment and the elasticity of substitution between domestic and imported investment goods respectively.

Let λ_{kt} be the Langrangian multiplier associated with (2.16). In the symmetric equilibrium with the binding borrowing constraint, the first order conditions for borrowing, B_{Et+1}, and private physical capital investment, k_{pft+1}, are given by

$$B_{Et+1}: \ \frac{1}{c_{Et}} - \lambda_{kt} R_{Et+1} = \beta_{Ef} E_t \frac{1}{c_{Et+1}} \frac{R_{Et+1}}{\pi_{t+1}} \ \& \tag{2.19}$$

$$kp_{ft+1}: \ \left(1 + \phi_{kt} \left(\frac{kp_{ft+1}}{k_{pft}} - 1 \right)\right) \frac{s_t}{c_{Et}} - \psi_t \lambda_{kt} E_t \pi_{t+1} q_{t+1} =$$

$$\beta_{Ef} E_t \frac{1}{c_{Et+1}} \left(r^k_{t+1}(1-\tau_{kt+1}) + s_{t+1} \left(1 - \delta - \frac{\phi_k}{2} \left(\frac{kp_{ft+2}}{kp_{ft+1}} - 1 \right)^2 + \phi_k \left(\frac{kp_{ft+2}}{kp_{ft+1}} - 1 \right) \frac{kp_{ft+2}}{kp_{ft+1}} \right) \right) \tag{2.20}$$

where $r^k_t \equiv \frac{p_{Eft} y_{Eft}}{kp_{ft}}$ is the real value of marginal product of capital at time t.

Demand for Loans

The total unit of loan contracts bought by ith formal entrepreneur, $B_{Et+1}(i)$, is a composite constant elasticity of substitution basket of differentiated loan contracts, $B_{Et+1}(i,j)$, bought from retail loan branches indexed $j \in (0,1)$ at the nominal interest rate, $R_{Et+1}(i,j)$, and is given by

$$B_{Et+1}(i) = \Big(\int_0^1 B_{Et+1}(i,j)^{\xi_e - 1/\xi_e} dj \Big)^{\xi_e/\xi_e - 1} \tag{2.21}$$

where $\xi_e > 1$ is the elasticity of substitution among loan contracts. The demand function for loans is given by the solution to the expenditure minimization problem

$$\min_{B_{Et+1}(i,j), B_{Et+1}(i)} \int_0^1 R_{Et+1}(i,j) B_{Et+1}(i,j) dj$$

subject to (2.21), which yields

$$B_{Et+1}(i,j) = B_{Et+1}(i) \left(\frac{R_{Et+1}(i,j)}{R_{Et+1}(i)} \right)^{-\xi_e} \tag{2.22}$$

where the loan interest rate index is given by

$$R_{Et+1}(i) = \Big(\int_0^1 R_{Et+1}(i,j)^{1-\xi_e} dj \Big)^{1/1-\xi_e}. \tag{2.23}$$

Final Good Producers, Retail Good Producers and Price Setting: Formal Sector

Formal final good producers combine a continuum of formal retail goods, $y_{ft}(i)$, indexed $i \in (0,1)$ to produce the formal final good, y_{ft},

$$y_{ft} = \Big(\int_0^1 y_{ft}(i)^{\xi_y - 1/\xi_y} di \Big)^{\xi_y/\xi_y - 1} \tag{2.24}$$

where ξ_y is the elasticity of substitution among formal retail goods. They sell their goods to consumers, entrepreneurs and government and export in a perfectly competitive market.

The optimization problem of formal final good producers can be expressed as

$$\max_{y_{ft}, y_{ft}(i)} p_{ft} y_{ft} - \int_0^1 p_{ft}(i) y_{ft}(i) di$$

subject to (2.24) where $p_{ft}(i)$ is the relative price of ith type of formal retail good. The optimization problem yields the demand function for formal retail goods

$$y_{ft}(i) = y_{ft} p_{ft}(i)^{-\xi_y} \tag{2.25}$$

where the aggregate relative price index of formal final good, p_{ft}, satisfies

$$p_{ft} = \left(\int_0^1 p_{ft}(i)^{1-\xi_y} di \right)^{1/1-\xi_y}. \tag{2.26}$$

There is a continuum of formal retail good producers indexed $i \in (0,1)$, who produce differentiated formal retail goods, $y_t(i)$, using domestic formal intermediate good as input. In each time period, a formal retailer receives a signal with probability $1-\gamma_p$ with $\gamma_p \in (0,1)$ that it can change its nominal price, $P^*_{ft}(i)$. The formal retailer who does not receive the signal keep its price unchanged.

The optimization problem faced by the ith formal retailer who can change the price at time t is given by

$$\max_{p^*_{ft}(i), y_{ft}(i)} E_t \sum_{n=0}^{\infty} \gamma_p^n \beta_R^n \hat{\lambda}^R_{ct+n} \pi_t \left[\frac{p^*_{ft}(i)}{\prod_{t+n}^{\infty} \pi_{t+n}} - p_{ft+n} \right] y_{ft+n}(i)$$

subject to (2.25) where $p^*_{ft}(i) \equiv \frac{P^*_{ft}(i)}{P_t}$ and $\hat{\lambda}^R_{ct}$ is the Langrangian multiplier associated with the budget constraint of representative household (2.10).

Labor Packers, Unions, and Wage Setting: Formal Sector

Labor packers in the formal sector combine a continuum of labor services, $l_{ft}(j)$, indexed $j \in (0,1)$, to produce composite formal labor, l_{ft}, and sell it to formal entrepreneurs in a competitive formal labor market with

$$l_{ft} = \Big(\int_0^1 l_{ft}(j)^{\xi_l - 1/\xi_l} dj \Big)^{\xi_l/\xi_l - 1} \tag{2.27}$$

where ξ_l is the elasticity of substitution among labor services.

The optimization problem of labor packers can be expressed as

$$\max_{l_{ft}, l_{ft}(j)} w_{ft} l_{ft} - \int_0^1 w_{ft}(j) l_t(j) dj$$

subject to (2.27) where $w_{ft}(j)$ is the real wage of jth type of labor service and w_{ft} is the aggregate formal real wage index. The optimization problem yields the demand function for formal labor services

$$l_{ft}(j) = l_{ft} \left(\frac{w_{ft}(j)}{w_{ft}} \right)^{-\xi_l} \tag{2.28}$$

and the aggregate formal real wage index is given by

$$w_{ft} = \Big(\int_0^1 w_{ft}(j)^{1-\xi_l} dj \Big)^{1/1-\xi_l}. \tag{2.29}$$

There is a continuum of unions in the formal sector indexed $j \in (0, 1)$, who buy homogeneous labor from households and produce differentiated labor services, $l_{ft}(j)$. Similar to formal retailers, in each time period, a union receives a signal with probability $1 - \gamma_w$ with $\gamma_w \in (0, 1)$ that it can change its nominal wage, $W^*_{ft}(j)$. The union which does not receive the signal keeps its nominal wage unchanged.

The optimization problem faced by the jth union which can change its wage in time t is given by

$$\max_{l_t(i), w^*_{ft}(j)} E_t \sum_{n=0}^{\infty} \gamma_w^n \beta_R^n \hat{\lambda}^R_{ct+n} \pi_t \left[\frac{w^*_{ft}(j)}{\prod_{t+n}^{\infty} \pi_{t+n}} - w_{hft+n} \right] l_{ft+n}(j)$$

subject to (2.28) where $w^*_{ft}(j) \equiv \frac{W^*_{ft}(j)}{P_t}$.

2.3 Banking Sector and Policy Interest Rate

Retail Loan Branches

The jth retail loan branch obtains credit, $B_{E+1}(j)$, from the wholesale branch at the nominal interest rate, R_{lt+1}, at time t, differentiates them at no cost and sells loan contracts to intermediate good producers at the nominal interest rate, $R_{Et+1}(j)$. As in Gerali et. al. (2010), it faces quadratic adjustment cost in changing its interest rate which is proportional to the aggregate returns on loans.

The optimization problem of jth retail loan branch is to

$$\max_{R_{Et+1}(j),B_{R+1}(j))} E_t \sum_{t=0}^{\infty} \frac{\hat{\lambda}_{ct}^R \beta_R^t}{P_t} \left[[R_{Et+1}(j) - R_{lt+1}]B_{Et+1}(j) - \frac{\phi_e}{2} \left(\frac{R_{Et+1}(j)}{R_{Et}(j)} - 1 \right)^2 R_{Et+1}\hat{B}_{Et+1} \right]$$

subject to (2.22), where $\hat{B}_{Et+1}$, R_{Et+1}, and ϕ_e are aggregate amount of loan, average nominal interest rate on loans and adjustment cost parameter respectively.

In the symmetric equilibrium, $R_{Et+1}(j) = R_{Et+1}$, and the first order condition reduces to

$$1 + \xi_e \left(\frac{R_{lt+1}}{R_{Et+1}} - 1 \right) - \phi_e \left(\frac{R_{Et+1}}{R_{Et}} - 1 \right) \left(\frac{R_{Et+1}}{R_{Et}} \right)$$

$$+\beta_R \phi_e E_t \frac{\lambda_{ct+1}^R}{\lambda_{ct}^R} \left(\frac{R_{Et+1}}{R_{Et}} - 1 \right) \left(\frac{R_{Et+1}}{R_{Et}} \right)^2 \left(\frac{B_{Et+1}}{B_{Et}} \right) = 0. \tag{2.30}$$

In the absence of adjustment cost ($\phi_e = 0$), $R_{Et+1} = \frac{\xi_e}{\xi_e - 1} R_{lt+1}$.

Retail Deposit Branches

Similarly, jth retail deposit branch collects deposits from households and puts its deposits, $D_{t+1}(j)$, with the wholesale branch at the nominal interest rate, R_{dt+1}. It faces quadratic adjustment cost in changing its interest rate which is proportional to the aggregate returns on deposits. The optimization problem of jth retail deposit branch is to

$$\max_{R_{ht+1}(j),D_{t+1}(j))} E_t \sum_{t=0}^{\infty} \frac{\hat{\lambda}_{ct}^R \beta_R^t}{P_t} \left[[R_{dt+1} - R_{ht+1}(j)]D_{t+1}(j) - \frac{\phi_d}{2} \left(\frac{R_{ht+1}(j)}{R_{ht}(j)} - 1 \right)^2 R_{ht+1}\hat{D}_{t+1} \right]$$

subject to (2.8), where $\hat{D}_{t+1}$, R_{ht+1} and ϕ_d are aggregate units of deposit, nominal interest rate on deposit and adjustment cost parameter respectively.

In the symmetric equilibrium, $R_{ht+1}(j) = R_{ht+1}$, the first order condition reduces to

$$-1 - \xi_d \left(\frac{R_{dt+1}}{R_{ht+1}} - 1 \right) - \phi_d \left(\frac{R_{ht+1}}{R_{ht}} - 1 \right) \left(\frac{R_{ht+1}}{R_{ht}} \right)$$

$$+\beta_R \phi_d E_t \frac{\lambda^R_{ct+1}}{\lambda^R_{ct}} \left(\frac{R_{ht+1}}{R_{ht}} - 1 \right) \left(\frac{R_{ht+1}}{R_{ht}} \right)^2 \left(\frac{D_{t+1}}{D_t} \right) = 0. \tag{2.31}$$

In the absence of adjustment cost ($\phi_d = 0$), $R_{ht+1} = \frac{\xi_d}{\xi_d - 1} R_{dt+1}$.

Wholesale Branches

Wholesale branches at time t accept deposits from retail deposit branches, D_{t+1}, and allocate these deposits among credit to retail loan branches, B_{lt+1}, the government, B_{gt+1}, and the central bank, B_{ct+1}. The amount of government borrowing follows an exogenous stochastic process described below.

The real cash flow of the representative wholesale bank at time t, $\frac{Div^{wb}_t}{P_t}$, is given by

$$\frac{Div^{wb}_t}{P_t} = \left[\frac{\hat{D}_{t+1}}{P_t} + \frac{R_{lt} B_{lt}}{P_t} + \frac{R_{gt} B_{gt}}{P_t} + \frac{R_{gt} B_{ct}}{P_t} \right] - \left[\frac{R_{dt} \hat{D}_t}{P_t} + \frac{B_{lt+1}}{P_t} + \frac{B_{gt+1}}{P_t} + \frac{B_{ct+1}}{P_t} \right] \tag{2.32}$$

where R_{gt+1} is the nominal interest rate on credit to government and central bank between time-periods t and $t+1$ respectively. In the Benchmark model, I assume that there is no financial repression and a wholesale bank is free to allocate its credit among retail loan branches, the government and the central bank. In section 5, I analyze the model with financial repression, in which wholesale banks are required to provide a policy determined amount of credit to the government and the central bank at administered interest rates.

Since wholesale branches can freely allocate the credit between the private and public sectors,

$$R_{lt+1} = R_{gt+1}. \tag{2.33}$$

Then the zero-profit condition for the wholesale branch implies that

$$R_{lt+1} = R_{dt+1} = R_{gt+1}. \tag{2.34}$$

The nominal interest rate on credit to the government and the central bank, R_{gt+1}, follows the standard Taylor rule[7]

$$\ln(R_{gt+1}/R_g) = \rho_{rg}\ln(R_{gt}/R_g) + (1-\rho_{rg})[\eta_\pi \ln(\pi_t/\pi) + \eta_y \ln(\hat{g}dp_t/\hat{g}dp)] + e_{rgt}$$

$$\text{with } e_{rgt} \sim NID(0, \sigma_{rg}^2) \tag{2.35}$$

where gdp_t, η_π and η_y are real GDP at time t and sensitivity parameters to inflation deviation from its steady-state and output gap respectively. Throughout the paper, a variable without subscript t indicates its steady state value.

Wholesale banks keep a certain fraction of their deposit, crr, with the central bank as cash-reserve:

$$B_{ct+1} = crrD_{t+1} \tag{2.36}$$

where crr is the cash-reserve ratio.

2.4 Government Expenditure and Taxes

I treat formal private and government investment symmetrically. Similar to formal private investment, government investment, $\hat{I}_{gt}$, consists of both domestic investment good, $\hat{I}g_{ht}$, and imported investment good, $\hat{I}g_{zt}$, and is given by the CES aggregator

$$\hat{I}_{gt} = [\chi_k^{1/\zeta_k} \hat{I}_{hgt}^{\zeta_k - 1/\zeta_k} + (1-\chi_k)^{1/\zeta_k} \hat{I}g_{zt}^{\zeta_k - 1/\zeta_k}]^{\zeta_k/\zeta_k - 1}. \tag{2.37}$$

The government chooses $\hat{I}g_{ht}$ and $\hat{I}g_{zt}$ to minimize its investment expenditure. The government capital stock evolves as follows:

$$\hat{k}g_{t+1} = (1-\delta)\hat{k}g_t + \hat{I}g_t \text{ with } 0 < \delta < 1. \tag{2.38}$$

The government finances its expenditure through taxes and domestic and foreign borrowing. I assume that the central bank makes available borrowed fund to the government every period. Then, the consolidated government budget constraint satisfies

[7]Given the captive nature of market for government bonds in India, taking rate of interest on government bonds as a policy instrument is fairy common in the literature (e.g. Lahiri and Patel 2016, Banerjee et. al. 2020).

$$\hat{t}ax_t + \frac{\hat{B}_{gt+1} + \hat{B}_{ct+1}}{P_t} + \frac{\hat{B}_{zt+1}}{P_t} = p_{ft}\hat{c}_{gt} + s_t\hat{I}g_t + R_{gt}\frac{\hat{B}_{gt} + \hat{B}_{ct}}{P_t} + R_{zt}\frac{\hat{B}_{zt}}{P_t} \quad (2.39)$$

where $\hat{t}ax_t$ and $\hat{B}_{zt+1}$ are total real tax receipt and nominal foreign borrowing in terms of domestic prices by the government respectively at time t. R_{zt} is the (gross) nominal international interest rate in terms of domestic prices on government borrowing between time periods $t-1$ and t.

The total real tax receipt, tax_t, is given by

$$\hat{t}ax_t = tc_t p_{ft}(\hat{c}_{Rft} + \hat{c}_{Efft} + \hat{c}_{Enft} + \hat{c}_{gt} + \hat{I}p_{fht} + \hat{I}g_{ht}) + tw_t w_{hft}\hat{l}_{Rft}$$

$$tk_t[p_{Eft}\hat{y}_{Eft} - w_{ft}\hat{l}_{ft} - p_{zt}(1+tz_t)\hat{v}_t] + tz_t p_{zt}(\hat{I}p_{zt} + \hat{I}g_{zt} + \hat{v}_t) + \hat{t}o_t. \quad (2.40)$$

I assume that government consumption expenditure, $\hat{p}c_{gt} \equiv p_{ft}c_{gt}$, government investment expenditure, $\hat{s}Ig_t \equiv s_t Ig_t$, and tax rates on consumption, wages, profits, and imported goods follow stochastic auto-regressive processes:

$$\ln\left[\frac{\hat{s}Ig_t}{\hat{s}Ig}\right] = \rho_{Ig}\ln\left[\frac{\hat{s}Ig_{t-1}}{\hat{s}Ig}\right] + e_{Igt}; \quad (2.41)$$

$$\ln\left[\frac{\hat{p}c_{gt}}{\hat{p}c_g}\right] = \rho_{cg}\left[\frac{\hat{p}c_{gt-1}}{\hat{p}c_g}\right] + e_{cgt}; \quad (2.42)$$

$$\ln(\frac{tc_t}{tc}) = \rho_{tc}\ln(\frac{tc_{t-1}}{tc}) + m_{bg}^{tc}ln(\frac{\hat{b}g_t}{\hat{b}g}) + e_{tc_t}; \quad (2.43)$$

$$\ln(\frac{tw_t}{tw}) = \rho_{tw}\ln(\frac{tw_{t-1}}{tw}) + m_{bg}^{tw}ln(\frac{\hat{b}g_t}{\hat{b}g}) + e_{tw_t}; \quad (2.44)$$

$$\ln(\frac{tk_t}{tk}) = \rho_{tk}\ln(\frac{tk_{t-1}}{tk}) + m_{bg}^{tk}ln(\frac{\hat{b}g_t}{\hat{b}g}) + e_{tk_t} \ \& \quad (2.45)$$

$$\ln(\frac{tz_t}{tz}) = \rho_{tz}\ln(\frac{tz_{t-1}}{tz}) + m_{bg}^{tz}ln(\frac{\hat{b}g_t}{\hat{b}g}) + e_{tz_t} \quad (2.46)$$

where $\hat{b}_{gt} \equiv \frac{\hat{B}_{gt}}{P_{t-1}}$ is government borrowing in real terms at time t and ρ_i and σ_i indicate the auto-regressive coefficient and standard deviation of variable i respectively. Shocks to variable i, e_i, are assumed to be normally and independently distributed with mean 0 and variance, σ_i^2, with $i = Ig_t,\ c_{gt},\ tc,\ tw,\ tk\ \&\ \ tz.$ m_{bg}^i measures the responsiveness of tax rate, $i = tc,\ tw,\ tk\ \&\ tz$ to the deviation of government debt from its steady state.

The government borrowing in real terms, $\hat{b}_{gt+1}$, follows the stochastic process

$$\ln(\hat{b}_{gt+1}/\hat{b}_g) = \rho_{bg}\ln(\hat{b}_{gt}/\hat{b}_g) + \frac{\hat{p}cg}{\hat{b}g}e_{cgt} + \frac{\hat{s}Ig}{\hat{b}g}e_{Igt} + e_{bgt}\text{with } e_{bgt} \sim NID(0, \sigma_{bg}^2). \tag{2.47}$$

Shocks to government spending is financed by government borrowing on impact. An increase in government spending leads to a rise in government borrowing by equal amount in the initial period.

Other Exogenous Stochastic Processes

The LTV ratio, ψ_t, follows an exogenous stochastic autoregressive process:

$$\ln(\psi_t/\psi) = \rho_\psi \ln(\psi_{t-1}/\psi) + e_{\psi t} \text{ with } e_{\psi t} \sim NID(0, \sigma_\psi^2). \tag{2.48}$$

The TFP, A_t, follows an exogenous stochastic autoregressive process:

$$\ln A_t = \rho_a \ln A_{t-1} + e_{at} \text{ with } e_{at} \sim NID(0, \sigma_a^2). \tag{2.49}$$

I assume that the government targets net-export to GDP ratio, $\hat{n}xy_t$, which is characterized by an exogenous stochastic autoregressive process

$$\hat{n}xy_t - \hat{n}xy = \rho_{nxy}(\hat{n}xy_{t-1} - \hat{n}xy) + e_{nxyt} \text{ with } e_{nxyt} \sim NID(0, \sigma_{nxy}^2). \tag{2.50}$$

It implies that the government adjusts its foreign borrowing to achieve the desired net-exports to GDP ratio, since the net-export in nominal terms, $\hat{N}X_t$, satisfies

$$\hat{N}X_t = R_{zt}\hat{B}_{zt} - \hat{B}_{zt+1}. \tag{2.51}$$

I assume that the law of one price holds for the relative price of imported goods/real exchange rate, p_{zt}, in the long run and $pz = 1$. In the short-run,

p_{zt} fluctuates around its long run value and responds to government spending shocks:

$$\ln p_{zt} = \rho_{pz} \ln p_{zt-1} + m_{cg}^{pz} e_{cgt} + m_{Ig}^{pz} e_{Igt} + e_{pzt} \text{ with } e_{pzt} \sim NID(0, \sigma_{pz}^2) \quad (2.52)$$

where m_i^{pz} measures the responsiveness of real exchange rate to government spending shock $i = cgt$ & Igt. This formulation captures the effects of government spending on the real exchange rate in a reduced form. Finally, I assume that preference shock follows an autoregressive process

$$\ln \nu_t = \rho_\nu \ln \nu_{t-1} + e_{\nu t} \text{ with } e_{\nu t} \sim NID(0, \sigma_\nu^2). \quad (2.53)$$

Aggregation and Equilibrium

The definition of equilibrium is standard. The economy satisfies following market clearing conditions and resource constraints.

$$\text{Credit Market} : \hat{B}_{Et+1} = \hat{B}_{lt+1}. \quad (2.54)$$

$$\text{Intermediate Formal Goods Market} : \hat{y}_{Eft} = \hat{y}_{ft} V_{pft}. \quad (2.55)$$

$$\text{Formal Labor Market} : \hat{l}_{Rft} = \hat{l}_{ft} V_{wft}. \quad (2.56)$$

where V_{pft} and V_{wft} are measures of price and wage dispersion respectively (defined in Appendix I).

$$\text{Informal Sector Labor Market} : \hat{l}_{nt} = \hat{l}_{Rnt}. \quad (2.57)$$

$$\text{Resource Constraint Formal Goods} :$$

$$p_{ft}\hat{y}_{ft} = p_{ft}(\hat{c}_{Rft} + \hat{c}_{Efft} + \hat{c}_{Enft} + \hat{c}_{gt} + \hat{I}p_{hft} + \hat{I}p_{nt} + \hat{I}g_{ht} + \hat{n}x_t) + p_{zt}(\hat{I}p_{zt} + \hat{I}g_{zt})$$

$$+ \frac{\phi_k}{2}\left(\frac{\hat{k}p_{ft+1}}{\hat{k}p_{ft}} - 1\right)^2 \hat{k}p_{ft} + \frac{\phi_d}{2}\left(\frac{R_{ht+1}}{R_{ht}} - 1\right)^2 \frac{R_{ht+1}\hat{D}_{t+1}}{P_t} + \frac{\phi_l}{2}\left(\frac{R_{Et+1}}{R_{Et}} - 1\right)^2 \frac{R_{Et+1}\hat{B}_{et+1}}{P_t}. \quad (2.58)$$

Resource Constraint Informal Goods :

$$\hat{y}_{Ent} = \hat{c}_{Rnt} + \hat{c}_{Efnt} + \hat{c}_{Ennt}. \tag{2.59}$$

$$\hat{g}dp_t = p_{ft}\hat{y}_{ft} + p_{nt}\hat{y}_{Ent}$$
$$-\frac{\phi_k}{2}\left(\frac{\hat{k}p_{ft+1}}{kp_{ft}} - 1\right)^2 \hat{k}p_{ft} - \frac{\phi_d}{2}\left(\frac{R_{ht+1}}{R_{ht}} - 1\right)^2 \frac{R_{ht+1}\hat{D}_{t+1}}{P_t} - \frac{\phi_e}{2}\left(\frac{R_{Et+1}}{R_{Et}} - 1\right)^2 \frac{R_{Et+1}\hat{B}_{et+1}}{P_t}. \tag{2.60}$$

In equilibrium, the real price of capital/Tobin's Q, q_t, equals the real marginal cost of investment:

$$q_t = s_t\left(1 + \left(\frac{\hat{k}p_{ft+1}}{\hat{k}p_{ft}} - 1\right)\right) \quad \& \tag{2.61}$$

$$s_t = [\chi_k((1+tc_t)p_{ft})^{1-\zeta_k} + (1-\chi_k)((1+tz_t)p_{zt})^{1-\zeta_k}]^{1/1-\zeta_k}. \tag{2.62}$$

3 Empirical Approach

I use Bayesian framework to estimate models using 13 observables: (i) real GDP (ii) real private consumption expenditure (iii) real government consumption expenditure (iv) real government investment (v) real credit of commercial banks to private sector (vi) real credit of commercial banks to the government (vii) inflation rate (viii) nominal interest rate on government borrowing (ix) real sales tax revenue (x) real income tax revenue (xi) real corporate tax revenue (xii) real custom duty revenue and (xiii) the real exchange rate for the period 1970-2016 from India. As separate data for the wage tax revenue is not available, I proxy it by the income tax revenue.[8]

All data series except for the real exchange rate are taken from the *Database of Indian Economy, Reserve Bank of India* available at *https* :

[8] In the model, real tax revenues are defined as: Wage Tax Revenue = $tw_t w_{hft}\hat{l}_{Rft}$, Sales Tax Revenue = $tc_t p_{ft}(\hat{c}_{Rft} + \hat{c}_{Efft} + \hat{c}_{Enft} + \hat{c}_{gt} + \hat{I}p_{fht} + \hat{I}g_{ht})$, Profit Tax Revenue = $tk_t[p_{Eft}\hat{y}_{Eft} - w_{ft}\hat{l}_{ft} - p_{zt}(1+tz_t)\hat{v}_t]$ & Custom Duty Revenue = $tz_t p_{zt}(\hat{I}_{zt} + \hat{I}g_{zt} + \hat{v}_t)$.

//dbie.rbi.org.in. The real exchange rate data is taken from Zsolt (2020).[9] All variables other than the inflation rate, interest rate on government borrowing and real exchange rate are in terms of real per-capita (Base 2004-05). To be consistent with model variables, the inflation rate is calculated using private consumption deflator. Except for the real exchange rate, nominal variables have been converted into real variables using private consumption deflator. To filter out trends in observables, I take the log of observables and filter them using quadratic time-trend.

For estimating models, I log-linearize them. Model likelihoods are obtained using Kalman filter. For posterior simulations, I use Markov Chain-Monte Carlo (MCMC) method. I employed three chains and two hundred thousand draws were taken from each chain. I discard first 50% of draws to minimize the impact of initial values. I also control the variance of candidate distribution from which simulations are drawn to achieve the acceptance rate of around 25%.

3.1 Priors and Calibrated parameters

As is standard, I estimate a set of parameters and calibrate the rest. The choice of estimated parameters are guided by feasibility. I am able to estimate autoregressive parameters and standard deviations of exogenous shock processes, parameters of Taylor rule, fiscal policies, real exchange rate and adjustment cost parameters, ϕ_k, ϕ_d & ϕ_l.

Rest of the parameters are calibrated. The values of calibrated parameters are chosen on the basis of existing literature and to match selected long-run features of the data. A period is taken to be one year. As discussed earlier, the break-up between private and government investment is only available at the annual frequency. The values of calibrated parameters of the Benchmark model and calibration targets are reported in Table 1 and Table 3 respectively. Below I discuss in detail the calibration process for the Benchmark model. I follow the same approach for calibrating other models.

Calibration

I proxy the retail interest rate on deposit, R_{ht}, retail interest rate on loans,

[9] The data set on real effective exchange rate is prepared by Darvas Zsolt for 178 countries and is available at $https://www.bruegel.org/2012/03/real-effective-exchange-rates-for-178-countries-a-new-database/$

R_{Et}, and interest rate on government borrowing, R_{gt}, by the interest rate on 1-3 years savings deposit account, interest rate on one year loan and annual weighted average call money rate respectively. Data shows that the average interest rate on 1-3 years savings deposit, interest rate on one year loan and annual weighted average call money rate in India between 1980-2016 were equal to 1.0847%, 1.1094% and 1.0878% respectively. I set $\xi_l = 138$ and $\xi_d = -350$ so that the Benchmark model matches the steady-state values of R_h, R_E and R_g.

The average inflation rate between 1970-2016 as measured by the private consumption deflator is equal to 1.07. I set $\pi = 1.07$. In the steady-state, $\beta_R = \frac{\pi}{R_h}$, which implies $\beta_R = 0.9864$. I set β_{En} & $\beta_{Ef} = 0.96$ such that $\beta_{En} R_E$ & $\beta_{Ef} R_E < 1$. Thus, in equilibrium both types of entrepreneurs would like to borrow and the collateral constraint binds for formal entrepreneurs in the neighborhood of steady-state.

I set the elasticity of substitution between domestic and imported capital goods, $\zeta_k = 1.5$, similar to Anand et. al. (2010). The weight of domestic investment good in composite investment good, χ_k, is set equal to 0.90 to match the average ratio of import of capital goods to total imports (0.26) for the period 1980-2015 at the prior/calibrated values of other parameters.

The elasticity of substitution among formal retail goods, ξ_y, is set equal to 6, which implies the steady state mark-up of 20% ($\frac{\xi_y}{\xi_y - 1}$) as estimated by Pal and Rathore (2016). I set the elasticity of substitution among formal labor services, ξ_l, symmetrically equal to 6 as there is no evidence regarding the wage mark-up in India. I set Calvo parameter in the formal goods market, $\gamma_p = 0.25$, similar to Banerjee and Basu (2019), who estimate that average price duration at the aggregate level in India is 2.6 months. Symmetrically, I set $\gamma_w = 0.25$.

There is no evidence regarding the elasticity of substitution between formal and informal goods in consumption for India. I set the elasticity of substitution between formal and informal goods in consumption, $\zeta_c = 8$, as in Fernández and Meza (2015). To check for the sensitivity of results, I also estimate the model with lower value of $\zeta_c = 4$ reported in section 7. I set the inverse Frisch labor supply elasticity to 2, which is standard in the literature. The weight of leisure in the utility function, μ^R, is set such that the households spend approximately 1/3rd of time working at the prior/calibrated values of other parameters.

I set the elasticity of output with respect to private capital in the formal sector, $\alpha_{f1} = 0.33$. The values of elasticities of output with respect to government capital, α_{gf} & α_{gn}, relative productivity of informal sector, κ, the elasticity of output with respect to private capital in the informal sector, α_n, the share of formal goods in consumption, χ_c, and the relative disutility from working in the formal sector, ϕ_{lf}, are set such that the model matches major features of formal and informal sectors in India.

Empirical evidence shows that the informal sector accounts for 86% of total employment and approximately 50% of GDP in India (NCEUS 2007a, GOI 2012). Agriculture is the most dominant sector accounting for the vast majority of informal employment, followed by services and manufacturing sectors. The services sector is the most dominant in the formal employment followed by manufacturing sector. Evidence also shows that the average wage in the formal sector is much higher than in the informal sector. Using data from two rounds of National Sample Survey for 2004-05 and 2011-12, Kumar and Pandey (2021) find that the average wage in formal sector was approximately 3.5 times larger that the average wage in informal sector in India.

There is no evidence regarding the effect of government investment on the output of formal and informal sectors. Chatterjee et al. (2021) examine and estimate the effects of public infrastructure on the output of formal and informal manufacturing sectors in India. They find that the output of the formal manufacturing sector is much more responsive to public infrastructure relative to the informal manufacturing sector. The public infrastructure has a negligible impact on the output of informal manufacturing sector.

At the same time empirical evidence suggests that government investment has a significant positive effect on output and private investment in the agricultural sector in India (Dhawan 1998, Fan et. al. 2008, Akber and Paltasingh 2019). Given the sectoral divergence in the effects of government investment on output, I set $\alpha_{gf} = 0.16$ and $\alpha_{gn} = 0.02$ in the Benchmark model in line with the estimates of Chatterjee et al. (2021). To check for the sensitivity of results, I also estimate the model with $\alpha_{gn} = 0.05$ reported in section 7. I set $\kappa = 0.085$, $\alpha_n = 0.27$, $\chi_c = 0.25$ and $\phi_{lf} = 3.40$ so as to match the share of informal employment in total employment (0.86) and GDP (0.50) and the formal and informal sector wage differential (3.50) at the prior/calibrated values of other parameters.[10]

[10] $\phi_{lf} > 0$ is needed because at margin households are going to be indifferent between working in formal and informal sectors. The tax on wage income in India is not large

The values of remaining calibrated parameters are set to match steady-state values of macro-aggregates in India. The elasticity of imported intermediate good in formal production, α_{f2}, the depreciation rate, δ, the steady-state levels of government consumption, pc_g, government investment, sI_g, and net-exports to GDP ratio, nxy, are set to match average private consumption to GDP ratio (0.66), private investment to GDP ratio (0.16), government investment to GDP ratio (0.09), government final consumption expenditure to GDP ratio (0.11) and net-exports to GDP ratio (-0.019) for the period 1970-2016. The steady state government domestic borrowing in real terms, bg, cash-reserve ratio, CRR, and loan-to-value ratio, ψ, are set to match the average commercial bank credit to government to deposit ratio (0.28), commercial bank credit to central bank to deposit ratio (0.08) and deposit to GDP ratio (0.40) respectively for the period 1970-2016. Steady state rates of wage tax, τ_w, sales tax, τ_c, corporate tax, τ_k, and custom duty, τ_z, are set to match average income tax revenue to GDP ratio (0.007), sales tax revenue to GDP ratio (0.061), corporate tax revenue to GDP ratio (0.015), and custom duty revenue to GDP ratio (0.02) for the period 1970-2016. Data suggests that indirect taxes, particularly sales tax, are far more important than direct taxes in terms of total tax revenue.

Priors

Priors for the parameters of Benchmark model are given in Table 4. In choosing priors, I largely follow previous literature. I choose Beta distribution with support [0, 1] for autoregressive coefficients, ρ_i, and the elasticity of tax rates to government debt, m^i_{bg}. For m^i_{bg}, I set their prior standard deviation to be 50% of their prior mean. For the auto-regressive coefficients, in general I set their prior standard deviation to be 25% of their prior mean except for the cases in which it leads to unbounded density. For these coefficients ($\rho_\psi,\ \rho_{rg},\ \rho_{tk},\ \rho_{tz}$ & ρ_{pz}), I set their prior standard deviation to be 15% of their prior mean.

For the standard deviation of structural shocks, σ_i, I choose very diffuse Inverse-Gamma distribution. For these parameters, I set their prior standard

enough to generate the observed wage differential between these two sectors. One can think of ϕ_{lf} as a reduced form of disutility incurred in obtaining formal jobs. One potential way to generate such a wage differential is to use search and matching framework as in Castillo and Montoro (2010), Shapiro (2015), and Anand and Khera (2015). The interaction among the labor market search, financial frictions and government spending is left for future research.

deviation to be infinity. For adjustment cost parameters ϕ_k, ϕ_d, and ϕ_l and Taylor rule parameters η_π and η_y, I assume that they are drawn from the Gamma distribution. For adjustment cost parameters, I set their prior standard deviation equal to 25% of their prior mean. As there is considerable uncertainty about monetary policy rules followed by the central bank in India, I set prior standard deviation of η_π and η_y equal to 50% of their prior mean.

Das (2015) estimates pass-through of shocks to policy rate to bank interest rates using monthly data from 2002:3-2014:10 for India. She finds that the pass-though is much faster for deposit rates than loan rates with the estimated duration of 50% pass-through to deposit rate and loan rate of 4.1 months and 8.1 months respectively. I set $\phi_d = 6$ and $\phi_l = 40$ such that the model generates pass-through of policy rates to interest rates similar in magnitude to Das (2015) at the prior/calibrated parameter values.

I set $\rho_a = 0.41$ and $\sigma_a = 0.013$, the values estimated by Ghate et. al. (2016) for the TFP process in India for the period 1992-2010. To set prior values of parameters of Taylor rule, I estimate (2.35) using filtered data of annual yield on 1-5 years government bond, per-capital real GDP, and inflation rate for the period 1980-2016. The estimation implies that $\rho_{rg} = 0.82$, $\eta_y = 0.35$, $\eta_\pi = 1.50$ and $\sigma_{rg} = 0.005$.

Similarly, to set prior mean of auto-regressive coefficients (ρ_{cg}, ρ_{Ig}, ρ_{bg}, ρ_{nxy} ρ_{pz}, ρ_{tw}, ρ_{tc}, ρ_{tk}, and ρ_{tz}), and their standard deviations, (σ_{cg}, σ_{Ig}, σ_{bg}, σ_{nxy} σ_{pz}, σ_{tw}, σ_{tc}, σ_{tk}, and σ_{tz}), I estimate the first order autoregressive process for these variables using filtered data for the period 1970-2016. I set their priors equal to estimated values.

Priors of elasticities of tax rates to government borrowing, m^{tc}_{bg}, m^{tz}_{bg}, m^{tk}_{bg} & $m^{tz}_{bg} = 0.13$ are chosen such that the increased tax revenue from distortionary taxes covers the additional debt repayment inclusive of interest rate. There is substantial degree of uncertainty about the response of real exchange rate to government spending, with some empirical studies finding that a higher government spending leads to an appreciation in real exchange rate (e.g. Kim and Roubini 2008), while others find that it leads to a depreciation (e.g. Ravn et. al. 2012). To reflect this uncertainty, I assume that m^{pz}_{cg} and m^{pz}_{Ig} are normally distributed with mean 0 and standard deviation of 0.25. Finally, I set ϕ_k, ρ_ν, σ_ν, ρ_ψ and σ_ψ such that the model matches the persistence and volatility of private consumption, private investment and bank credit to private sector in India at calibarted/prior mean values of parameters.

4 Posterior Estimation

Estimated posterior distributions for the Benchmark model are summarized in Table 5. Second and third columns of table report the posterior mean and its 90% credible interval respectively.

Estimation results show that all shocks except for the TFP, government borrowing, policy rate and net-exports to GDP ratio processes are very persistent. The posterior 90% intervals of parameters of shocks processes and Taylor rule are much narrower than their prior 90% interval suggesting that data is very informative about these parameters. The posterior mean of policy rate response to inflation, η_π, at 1.05 is somewhat lower than the values commonly used in the literature (usually between 1.5 to 2.5). However, it is in line with the empirical evidence from India that the central bank has been less responsive to inflation particularly prior to 2000's (Hutchinson *et. al.* 2010, Singh 2010). The posterior mean of elasticity of sales tax rate to government debt, m_{bg}^{tc}, and custom duty, m_{bg}^{tz}, are lower than their prior means. But they are not estimated precisely. The mean estimate of m_{cg}^{pz} (-0.1223) suggests that a higher government consumption spending leads to an appreciation of real exchange rate. But its estimate is not statistically different from zero. Similarly, data suggests that government investment spending has an insignificant effect on the real exchange rate. Data is not very informative about the adjustment cost parameters, ϕ_l, ϕ_d and ϕ_k as they are not precisely estimated.

Matching Moments

In Table 6, I compare cross-correlations and volatility of key macroeconomic variables generated by the estimated model relative to data.[11] Results show that the estimated model does well in matching the correlation pattern of GDP with private consumption, private investment, government investment and borrowing. It generates pro-cyclical aggregate deposit and credit to private sector and government consumption as in data. However, it underestimates their pro-cyclicality. The model matches well the volatility of GDP, private consumption, private investment, aggregate deposit, credit to private sector and government consumption and investment.

Variance Decomposition

[11] Values of estimated parameters are set at their posterior mean.

Table 7 reports the variance decomposition. Results show that the majority of variations in GDP is explained by shocks to TFP (29%) and net-exports to GDP ratio (22%). Other major drivers of variations in GDP are shocks to government investment and leverage ratio. Shocks to leverage ratio account for majority of variations in private investment (58%), aggregate deposit (70%) and credit to private sector (91%). Shocks to policy rate also play an important role in explaining fluctuations in private investment. Variations in private consumption are mainly explained by shocks to TFP (40%) and net export to GDP ratio (21%). Shocks to government borrowing account for a significant share of variations in aggregate deposit (16%). Overall results show that shocks originating in credit market play a major role in accounting for variations in macro-aggregates in India.

Impulse Response

Figures 1 and 2 depict impulse responses of key macro-variables to a 1% positive shock to government consumption and investment respectively with values of estimated parameters set at their posterior mean. Figure 1 shows that real GDP (gdp), real private investment, labor supply and inflation rate increase in response to a positive shock to government consumption on impact. However, real private consumption falls.

Formal and informal sectors respond differently to a positive government consumption shock. Real GDP (gdp_F), employment, real private investment and the price of final good in the formal sector rise. But, real GDP (gdp_N), employment, real private investment and the price of good in the informal sector fall.[12] The informal real wage rises. But the formal real wage falls. The impulse response also shows that the fall in private consumption is due to a decline in consumption of households. But the consumption of entrepreneurs increases.

Similar to a standard new-Keynesian model, a positive government consumption shock increases the aggregate demand for formal goods leading to a higher relative price of formal goods and formal sector GDP and employment. It incentivizes formal entrepreneurs to increase their consumption and private investment. A fall in the marginal product of labor in the formal sector reduces formal real wage. The relative price of informal goods falls, which reduces informal sector GDP and employment and private investment of informal entrepreneurs. A rise in the marginal product of labor in the

[12] $gdp_{Nt} \equiv p_{nt} y_{Ent}$ and $gdp_{Ft} \equiv gdp_t - gdp_{Nt}$

informal sector raises informal real wage. A fall in wage bill and private investment leads to a rise in consumption of informal entrepreneurs despite a fall in their income.

The negative wealth effect due to an expected increase in taxes reduces consumption of households and increases their labor supply. The total real GDP, private invetment and employment rise despite a fall in the informal sector real GDP, private investment and employment. A rise in the price of formal goods results in higher inflation.

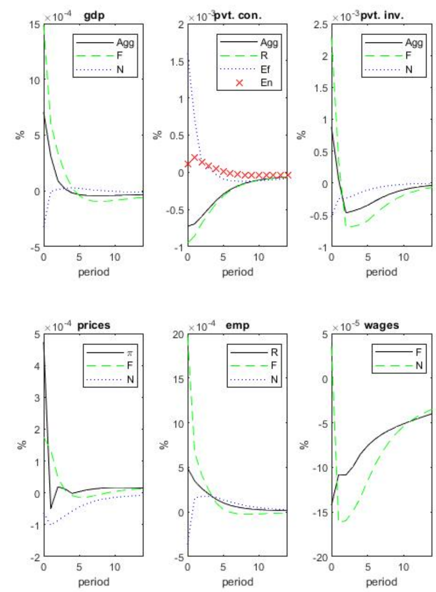
The model has additional effects due to separation between entrepreneurs and households and collateral constraint. A rise in demand for investment good increases Tobin's Q, which further encourages investment by formal entrepreneurs. In the model, a rise in investment and consumption of entrepreneurs moderates the fall in aggregate demand due to negative wealth effect compared to a standard New-Keynesian model.[13]

The impulse response also shows that the informal sector real GDP and employment rise above their steady-state values following their initial fall before converging back to their steady-state. Also the relative price of informal goods falls further before it starts increasing. The reason is that a rise in formal sector private investment increases future formal sector private capital stock. Thus relatively less workers are needed to produce a given amount of formal goods. As the formal sector output is demand constrained, formal sector employment falls relatively more. But as the labor supply remains at the elevated level, more workers are absorbed in the informal sector. To accommodate the increased supply of informal goods the price of informal goods falls further.

A rise in formal sector private investment leads to a higher future marginal productivity and a lower marginal cost in the formal sector. It induces formal retailers who can change their prices to reduce their prices. At the same time a continuing fall in the price of informal goods results in the inflation rate falling below its steady-state value following its initial increase before converging back to its steady-state.

[13]For example, in the Smets and Wouters (2007) model, a positive government consumption shock reduces private investment.

Figure 1: Effects of a Positive Government Consumption Shock (in%)

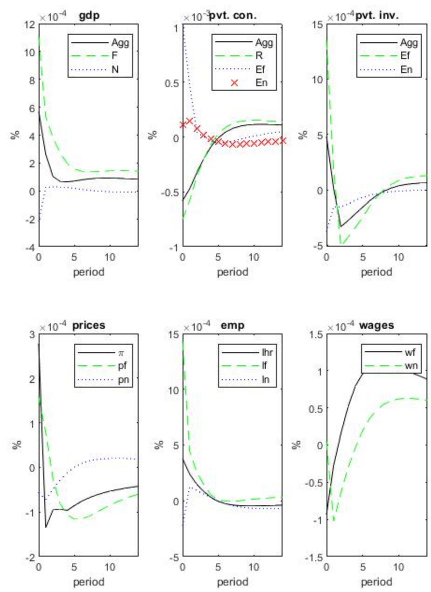


Note: Agg- Aggregate, F-Formal Sector, N- Informal Sector, R-Households, Ef- Formal Entrepreneurs, En- Informal Entrepreneurs

The impulse response to a positive government investment shock is qualitatively similar to a positive government consumption shock (Figure 2). The main difference is that the real GDP and formal sector real GDP remain elevated for a longer period relative to government consumption shock. Also after the initial rise, inflation rate and the price of formal goods fall much more before converging back to their steady-state.

A higher government investment increases demand for formal goods similar to an increase in higher government consumption. It addition it increase the future productivity, particularly of formal sector. Thus the real GDP and formal sector real GDP remain elevated for a longer period. A higher future productivity raises future marginal product of private inputs and lowers future marginal cost in the formal sector which induces formal retailers who can change their prices to reduce their prices relatively more. Thus inflation rate and the price of formal goods fall relatively more before converging back to their steady-state.

Figure 2: Effects of a Positive Government Investment Shock (in%)



Note: Agg- Aggregate, F-Formal Sector, N- Informal Sector, R-Households, Ef- Formal Entrepreneurs, En- Informal Entrepreneurs

5 Other Forms of Financial Frictions

As discussed earlier, a significant proportion of households do not have access to formal banking sector in India (Demigruc-Kunt and Klapper 2013, RBI 2014, Badrinza et. al. 2017). These households generally have low income and mainly work in low paying informal jobs. They are a major source of labor for the informal sector. In addition, the existing literature on government consumption multipliers shows that the presence of financially-excluded households weakens the negative wealth effective on private consumption and it can significantly enhance government consumption multiplier (e.g. Gali et. al. 2007, Leeper et. al. 2017).

Financial repression has been an important source of revenue for the government in India, as discussed earlier.[14] In order to reduce the cost of

[14] The instruments of financial repression include high reserve requirement for commercial banks, requirements that banks hold government debt issued at low interest rate and

borrowing the Indian government uses both quantitative and pricing restrictions in allocation of credit by the financial sector. In essence, these policies have aimed to create captive domestic market for government bonds and to reduce arbitrage opportunity for banks between lending to the private sector and to the government and the central bank.

In this section, I extend the Benchmark model to incorporate financially-excluded households and financial repression to examine their role in shaping government spending multipliers and explaining macro-economic features of India. In the model with financially-excluded households, now we have both financially-excluded entrepreneurs and financially-excluded (worker) households. In addition, I also examine a model with competitive banking to examine the role of monopolistic competition in banking sector in matching and explaining macro-economic dynamics of India.

Non-Ricardian Households

Assume that households are of two types: Ricardian (R) and non-Ricardian (NR). Fraction $\theta \in (0,1)$ of households are Ricardian and $1-\theta$ fraction non-Ricardian. Non-Ricardian households do not have access to financial markets unlike Ricardian households and they consume their income every period. They supply their labor only to the informal sector. This is consistent with the evidence that these households are relatively poor and are employed in low productivity activities. Ricardian households are modeled identical to households in the Benchmark model.

The representative non-Ricardian household maximizes its expected utility

$$E_0 \sum_{t=0}^{\infty} \beta_{NR}^t \left[\ln c_{NRt} - \frac{\mu_{NR}}{1+\tau} l_{NRt}^{1+\tau} \right]$$

subject to its budget constraint

$$c_{NRt} = w_{nt} l_{NRt} + \hat{tr}_t \;\forall\; t \geq 0 \tag{5.1}$$

given prices and laws of motion for exogenous stochastic processes. β_{NR} is the discount rate and tr_t is the real lump-sum transfer received by a non-Ricardian household which follows the stochastic process:

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capital account controls. It is widely recognized that financial repression has been one of the important causes of weak monetary transmission mechanism in India (e.g. RBI 2014, Lahiri and Patel 2016).

$$\ln(\frac{\hat{tr}_t}{\hat{tr}}) = \rho_{tr} \ln(\frac{\hat{tr}_{t-1}}{\hat{tr}}) - m_{bg}^{tr} ln(\frac{\hat{bg}_t}{\hat{bg}}) + e_{tr_t} \tag{5.2}$$

where m_{bg}^{tr} is the elasticity of lump-sum transfer to the deviation of government borrowing from its steady-state. The demand for formal and informal consumption goods by non-Ricardian households is continued to be given by (2.3) and (2.4) respectively with $i = NR$.

The introduction of non-Ricardian households modifies resource constraints and labor and credit market conditions. All the equilibrium conditions are listed in Appendix A1.

The model with non-Ricardian households has six additional parameters (β_{NR}, θ, tr, ρ_{tr}, m_{bg}^{tr} & σ_{tr}) compared to the Benchmark model. As discussed below, I calibrate θ and tr and estimate ρ_{tr}, m_{bg}^{tr} & σ_{tr}.[15]

Financial Repression

Now I add financial repression to the Benchmark model. The main difference from the Benchmark model is that the government and the central bank decide how much credit wholesale banks must provide to them at administered interest rates. They can loan the remaining deposits to retail loan banks.[16] The central bank pays zero net nominal interest rate on its borrowing.[17]

In this environment, the zero profit condition for wholesale branch implies that

$$R_{lt+1} = \frac{R_{dt+1} - R_{gt+1} slr_t - crr}{1 - crr - slr_t} \tag{5.3}$$

where $slr_t \equiv \frac{\hat{B}_{gt+1}}{\hat{D}_{t+1}}$ is the ratio of value of government borrowing to deposits at time t. Rest of the model structure remains as in the Benchmark model.

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[15]The value of β_{NR} does not matter as these households consume their entire income every period.

[16]This approach of introducing financial repression is common in the literature (e.g. Chari et. al. 2020, Banerjee et. al. 2020).

[17]See the Master Circular - Cash Reserve Ratio (CRR) and Statutory Liquidity Ratio (SLR) of the Reserve Bank of India available at *https://rbidocs.rbi.org.in/rdocs/notification/PDFs/98MNDADA89616D1B44C1B8106ED375AE0E57.PDF*.

Model with Competitive Banking and Flexible Retail Interest Rates

In this model, I assume that retail banks have no market power ($\xi_l = \infty$ & $\xi_d = -\infty$) and they can freely adjust their interest rates ($\phi_l = \phi_d = 0$). In this case,

$$R_{ht+1} = R_{dt+1} = R_{gt+1} = R_{Et+1} = R_{lt+1}. \tag{5.4}$$

Rest of the model structure remains as in the Benchmark model. For this model, I do not estimate adjustment cost parameters ϕ_l and ϕ_d.

Calibration and Estimation Results

I follow the same approach in calibrating and estimating parameters of these models as for the Benchmark model. These models are calibrated in order to match calibration targets given in Table 3, which required changing values of some of the parameters. The new values of these parameters are reported in Table 2. Priors of estimated parameters for the model with financial repression and the model with competitive banking are same as in the Benchmark model.

Table 8 reports estimation results of alternative models. For brevity, I only report posterior mean of estimated parameters for these models. The estimation results show that the log marginal data density (Laplace) of model with competitive banking (698.36) is much lower than that of Benchmark model at 707.47. Data strongly favors the Benchmark model over the model with competitive banking, which highlights the importance of incorporating monopolistic competition in the banking sector with sticky interest rates in the model. Data also favors the Benchmark model over the model with financial repression, but not strongly (log marginal data density=704.73). In terms of parameter estimates, mean parameter estimates of both these models are similar to the Benchmark model.

The Global Findex Database, World Bank reports that only 35% of individual 15 years and above had bank account in 2011 in India.[18] Accordingly for the model with non-Ricardian households, I set $\theta = 0.35$. The data shows that government expenditure on food-subsidy averaged 1% in India during 1980-2016. I set the value of tr is such that the total transfer to non-Ricardian households equals 1% of GDP. Finally, I set the value of μ_{NR}

[18]Data available at $https : //www.worldbank.org/en/publication/globalfindex/Data$.

such that non-Ricardian households spend approximately one-third of their time working.

ρ_{tr} and σ_{tr} are assumed to have Beta and inverse-Gamma distributions respectively. To set the prior mean and standard deviation of these two parameters, I estimate the first-order autoregressive process for a filtered data of the real food-subsidy in India for 1980-2016 period. Accordingly, I set the prior mean of ρ_{tr} equal to 0.60 with the standard deviation of 0.15. The prior mean of σ_{tr} is set equal to 0.02 with the standard deviation of ∞. m_{bg}^{tr} assumed to be normally distributed with the prior mean and standard deviation of 0.13 and 0.065 respectively. Priors for the rest of estimated parameters are same as in the Benchmark model.

Table 8 reports the posterior mean of estimated parameters for the model with non-Ricardian households. The estimation result shows that data very strongly favors the Benchmark model over the model with non-Ricardian households with $\theta = 0.35$ (log marginal data density=413.89). Since there is less consumption-smoothing due to a high share of non-Riacardian households, the model generates strongly pro-cyclical private consumption (0.49), while in the data its is mildly pro-cyclical. Also private consumption becomes much more volatile.

To further explore the role of non-Ricardian households, I also estimate the model with higher values of $\theta = 0.50$ & 0.90. I find that data strongly favors models with higher values of θ. The log marginal data densities of model with $\theta = 0.50$ and $\theta = 0.90$ are 592.99 and 707.86 respectively. These results suggest that within the class of models (for the given set of observables) analyzed in this paper, the inclusion of financially-excluded entrepreneurs obviates the need to include the financially-excluded households.

As the log marginal densities of the Benchmark model and the model with low share of non-Ricardian households ($\theta = 0.90$) are similar, I use posterior distribution of parameters of these two models to quantify government spending multipliers. Also since data does not strongly favor the Benchmark model over the model with financial repression, I also quantify government spending multipliers for the model with financial repression for comparison purpose.

6 Posterior Government Spending Multipliers

Using posterior distribution of parameters, I calculate impact and present value government spending multipliers commonly used in the literature:

$$\text{Impact Spending Multiplier} \equiv \frac{\Delta X_t}{\Delta F_t} \ \& \tag{6.1}$$

$$\text{Present Value of Spending Multiplier} \equiv \frac{E_t \sum_{j=0}^{k} r_{ht+1}^{-j} \Delta X_{t+j}}{E_t \sum_{j=0}^{k} r_{ht+1}^{-j} \Delta F_{t+j}}$$

$$\text{with } X_t = gdp_t,\ c_{pt} \ \& \ Ip_t \ \& \ \ F_{t+j} = pc_{gt+j} \ \& \ sIg_{t+j} \tag{6.2}$$

where $r_{ht+1} \equiv E_t \frac{R_{ht+1}}{\pi_{t+1}}$ is the real retail interest rate on deposits between periods t and $t+1$. I report present value multipliers for 10 and 25 years. In all the results, multipliers are calculated as a change in $gdp_t,\ pc_{pt}$ & sIp_t relative to their steady-state values in response to 1% initial rise in government consumption or investment from its steady-state.[19]

For the calculation of multipliers, I simulate selected models by independently drawing 20,000 values of parameters from estimated posterior distributions. The mean values of estimated multipliers for government consumption and investment and their 95% interval for the Benchmark model are reported in Table 9. For comparison purpose, I also report mean values of multipliers and their 95% interval based on prior distributions in Table 10. Table 12 shows the values of spending multipliers based on alternative models of financial frictions. For brevity, I only report their mean values.

The comparison of posterior and prior government spending multipliers of the Benchmark model shows that data is very informative about spending multipliers. The posterior 95% intervals of both government consumption and investment multipliers are much narrower than their prior 95% intervals.

Table 9 shows that the mean output multiplier of government consumption is positive at all horizons. Its size falls over time with mean impact and 25-years present value multiplier being 0.72 and 0.60 respectively. The 95%

[19] For example impact output multiplier of government consumption is calculated as $\frac{\%\Delta gdp_t}{\%\Delta pc_{gt}} \frac{gdp}{pc_g}$.

interval of output multiplier suggests that output multiplier of government consumption is likely to be below one at all horizons.

The analysis finds that the mean value of impact output multiplier of government investment at 0.61 is smaller than the impact output multiplier of government consumption. However, the output multiplier of government investment increases over time. The mean 25-years present value output multiplier of government investment is 1.09.

Results from the model with financial repression and non-Ricardian households ($\theta = 0.90$) are essentially the same (Table 12), with the mean output multiplier of government consumption and government investment being similar to the Benchmark model. The time pattern of output multipliers is also similar with the mean output multiplier of government consumption falling over time and the mean output multiplier of government investment rising over time.

The response of output to government spending shocks is consistent with the SVAR evidence from India. Goyal and Sharma (2018) estimate output multipliers of central government revenue expenditure and capital expenditure using data from 1998:Q1-2014:Q1. Their estimate suggests that the impact revenue expenditure multiplier and impact capital expenditure multiplier are significantly below one. They also find that the size of capital expenditure multiplier increases with time, while revenue expenditure multiplier declines. Yadav et. al. (2012) using data from 1997:Q1-2009:Q2 find similar pattern.

The analysis also finds that government consumption has a negative impact on private consumption at all horizons. Government investment crowds out private consumption on impact. However, it has an insignificant effect on private consumption over long run. Government consumption has a marginally positive effect on private investment on impact. But government investment has an insignificant effect on private investment at all horizons.

7 Discussion

As discussed earlier, there is considerable uncertainty about the value of elasticity of production w.r.t. government capital in the informal sector, α_{gn}, and the value of elasticity of consumption between formal and informal goods, ζ_c. α_{gn} directly affects the productivity of private inputs in the informal sector. ζ_c governs the ease of substitution between formal and informal goods in consumption and affects the elasticity of demand with respect to their relative prices.

Also major structural reforms took place in 1991 in India which were focused on deregulating and opening of Indian economy. There is evidence that economic dynamics have changed in the post-reform period (Ghate et. al. 2013, Banerjee and Basu 2019). In addition, in the post-reform period the central bank also changed the conduct and operating procedure of monetary policy moving away from financial repression to a more market based interest rates (Hutchinson *et. al.* 2010, Singh 2010).

To analyze the sensitivity of results, I reestimate the Benchmark model for a higher value of $\alpha_{gn} = 0.05$ and a lower value of $\zeta_c = 4$ and calculate spending multipliers. I also reestimate the Benchmark model using only post-reform period data and examine whether these spending multipliers have changed during this period. For the models with $\alpha_{gn} = .05$ and $\zeta_c = 4$, the values of some of the calibrated parameters needed to be changed in order to match calibration targets given in Table 3. The new values of these parameters are reported in Table 2.

For all these models, I keep the prior distribution of estimated parameters same as in the Benchmark model. The posterior mean values of estimated parameters are given in Table 11. Estimation results show that the log marginal densities of model with $\alpha_{gn} = 0.05$ and $\zeta_c = 4$ at 707.10 and 705.01 respectively are similar to that of the Benchmark model. Also the values of estimated parameters are similar.

Similar to previous exercises, I simulate estimated models using the posterior distributions and calculate government spending multipliers. For brevity, I only report mean values of multipliers (Table 12). Results show that the size and time pattern of government spending multipliers for the model with higher α_{gn} are essentially the same as for the Benchmark model. However, the mean impact government spending multipliers for the model with lower ζ_c are higher particularly for government investment. The reason is that with lower ζ_c the consumption of informal goods and thus the output of informal sector falls relatively less in response to a positive government spending shock leading to higher impact government spending multipliers.

Post-Reform Period (1992-2016)

The estimation result for post-reform period shows that the policy interest rate has become much more responsive to inflation with the mean estimate of η_π at 1.8271. This is significantly higher than its value (1.0514) estimated using full data set (Table 11).[20] This result is consistent with the evidence that the central bank in India has become much more responsive to inflation starting 2000's (Hutchinson *et. al.* 2010, Singh 2010). Estimates also show that the profit tax and custom duty have become more sensitive to government borrowing and the TFP process has become less volatile. The result that the TFP process has become less volatile in the post-reform period is consistent with the finding of Banerjee and Basu (2020) that TFP shocks have become less prominent in accounting for macro-economic volatility in India in the post-reform period.

Regarding posterior government spending multipliers, results show a fall in the mean government consumption multiplier particularly at longer horizons compared to results based on full data set (Table 12). The mean impact government consumption multiplier at 0.62 remain significantly higher than zero, but the present value of 10-years and 25-years government consumption multiplier are not significantly different from zero. As inflation rises due to higher aggregate demand, the central bank increases policy rate relatively more. Thus the real interest rate rises more leading to a larger displacement of private consumption and investment over longer horizons. The size and time pattern of mean government investment multiplier remains similar to that based on the entire data set. Overall these results show that government consumption has limited efficacy in stimulating economy.

8 Conclusion

In this paper, I developed and estimated a two-sector new-Keynesian DSGE model with two types of entrepreneurs: formal and informal using data from India. The model incorporates a rich set of financial frictions commonly found in developing countries. Informal entrepreneurs are financially-excluded and the banking sector is monopolistically competitive featuring collateral constraint and sticky interest rates. In addition, it also analyzed effects of financial repression and financially-excluded worker households. Using the posterior estimates of parameters, it quantified government consumption and investment multipliers in India.

It finds that the impact output multipliers of both government consumption and investment are significantly less than one, suggesting that govern-

[20] The 90% HPD interval of η_π using the full data set is $[0.9020, 1.2110]$. Its 90% using only the post-reform period data is $[1.5364, 2.1123]$.

ment spending may not be very effective tool in stimulating economy in the short run. However, in the long run the output multiplier of government investment becomes approximately one. It also finds that government investment has an insignificant effect on private investment. While it does not crowd out private investment, it also does not stimulate private investment.

Appendix 1

Equilibrium Conditions: Model with Riacardian and Non-Ricardian (Worker) Households

Let $b_{ct} = \frac{B_{ct}}{P_{t-1}}$, $b_{Et} = \frac{B_{Et}}{P_{t-1}}$, $d_t = \frac{d_t}{P_{t-1}}$ and $nx_t = \frac{NX_t}{P_t}$. Denote the total nominal deposit received by a wholesale bank as $\tilde{D}_t$ and let $\tilde{d}_{t+1} = \frac{\tilde{D}_{t+1}}{P_t}$.

$$1 = \chi_c((1 + tc_t)p_{ft})^{1-\zeta_c} + (1 - \chi_c)p_{nt}^{1-\zeta_c}; \tag{A1}$$

$$c_{ift} = \chi_c c_{it}((1 + tc_t)p_{ft})^{-\zeta_c} \ \& \tag{A2}$$

$$c_{int} = (1 - \chi_c)c_{it}p_{nt}^{-\zeta_c} \tag{A3}$$

for $i = R, N, Ef$ & En.

Ricardian Households

Let λ_{ct}^R be Langrangian multiplier associated with the budget constraint of the representative Ricardian household (2.10). Then the first order conditions are given by

$$c_{Rt} \ : \ \frac{1}{c_{Rt}} = \lambda_{ct}^R; \tag{A4}$$

$$l_{Rt} \ : \mu_R \phi_{lf} l_{Rt}^{\tau} = (1 - tw_t) w h_{ft} \lambda_{ct}^R; \tag{A5}$$

$$l_{Rnt} : (1 - tw_t) w h_{ft} = \phi_{lf} w_{nt} \tag{A6}$$

$$l_{Rt} = \phi_{lf} l_{Rft} + l_{Rnt} \tag{A7}$$

$$d_{t+1} : \ \lambda_{ct}^R = \beta_R E_t \lambda_{ct+1}^R \frac{R_{ht+1}}{\pi_{t+1}}. \tag{A8}$$

Non-Ricardian Households

Let λ_{ct}^{NR} be Langrangian multiplier associated with the budget constraint of representative non-Ricardian household (5.1). Then the first order conditions are given by

$$c_{NRt} \;:\; \frac{1}{c_{NRt}} = \lambda_{ct}^{NR} \;\& \tag{A9}$$

$$l_{NRt} \;:\; \mu_{NR} l_{NRt}^{\tau} = w_{nt}\lambda_{ct}^{NR}. \tag{A10}$$

$$c_{NRt} = w_{nt} l_{NRt} + tr_t. \tag{A11}$$

Informal Sector Entrepreneurs

$$l_{nt}:\; w_{nt} = (1-\alpha_n)\frac{p_{nt} y_{Ent}}{l_{nt}}; \tag{A12}$$

$$kp_{nt+1}:\; (1+tc_t)\frac{p_{ft}}{c_{Ent}} = \beta_{En}\frac{1}{c_{Ent+1}} E_t\left(\alpha_n \frac{p_{nt+1} y_{Ent+1}}{kp_{nt+1}} + 1 - \delta\right); \tag{A13}$$

$$kp_{nt+1} = Ip_{nt} + (1-\delta)kp_{nt}; \tag{A14}$$

$$y_{Ent} = \kappa A_t kg_t^{\alpha_{gn}} kp_{nt}^{\alpha_n} l_{nt}^{1-\alpha_n} \;\& \tag{A15}$$

$$c_{Ent} = p_{nt} y_{Ent} - w_{nt} l_{nt} - (1+tc_t) p_{ft} Ip_{nt}. \tag{A16}$$

Formal Sector Entrepreneurs

$$l_{ft}:\; w_{ft} = (1-\alpha_{f1}-\alpha_{f2})\frac{p_{Eft} y_{Eft}}{l_{ft}}; \tag{A17}$$

$$v_t:\; (1+tz_t)p_{zt} = \alpha_{f2}\frac{p_{Eft} y_{Eft}}{v_t}; \tag{A18}$$

$$kp_{ft+1}:\; s_t q_t \frac{1}{c_{Eft}} - \psi_t \lambda_{kt} E_t \pi_{t+1} q_{t+1} =$$

$$\beta_{Ef}\frac{1}{c_{Eft+1}}E_t\left(r^k_{t+1}(1-\tau_{kt+1})+s_{t+1}\left(1-\delta-\frac{\phi_k}{2}\left(\frac{kp_{ft+2}}{kp_{ft+1}}-1\right)^2+\phi_k\left(\frac{kp_{ft+2}}{kp_{ft+1}}-1\right)\frac{kp_{ft+2}}{kp_{ft+1}}\right)\right); \quad (A19)$$

$$b^e_{t+1}:\ \frac{1}{c_{Eft}}-\lambda_{kt}R_{Et+1}=\beta_{Ef}E_t\frac{1}{c_{Eft+1}}\frac{R_{Et+1}}{\pi_{t+1}}; \quad (A20)$$

$$b^e_{t+1}R_{Et+1}=\psi_t kp_{ft+1}E_t q_{t+1}\pi_{t+1}; \quad (A21)$$

$$Ip_{hft}:\ Ip_{hft}=\chi_k\Big(\frac{s_t}{(1+\tau_{ct})p_{ft}}\Big)^{\zeta}_k Ip_{ft}; \quad (A22)$$

$$Ip_{zt}:\ Ip_{zt}=(1-\chi_k)\Big(\frac{s_t}{(1+\tau_{zt})p_{zt}}\Big)^{\zeta}_k Ip_{ft}; \quad (A23)$$

$$kp_{ft+1}=Ip_{ft}+(1-\delta)kp_{ft}-\frac{\phi_k}{2}\left(\frac{kp_{ft+1}}{kp_{ft}}-1\right)^2 kp_{ft}; \quad (A24)$$

$$y_{Eft}=A_t kg_t^{\alpha_{gf}}kp_{ft}^{\alpha_{f1}}v_t^{\alpha_{f2}}l_{ft}^{1-\alpha_{f1}-\alpha_{f2}}; \quad (A25)$$

$$s_t:\ s_t=[\chi_k((1+tc_t)p_{ft})^{1-\zeta_k}+(1-\chi_k)((1+tz_t)p_{zt})^{1-\zeta_k}]^{1/1-\zeta_k}; \quad (A26)$$

$$rk_t=\alpha_1\frac{p_{Eft}y_{Eft}}{kp_{ft-1}}\ \& \quad (A27)$$

$$c_{Eft}+RE_{t-1}\frac{be_t}{\pi_{t-1}}+s_t Ip_{ft}=be_{t+1}+(1-tk)[p_{Eft}y_{Eft}-w_{ft}l_{ft}-p_{zt}v_t]. \quad (A28)$$

Final Good and Retail Goods Producers: Formal Goods

In the symmetric equilibrium, $p^*_{ft}(i)=p^*_{ft}\ \forall\ i$. The optimal price of formal retail goods, p^*_{ft}, is given by

$$p^*_{ft}:\ (\xi_{yf}-1)f_{1t}=\xi_{yf}f_{2t}; \quad (A29)$$

where

$$f_{1t} = \lambda_{ct}^{R} y_{ft}^{*} p_{ft}^{*} + \gamma_{pf} \beta_{R} E_{t} f_{1t+1} \ \& \tag{A30}$$

$$f_{2t} = \lambda_{ct}^{R} y_{ft}^{*} p_{eft} + \gamma_{pf} \beta_{R} E_{t} f_{2t+1}. \tag{31}$$

The demand function for formal retail goods at price, p_{ft}^{*}, is given by

$$y_{ft}^{*} \ : \ y_{ft}^{*} = y_{ft} {p_{ft}^{*}}^{-\xi_{yf}}. \tag{A32}$$

Formal Sector: Labor Packers and Unions

In the symmetric equilibrium, $w_{ft}^{*}(j) = w_{ft}^{*} \ \forall \ j$. The optimal real wage in the formal sector, w_{ft}^{*}, is given by

$$w_{ft}^{*} : \ (\xi_{lf} - 1) g_{1t} = \xi_{lf} g_{2t} \tag{A33}$$

where

$$g_{1t} = \lambda_{ct}^{R} l_{ft}^{*} w_{ft}^{*} + \gamma_{wf} \beta_{R} E_{t} g_{1t+1} \ \& \tag{A34}$$

$$g_{2t} = \lambda_{ct}^{R} l_{ft}^{*} w h_{ft} + \gamma_{wf} \beta_{R} E_{t} g_{2t+1}. \tag{A35}$$

The demand for jth type of labor in the formal sector at real wage, w_{ft}^{*}, is given by

$$l_{ft}^{*} : \ l_{ft}^{*} = l_{ft} \left(\frac{w_{ft}^{*}}{w_{ft}} \right)^{-\xi_{lf}}. \tag{A36}$$

Banks

$$1 + \xi_{l} \left(\frac{R_{lt+1}}{R_{et+1}} - 1 \right) - \phi_{l} \left(\frac{R_{Et+1}}{R_{Et}} - 1 \right) \left(\frac{R_{Et+1}}{R_{Et}} \right)$$
$$+ \beta_{R} \phi_{l} E_{t} \frac{\lambda_{ct+1}^{R}}{\lambda_{ct}^{R}} \left(\frac{R_{Et+1}}{R_{Et}} - 1 \right) \left(\frac{R_{Et+1}}{R_{Et}} \right)^{2} \left(\frac{b_{et+1}}{\pi_{t} b_{et}} \right) = 0; \tag{A37}$$
$$1 - \xi_{d} \left(\frac{R_{dt+1}}{R_{ht+1}} - 1 \right) - \phi_{d} \left(\frac{R_{ht+1}}{R_{ht}} - 1 \right) \left(\frac{R_{ht+1}}{R_{ht}} \right)$$

$$+\beta_R \phi_d E_t \frac{\lambda^R_{ct+1}}{\lambda^R_{ct}} \left(\frac{R_{ht+1}}{R_{ht}} - 1 \right) \left(\frac{R_{ht+1}}{R_{ht}} \right)^2 \left(\frac{\tilde{d}_{t+1}}{\pi_t \tilde{d}_t} \right) = 0; \qquad (A38)$$

$$slr_t \equiv \frac{b_{gt+1}}{\tilde{d}_{t+1}}; \qquad (A39)$$

$$R_{lt+1} = R_{gt+1}; \qquad (A40)$$

$$b_{ct+1} = crr\tilde{d}_{t+1} \ \& \qquad (A41)$$

$$R_{dt+1} = R_{gt+1}. \qquad (A42)$$

Government Investment

$$kg_{t+1} = (1-\delta)kg_t + Ig_t; \qquad (A43)$$

$$Ig_{ht}: \ Ig_{hft} = \chi_k \Big(\frac{s_t}{(1+\tau_{ct})p_{ft}} \Big)^{\zeta}_k Ig_t \ \& \qquad (A44)$$

$$Ig_{zt}: \ Ig_{zt} = (1-\chi_k) \Big(\frac{s_t}{(1+\tau_{zt})p_{zt}} \Big)^{\zeta}_k Ig_t. \qquad (A45)$$

Aggregate Conditions

$$q_t = s_t \left(1 + \phi_k \left(\frac{kp_{ft+1}}{kp_{ft}} - 1 \right) \right); \qquad (A46)$$

$$p_{ft}^{1-\xi_{yf}} = \gamma_{pf} \left(\frac{p_{ft-1}}{\pi_t} \right)^{1-\xi_{yf}} + (1-\gamma_p) {p^*_{ft}}^{1-\xi_{yf}} \qquad (A47)$$

$$Vp_{ft} = \gamma_{pf} \Big(\frac{1}{\pi_t} \Big)^{-\xi_{yf}} Vp_{ft-1} + (1-\gamma_{pf}) \Big(\frac{p^*_{ft}}{p_{ft}} \Big)^{-\xi_{yf}}; \qquad (A48)$$

$$w_{ft}^{1-\xi_{lf}} = \gamma_{wf} \Big(\frac{w_{ft-1}}{\pi_t} \Big)^{1-\xi_{lf}} + (1-\gamma_{wf}) w_{ft}^{*1-\xi_{lf}}; \qquad (A49)$$

$$Vw_{ft} = \gamma_{wf}\Big(\frac{w_{ft-1}}{w_{ft}}\frac{1}{\pi_t}\Big)^{-\xi_{lf}} Vw_{ft-1} + (1-\gamma_{wf})\Big(\frac{w^*_{ft}}{w_{ft}}\Big)^{-\xi_{lf}}; \qquad (A50)$$

$$\tilde{d}_{t+1} = \int_0^\theta d_{t+1}(i)di = \theta d_{t+1}; \qquad (A51)$$

$$\text{Formal Intermediate Goods Market}: y_{Eft} = y_{ft}Vp_{ft}; \qquad (A52)$$

$$\text{Formal Sector Labor Market}: l_{Rft} = l_{ft}Vw_{ft} \ \& \qquad (A53)$$

$$\text{Informal Sector Labor Market}: l_{nt} = \theta l_{Rnt} + (1-\theta)l_{NRt}. \qquad (A54)$$

Resource Constraint Formal Goods :

$$p_{ft}y_{ft} = p_{ft}(\theta c_{Rft} + (1-\theta)c_{NRft} + c_{Efft} + c_{Enft} + c_{gt} + Ip_{hft} + Ip_{nt} + Ig_{ht} + nx_t) + p_{zt}(Ip_{zt} + Ig_{zt})$$
$$+\frac{\phi_k}{2}\left(\frac{kp_{ft+1}}{kp_{ft}} - 1\right)^2 kp_{ft} + \frac{\phi_d}{2}\left(\frac{R_{ht+1}}{R_{ht}} - 1\right)^2 R_{ht+1}\tilde{d}_{t+1} + \frac{\phi_l}{2}\left(\frac{R_{Et+1}}{R_{Et}} - 1\right)^2 R_{Et+1}b_{et+1} \qquad (A55)$$

Resource Constraint Informal Goods :

$$y_{Ent} = \theta c_{Rnt} + (1-\theta)c_{NRnt} + c_{Efnt} + c_{Ennt}; \qquad (A56)$$

$$\hat{g}dp_t = p_{ft}y_{ft} + p_{nt}y_{Ent}$$
$$-\frac{\phi_k}{2}\left(\frac{kp_{ft+1}}{kp_{ft}} - 1\right)^2 kp_{ft} - \frac{\phi_d}{2}\left(\frac{R_{ht+1}}{R_{ht}} - 1\right)^2 R_{ht+1}\tilde{d}_{t+1} - \frac{\phi_e}{2}\left(\frac{R_{Et+1}}{R_{Et}} - 1\right)^2 R_{Et+1}b_{et+1} \ \& \qquad (A57)$$

$$p_{ft}nx_t = nxy_t gdp_t. \qquad (A58)$$

Stochastic Processes

$$\ln A_t = \rho_a \ln A_{t-1} + e_{at} \text{ with } e_{at}; \tag{A59}$$

$$\hat{n}xy_t - \hat{n}xy = \rho_{nxy}(\hat{n}xy_{t-1} - \hat{n}xy) + e_{nxyt}; \tag{A60}$$

$$\ln(\hat{b}_{gt+1}/\hat{b}_g) = \rho_{bg} \ln(\hat{b}_{gt}/\hat{b}_g) + \frac{pcg}{bg} e_{cgt} + \frac{sIg}{bg} e_{Igt} + e_{bgt}; \tag{A61}$$

$$\ln(R_{gt+1}/R_g) = \rho_{rg} \ln(R_{gt}/R_g) + (1-\rho_{rg})[\eta_\pi \ln(\pi_t/\pi) + \eta_y \ln(gdp_t/gdp)] + e_{rgt}; \tag{A62}$$

$$\ln(\psi_t/\psi) = \rho_\psi \ln(\psi_{t-1}/\ln\psi) + e_{\psi t}; \tag{A63}$$

$$\ln(sIg_t/sIg) = \rho_{Ig} \ln(sIg_{t-1}/sIg) + e_{Ig}; \tag{A64}$$

$$\ln(pc_{gt}/pc_g) = \rho_{cg} \ln(pc_{gt-1}/pc_g) + e_{cgt}; \tag{A65}$$

$$\ln(\frac{tc_t}{tc}) = \rho_{tc} \ln(\frac{tc_{t-1}}{tc}) + m_{bg}^{tc} ln(\frac{bg_t}{bg}) + e_{tc_t}; \tag{A66}$$

$$\ln(\frac{tw_t}{tw}) = \rho_{tw} \ln(\frac{tw_{t-1}}{tw}) + m_{bg}^{tw} ln(\frac{bg_t}{bg}) + e_{tw_t}; \tag{A67}$$

$$\ln(\frac{tk_t}{tk}) = \rho_{tk} \ln(\frac{tk_{t-1}}{tk}) + m_{bg}^{tk} ln(\frac{bg_t}{bg}) + e_{tk_t}; \tag{A68}$$

$$\ln(\frac{tz_t}{tz}) = \rho_{tz} \ln(\frac{tz_{t-1}}{tz}) + m_{bg}^{tz} ln(\frac{bg_t}{bg}) + e_{tz_t}; \tag{A69}$$

$$\ln(\frac{tr_t}{tr}) = \rho_{tr} \ln(\frac{tr_{t-1}}{tr}) - m_{bg}^{tr} ln(\frac{bg_t}{bg}) + e_{tr_t} \ \& \tag{A70}$$

$$\ln p_{zt} = \rho_{pz} \ln p_{zt-1} + m_{cg}^{pz} e_{cgt} + m_{Ig}^{pz} e_{Igt} + e_{pzt}. \tag{A71}$$

Benchmark Model

Just set $\theta = 1$ in the above model.

Benchmark Model with Financial Repression

The interest rates are given by

$$R_{lt+1} = \frac{R_{dt+1} - R_{gt+1} slr_t - crr}{1 - crr - slr_t} \tag{A72}$$

and R_{ht+1} and R_{Et+1} are given by $A37$ and $A38$ respectively.

Benchmark Model with Competitive Banking

The interest rates are given by

$$R_{ht+1} = R_{dt+1} = R_{gt+1} = R_{Et+1} = R_{lt+1}. \tag{A73}$$

Tables

Table 1
Calibrated Parameters and Values for the Benchmark Model

Parameters	Value
Discount Rate of (Ricardian) HH, β_R	0.9864
Discount Rate of Formal Entrepreneurs, β_{Ef}	0.96
Discount Rate of Informal Entrepreneurs, β_{En}	0.96
Elasticity of Substitution between Formal and Informal Goods in Consumption, ζ_c	8.00
Parameter of Share of Formal Goods in Consumption, χ_c	0.25
Weight of Labor Supply in Utility for HH, μ^R	8.26
Inverse Frisch Elasticity, τ	2.00
Relative Disutility of Working in Formal Sector, ϕ_{lf}	3.40
Elasticity of Government Capital in Formal Production, α_{gf}	0.16
Elasticity of Private Capital in Formal Production, α_{f1}	0.33
Elasticity of Imported Intermediate Good in Formal Production, α_{f2}	0.12
Elasticity of Government Capital in Informal Production, α_{gn}	0.02
Elasticity of Private Capital in Informal Production, α_n	0.27
Relative Productivity Parameter in Informal Sector, κ	0.085
Depreciation Rate, δ	0.09
Elasticity of Substitution Among Retail Goods, ξ_y	6
Elasticity of Substitution Among Labor Services, ξ_l	6
Calvo Parameter in the Goods Market, γ_p	0.25
Calvo Parameter in the Labor Market, γ_w	0.25
Elasticity of Substitution between Domestic and Imported Goods in Investment , ζ_k	1.50
Parameter of Share of Domestic Good in Investment, χ_k	0.90
Steady-State Borrowing Requirement Ratio, ψ	0.255

Table 1 continued ...

Parameters	Value
Mark-Up Parameter Deposit Rate, ξ_d	-350
Mark-Up parameter Lending Rate, ξ_l	138
Steady-State Government Consumption, pc_g	0.0027
Steady-State Government Investment, sIg	0.0022
Steady-State Government Borrowing, bg	0.0028
Net-Exports to GDP Ratio, nxy	-0.019
Steady-State Policy Rate, RG	1.0878
Steady-State Inflation Rate, π	1.07
Cash Reserve Ratio, crr	0.08
Steady State Tax Rate on Wage Income, tw	0.032
Steady State Tax Rate on Return from Capital, tk	0.08
Steady State Sales Tax Rate, tc	0.121
Steady State Custom Duty Rate, tz	0.15

Table 2: Calibration: Alternative Models[1]

	Non-Ricardian Households						
Parameter	$\theta = 0.35$	$\theta = 0.50$	$\theta = 0.90$	Fin. Rep.	Com. Bank	High α_{gn}	Low ζ_c
κ	0.0845	0.0847	0.08511	0.0846	0.0867	0.0949	0.0841
μ^R	2.55267	4.1745	7.5920	8.2534	8.3631	8.2561	8.2637
μ^{NR}	20.6830	20.4594	20.4664	–	–	–	–
ψ	0.0928	0.1300	0.2300	0.2660	0.2660	0.2450	0.2550
bg	0.0099	0.0014	0.0025	0.0028	0.0029	0.0028	0.0028
pc_g	0.0027	0.0027	0.0027	0.0027	0.0028	0.0027	0.0026
tr	0.004	0.0005	0.0005	–	–	–	–

Note: [1] The values of other calibrated parameters are same as for the Benchmark model (Table 1).

Table 3: Calibration Targets

Variables	Target	Models
Share of Informal Sector in GDP	0.50	0.50
Share of Informal Sector in Household Employment	0.86	0.86
Formal and Informal Wage Ratio	3.50	3.50
Private Consumption Expenditure to GDP Ratio	0.66	0.66
Private Investment Expenditure to GDP Ratio	0.16	0.16
Govt. Investment Expenditure to GDP Ratio	0.09	0.09
Govt. Consumption Expenditure to GDP Ratio	0.11	0.11
Net-Exports to GDP Ratio	-0.019	-0.019
Share of Imported Capital Good to Total Imports	0.26	0.26
Bank Credit to Government to Deposit Ratio	0.28	0.28
Bank Credit to Central Bank to Deposit Ratio	0.08	0.08
Bank Credit to GDP Ratio	0.40	0.40
Long Run Inflation Rate	1.07	1.07
Fraction of Time-Spent Working by H.H.	0.36	0.36
Price Mark Up in Retail Goods: Formal Sector	1.20	1.20
Wage Mark Up by Unions: Formal Sector	1.20	1.20
Ratio of Consumption Tax Revenue to GDP	0.061	0.061
Ratio of Income Tax Revenue to GDP	0.007	0.007
Ratio of Corporate Tax Revenue to GDP	0.015	0.015
Ratio of Custom Duty Revenue to GDP	0.02	0.02

Table 4: Prior Distributions for Parameters

Parameter	Distribution	Range	Mean	S.D.	90% Interval
ϕ_k	Gamma	$R+$	6.00	1.50	[4.1757, 7.9846]
ϕ_l	Gamma	$R+$	40	10	[20.1757, 63.9846]
ϕ_d	Gamma	$R+$	6	1.50	[4.1757, 7.9846]
η_π	Gamma	$R+$	1.50	0.75	[0.7633, 2.9228]
η_y	Gamma	$R+$	0.35	0.175	[0.1396, 0.5345]
m_{bg}^{tc}	Beta	[0,1]	0.13	0.0650	[0.0545, 0.2184]
m_{bg}^{tw}	Beta	[0,1]	0.13	0.065	[0.0545, 0.2184]
m_{bg}^{tk}	Beta	[0,1]	0.13	0.0650	[0.0545, 0.2184]
m_{bg}^{tz}	Beta	[0,1]	0.13	0.0650	[0.0545, 0.2184]
m_{cg}^{pz}	Normal	$[-\infty, +\infty]$	0.00	0.2500	[-0.3204, 0.3204]
m_{Ig}^{pz}	Normal	$[-\infty, +\infty]$	0.00	0.2500	[-0.3204, 0.3204]

Autoregressive Coefficients

Parameter	Distribution	Range	Mean	S.D.	90% Interval
ρ_a	Beta	[0,1]	0.41	0.1025	[0.2787, 0.5450]
ρ_{cg}	Beta	[0,1]	0.73	0.1825	[0.4662, 0.9428]
ρ_{Ig}	Beta	[0,1]	0.65	0.1625	[0.4255 0.8544]
ρ_{bg}	Beta	[0,1]	0.61	0.1525	[0.4030, 0.8052]
ρ_{rg}	Beta	[0,1]	0.82	0.1200	[0.6516, 0.9547]
ρ_ψ	Beta	[0,1]	0.81	0.1200	[0.6421, 0.9468]
ρ_{tc}	Beta	[0,1]	0.70	0.1750	[0.4517, 0.9120]
ρ_{tw}	Beta	[0,1]	0.73	0.1825	[0.4662 0.9428]
ρ_{tk}	Beta	[0,1]	0.80	0.1200	[0.6326, 0.9387]
ρ_{tz}	Beta	[0,1]	0.82	0.1200	[0.6516 0.9547]
ρ_{pz}	Beta	[0,1]	0.81	0.1200	[0.6421, 0.9468]
ρ_{nxy}	Beta	[0,1]	0.61	0.1525	[0.4030, 0.8052]
ρ_ν	Beta	[0,1]	0.60	0.1500	[0.3972, 0.7926]

Table 4 continued ...

Standard Deviation of Shocks

Parameter	Distribution	Range	Mean	S.D.	90% Interval
σ_a	Inverse-Gamma	R^+	0.013	∞	[0.0033, 0.0244]
σ_{cg}	Inverse-Gamma	R^+	0.040	∞	[0.0103, 0.0752]
σ_{Ig}	Inverse-Gamma	R^+	0.089	∞	[0.0229, 0.1674]
σ_{bg}	Inverse-Gamma	R^+	0.080	∞	[0.0206, 0.1504]
σ_{rg}	Inverse-Gamma	R^+	0.005	∞	[0.0013, 0.0094]
σ_{ψ}	Inverse-Gamma	R^+	0.040	∞	[0.0103, 0.0752]
σ_{tc}	Inverse-Gamma	R^+	0.054	∞	[0.0139, 0.1015]
σ_{tw}	Inverse-Gamma	R^+	0.295	∞	[0.0758, 0.5447]
σ_{tk}	Inverse-Gamma	R^+	0.124	∞	[0.0319, 0.2332]
σ_{tz}	Inverse-Gamma	R^+	0.128	∞	[0.0329, 0.2407]
σ_{pz}	Inverse-Gamma	R^+	0.058	∞	[0.0149, 0.1091]
σ_{nxy}	Inverse-Gamma	R^+	0.009	∞	[0.0023, 0.0169]
σ_{ν}	Inverse-Gamma	R^+	0.005	∞	[0.0013, 0.0094]

Table 5: Posterior Estimation (Benchmark Model)

Parameter	Mean	90% Interval
ϕ_k	3.7523	[1.9181, 5.4695]
ϕ_l	47.4568	[29.8598, 64.2457]
ϕ_d	6.5094	[3.8052, 9.0976]
η_π	1.0514	[0.9020, 1.2110]
η_y	0.2129	[0.1056, 0.3227]
m_{bg}^{tc}	0.0649	[0.0138, 0.1095]
m_{bg}^{tw}	0.1319	[0.0300, 0.2268]
m_{bg}^{tk}	0.1272	[0.0395, 0.2124]
m_{bg}^{tz}	0.0831	[0.0187, 0.1451]
m_{cg}^{pz}	-0.1223	[-0.3524, 0.1172]
m_{Ig}^{pz}	0.0427	[-0.0935, 0.1780]
ρ_a	0.4061	[0.3146, 0.4974]
ρ_{cg}	0.6696	[0.5449, 0.7936]
ρ_{Ig}	0.8040	[0.7498, 0.8583]
ρ_{bg}	0.4646	[0.3439, 0.5878]
ρ_{rg}	0.4987	[0.4408, 0.5611]
ρ_ψ	0.8484	[0.8019, 0.8945]
ρ_{tc}	0.6293	[0.5189, 0.7404]
ρ_{tw}	0.7458	[0.6609, 0.8386]
ρ_{tk}	0.5959	[0.4858, 0.7127]
ρ_{tz}	0.7865	[0.7059, 0.8672]
ρ_{pz}	0.7923	[0.7290, 0.8610]
ρ_{nxy}	0.5013	[0.3800 0.6234]
ρ_ν	0.6142	[0.5329 0.6982]

Table 5 continued ...

Parameter	Mean	90% Interval
σ_a	0.0144	[0.0130, 0.0157]
σ_{cg}	0.0441	[0.0381, 0.0503]
σ_{Ig}	0.0809	[0.0701, 0.0916]
σ_{bg}	0.1109	[0.0978, 0.1242]
σ_{rg}	0.0172	[0.0157, 0.0188]
σ_{ψ}	0.0636	[0.0528, 0.0747]
σ_{tc}	0.0582	[0.0500, 0.0661]
σ_{tw}	0.3146	[0.2682, 0.3604]
σ_{tk}	0.1067	[0.0924, 0.1211]
σ_{tz}	0.1303	[0.1110, 0.1495]
σ_{pz}	0.0548	[0.0464, 0.0628]
σ_{nxy}	0.0167	[0.0146, 0.0189]
σ_{ν}	0.0399	[0.0347, 0.0452]
Log Density[1]	707.47	

Note: 1. The log marginal data density (Laplace)

Table 6: Matching Moments: Benchmark Model

Correlation			Standard Deviation		
Variables	Data	Model	Variable	Data	Model
$(gdp,\ cp)$	0.20	0.15	gdp	0.032	0.027
$(gdp,\ Ip)$	0.66	0.55	cp	0.021	0.032
$(gdp,\ pcg)$	0.44	0.15	Ip	0.164	0.111
$(gdp,\ sIg)$	0.29	0.31	d	0.094	0.094
$(gdp,\ d)$	0.64	0.23	be	0.167	0.117
$(gdp,\ be)$	0.65	0.19	pcg	0.061	0.060
$(gdp,\ bg)$	0.22	0.14	sIg	0.161	0.131

Note:- cp = Aggregate real private consumption; Ip = Aggregate real private investment

Table 7: Variance Decomposition (in %) : Benchmark Model

Shocks	gdp	cp	Ip	d	be
σ_a	29.26	39.59	3.58	0.54	0.72
σ_{cg}	2.23	2.04	0.25	3.27	0.03
σ_{Ig}	12.02	8.28	0.16	6.08	0.18
σ_{bg}	0.33	0.21	0.13	15.61	0.11
σ_{RG}	6.42	7.27	21.78	2.35	3.08
σ_{nxy}	22.18	20.60	2.68	0.20	0.26
σ_{tc}	6.08	5.10	1.55	0.38	0.50
σ_{tw}	0.36	0.56	0.05	0.21	0.28
σ_{tk}	0.28	0.21	0.78	0.15	0.20
σ_{tz}	0.39	0.41	0.06	0.07	0.09
σ_{pz}	4.02	5.57	0.22	0.70	0.91
σ_{ψ}	9.72	8.85	57.85	69.64	91.43
σ_{ν}	4.24	3.15	11.21	2.18	2.86

Note:- cp = Aggregate real private consumption; Ip = Aggregate real private investment

Table 8: Posterior Estimation (Mean)
Other Forms of Financial Frictions

Non-Ricardian Households					
Parameter	$\theta = 0.35$	$\theta = 0.50$	$\theta = 0.90$	Fin. Rep.	Comp. Banks
η_π	1.9333	1.5400	1.0706	1.0929	1.0705
η_y	0.1974	0.2124	0.2242	0.2805	0.2756
ϕ_k	0.9165	1.0632	1.3921	3.7118	3.3102
ϕ_d	56.1732	31.0079	22.8107	6.5299	–
ϕ_l	95.3295	80.1377	69.5015	48.5519	–
m_{bg}^{tc}	0.0560	0.0617	0.0620	0.0642	0.0637
m_{bg}^{tw}	0.1499	0.1394	0.1334	0.1347	0.1369
m_{bg}^{tk}	0.1211	0.1386	0.1294	0.1261	0.1251
m_{bg}^{tz}	0.1076	0.0991	0.0844	0.0845	0.0835
m_{bg}^{tr}	0.1268	0.1297	0.1302	–	–
m_{cg}^{pz}	-0.0312	-0.0720	-0.1318	-0.1186	-0.1176
m_{Ig}^{pz}	0.0238	0.0218	0.0439	0.0514	0.0527
ρ_a	0.5742	0.4853	0.3874	0.4007	0.3995
ρ_{cg}	0.7849	0.7188	0.6625	0.6749	0.6811
ρ_{Ig}	0.9487	0.9135	0.8106	0.7963	0.8007
ρ_{bg}	0.1486	0.2190	0.4293	0.4656	0.4602
ρ_{rg}	0.6549	0.5943	0.5007	0.5151	0.5147
ρ_ψ	0.8368	0.8447	0.8519	0.8418	0.8341
ρ_{tc}	0.6764	0.6561	0.6314	0.6241	0.6250
ρ_{tw}	0.8226	0.7884	0.7464	0.7423	0.7475
ρ_{tk}	0.6066	0.6096	0.6090	0.5906	0.5942
ρ_{tz}	0.8306	0.8176	0.7872	0.7855	0.7835
ρ_{tr}	0.5892	0.5949	0.5974	–	–
ρ_{pz}	0.7625	0.7807	0.7895	0.7880	0.7891
ρ_{nxy}	0.7587	0.6837	0.5024	0.4921	0.4959
ρ_ν	0.7200	0.6557	0.6138	0.6291	0.6430

Table 8 continued ...

Non-Ricardian Households					
Parameter	$\theta = 0.35$	$\theta = 0.50$	$\theta = 0.90$	Fin. Rep.	Comp. Banks
σ_a	0.0138	0.0144	0.0143	0.0143	0.0143
σ_{cg}	0.0321	0.0377	0.0432	0.0439	0.0439
σ_{Ig}	0.0513	0.0618	0.0780	0.0814	0.0822
σ_{bg}	0.1505	0.1360	0.1150	0.1105	0.1105
σ_{rg}	0.0148	0.0164	0.0178	0.0173	0.0168
σ_{ψ}	0.0544	0.0558	0.0550	0.0648	0.0653
σ_{tc}	0.0534	0.0563	0.0581	0.0583	0.0586
σ_{tw}	0.3235	0.3208	0.3138	0.3157	0.3145
σ_{tk}	0.1057	0.1059	0.1073	0.1069	0.1062
σ_{tz}	0.1401	0.1385	0.1309	0.1302	0.1310
σ_{tr}	0.0169	0.0909	0.0169	–	–
σ_{pz}	0.0528	0.0539	0.0548	0.0547	0.0546
σ_{nxy}	0.0133	0.0140	0.0160	0.0170	0.0172
σ_{ν}	0.0410	0.0408	0.0401	0.0407	0.0401
Log Density[1]	413.89	592.99	707.86	704.73	698.36

Note:- 1. Log marginal data density (Laplace):

Table 9: Posterior Government Spending Multipliers
(Benchmark Model)

Government Consumption

Multiplier	Impact	10-Year	25-Year
Output			
Mean	0.7222	0.5575	0.5959
95% Interval	[0.6553, 0.7903]	[0.3889, 0.7292]	[0.3610 0.8397]
Private Consumption			
Mean	-0.4418	-0.4818	-0.4392
95% Interval	[-0.4955, -0.3856]	[-0.6299, -0.3279]	[-0.6550, -0.2134]
Private Investment			
Mean	0.1777	0.0499	0.0464
95% Interval	[0.1343, 0.2223]	[0.0134, 0.0861]	[0.0095, 0.0831]

Government Investment

Multiplier	Impact	10-Year	25-Year
Output			
Mean	0.6137	0.7204	1.0904
95% Interval	[0.5419, 0.6836]	[0.5936, 0.8433]	[0.8675, 1.3039]
Private Consumption			
Mean	-0.3475	-0.2821	0.0558
95% Interval	[-0.4532, -0.2191]	[-0.3534, 0.2096]	[-0.0829, 0.1908]
Private Investment			
Mean	- 0.0272	0.0162	0.0553
95% Interval	[-0.2078, 0.1238]	[-0.0766, 0.0987]	[-0.0489, 0.1515]

Table 10: Prior Government Spending Multipliers
(Benchmark Model)

Government Consumption

Multiplier	Impact	10-Year	25-Year
Output			
Mean	0.6600	0.1983	-0.0296
95% Interval	[0.5176, 0.7992]	[-0.2784, 0.5545]	[-0.9299 0.5798]
Private Consumption			
Mean	-0.4375	-0.7181	-0.8837
95% Interval	[-0.5860, -0.3062]	[-1.0711, -0.4418]	[-1.5704, -0.4059]
Private Investment			
Mean	0.1100	-0.0798	-0.1464
95% Interval	[-0.0521, 0.2746]	[-0.2497, 0.0352]	[-0.4202, 0.0339]

Government Investment

Multiplier	Impact	10-Year	25-Year
Output			
Mean	0.6327	0.4951	0.6491
95% Interval	[0.4702, 0.8012]	[-0.0711, 0.9928]	[-0.4417, 1.5575]
Private Consumption			
Mean	-0.4022	-0.4207	-0.2341
95% Interval	[-0.5405, -0.2265]	[-0.8674, -0.0207]	[-1.0953, 0.5054]
Private Investment			
Mean	0.0470	-0.0748	-0.1044
95% Interval	[-0.1375, 0.2278]	[-0.2565, 0.0881]	[-0.4013, 0.1526]

Table 11: Posterior Estimation (Mean)
Models with High $\alpha_{gn}(=0.05)$ and Low $\zeta_c(=4)$ and Post-Reform Period

Parameter	High α_{gn}	Low ζ_c	Post-Reform
η_π	1.0616	1.0864	1.8271
η_y	0.2104	0.2047	0.1730
ϕ_k	3.7471	1.8452	0.8796
ϕ_d	6.5089	6.6099	8.2094
ϕ_l	47.4065	50.0080	65.4091
m_{bg}^{tc}	0.0643	0.0642	0.0451
m_{bg}^{tw}	0.1377	0.1351	0.1514
m_{bg}^{tk}	0.1268	0.1227	0.1893
m_{bg}^{tz}	0.0850	0.0849	0.1512
m_{cg}^{pz}	-0.1216	-0.1043	0.1215
m_{Ig}^{pz}	0.0562	0.0545	0.1344
ρ_a	0.4069	0.3922	0.5181
ρ_{cg}	0.6697	0.6972	0.6753
ρ_{Ig}	0.8008	0.8071	0.8077
ρ_{bg}	0.4696	0.4694	0.7697
ρ_{rg}	0.5006	0.5022	0.4515
ρ_ψ	0.8472	0.8612	0.8704
ρ_{tc}	0.6273	0.6209	0.5976
ρ_{tw}	0.7467	0.7539	0.7656
ρ_{tk}	0.5957	0.6108	0.7597
ρ_{tz}	0.7868	0.7939	0.8787
ρ_{pz}	0.7911	0.7963	0.7922
ρ_{nxy}	0.4987	0.4790	0.5851
ρ_ν	0.6127	0.6227	0.7112

Table 11 continued ...

Parameter	High α_{gn}	Low ζ_c	Post-Reform
σ_a	0.0144	0.0139	0.0100
σ_{cg}	0.0442	0.0448	0.0401
σ_{Ig}	0.0809	0.0805	0.0989
σ_{bg}	0.1107	0.1116	0.1055
σ_{rg}	0.0173	0.0169	0.0131
σ_{ψ}	0.0637	0.0552	0.0409
σ_{tc}	0.0584	0.0549	0.0479
σ_{tw}	0.3142	0.3134	0.2976
σ_{tk}	0.1071	0.1061	0.0951
σ_{tz}	0.1301	0.1305	0.1780
σ_{pz}	0.0548	0.0550	0.0471
σ_{nxy}	0.0167	0.0173	0.0131
σ_{ν}	0.0401	0.0387	0.0314
Log Density[1]	707.10	705.01	317.15

Note:- 1. Log marginal data density (Laplace):

Table 12: Posterior Government Spending Multipliers: Alternative Models

Government Consumption

Model	Impact	10-Year	25-Year
Output			
Non-Ricardian ($\theta = 0.90$)	0.7214	0.5703	0.6117
Fin. Repression	0.7149	0.5383	0.5658
High α_{gn}	0.7221	0.5567	0.5959
Low ζ_c	0.7734	0.5728	0.5953
Post-Reform	0.6179	0.1096	-0.2916
Private Consumption			
Non-Ricardian ($\theta = 0.90$)	-0.4549	-0.4747	-0.4273
Fin. Repression	- 0.4272	-0.4898	-0.4589
High α_{gn}	-0.4425	-0.4829	-0.4397
Low ζ_c	-0.3996	-0.4775	-0.4468
Post-Reform	-0.4620	-0.7303	-1.0627
Private Investment			
Non-Ricardian ($\theta = 0.90$)	0.1900	0.0569	0.0507
Fin. Repression	0.1557	0.0384	0.0354
High α_{gn}	0.1783	0.0501	0.0469
Low ζ_c	0.1878	0.0611	0.0534
Post-Reform	0.0917	-0.1581	-0.2345

Table 12 continued ...

Government Investment

Model	Impact	10-Year	25-Year
Output			
Non-Ricardian ($\theta = 0.90$)	0.6275	0.7209	1.0995
Fin. Repression	0.5832	0.7522	1.1426
High α_{gn}	0.5971	0.7760	1.1923
Low ζ_c	0.7289	0.7528	1.1223
Post-Reform	0.6153	0.6422	1.0007
Private Consumption			
Non-Ricardian ($\theta = 0.90$)	-0.3567	-0.2857	0.0573
Fin. Repression	-0.3097	-0.2232	0.1269
High α_{gn}	-0.3431	-0.2237	0.1496
Low ζ_c	-0.2738	-0.2756	0.0605
Post-Reform	-0.4707	-0.3800	-0.0691
Private Investment			
Non-Ricardian ($\theta = 0.90$)	-0.0039	0.0203	0.0630
Fin. Repression	-0.0960	-0.0103	0.0374
High α_{gn}	-0.0484	0.0144	0.0643
Low ζ_c	0.0165	0.0427	0.0831
Post-Reform	0.0977	0.0344	0.0888

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