Essays on Monetary-Fiscal Interactions in Emerging Market and Developing Economies

Ojasvita Bahl

A dissertation submitted in partial fulfillment of the requirements

of the degree of

Doctor of Philosophy

(Economics)

at the

Economics and Planning Unit

Indian Statistical Institute

New Delhi

July 2025

Supervisor : Chetan Ghate

Professor, EPU, ISI- Delhi

Acknowledgements

I wish to convey my deep gratitude to my supervisor Prof. Chetan Ghate for his relentless support and guidance throughout this journey. I am thankful for his readiness to discuss research post working hours during his directorship at the Institute of Economic Growth. His approach of prioritising simplicity in modelling to uncover powerful results remains a valuable lesson for me. I am fortunate to be guided by someone whose passion for knowledge is insatiable. I am grateful for his meticulous review and unwavering commitment, both of which were instrumental in ensuring the successful completion of this study.

I am deeply indebted to Prof. Debdulal Mallick for being available for discussions and deliberations despite the time difference. His 'don't worry' always yielded a way out. I am extremely grateful to Prof. Tridip Ray for his patient listening and thoughtful advice during this journey.

Two qualities that signify the professors at ISI Delhi are humility and excellence. I feel lucky to have studied under the esteemed guidance of Prof. Arunava Sen, Dr Debasis Mishra, Prof. E. Somanathan, Prof. Monisankar Bishnu, Prof. Abhiroop Mukhopadhyay, and Prof Farzana Afridi whose dedication towards their subjects encouraged me to strive for a deeper perspective.

I am grateful for the opportunity to interact and discuss my research with Prof. V.V. Chari and Prof. B. Ravikumar at the Annual Conference on Economic Growth and Development. I thank the Indian Statistical Institute for providing me with a generous fellowship.

My sincere gratitude to Dr Medha Kudaisya, Dr Padma Suresh and Dr K. Krishna Kumar for motivating me to persevere in this endeavour. I am deeply grateful to Dr Harendra Behera for respecting my time and prioritising my research. I am extremely grateful to Dr Pawan Gopalakrishnan - a senior, mentor and friend who has been a constant support throughout this journey. I am deeply thankful to my friends- Nikita, Pranav, Priyanka, Ojasvi, Praveen, Shriya, Aayush, and Subhadeep for their continuous encouragement, companionship, and moral support, which made this endeavor meaningful and enjoyable.

I am deeply indebted to my parents Dr (Mrs) Preeti Bahl and Dr Rajesh Bahl for their unwavering support and encouragement, my sister, Dr Vanndita Bahl for strengthening my resolve, my parents in-law Mrs Neelam Kamra and Mr Surinder Pal Kamra, for their blessings and my husband Kartik Krishan Kamra for his patience, motivation and constant reassurance.

This thesis would not have been possible without the blessings of my Gurujans and the grace of the Almighty. I owe my success to them.

To my parents and teachers

Contents

List of Tables

List of Figures

Abstract

This thesis contains three chapters on monetary-fiscal interactions in Emerging Market and Developing Economies.

Governments in emerging markets and developing economies (EMDEs) frequently intervene in agricultural markets to stabilize food prices following adverse shocks. These interventions often take the form of large-scale food procurement and redistribution, which we define as a redistributive policy shock. This chapter examines the effects of such shocks on inflation and the distribution of consumption between rich and poor households. We develop a tractable two-sector, two-agent New Keynesian DSGE model and estimate its parameters for the Indian economy using Bayesian methods. Our findings reveal that under an inflation-targeting regime, consumer heterogeneity plays a crucial role in determining whether monetary policy responses to various shocks enhance or reduce aggregate welfare.

The second chapter evaluates the welfare implications of redistributive policy shocks under alternative monetary policy regimes. Building on Chapter 1, which finds that redistributive policy shocks are inflationary and expansionary in terms of aggregate output, we assess how different monetary responses alter welfare outcomes. Following Schmitt-Grohe Uribe (2007), we compute consumption-equivalent welfare gains to compare the welfare cost of these shocks under the optimised simple monetary rule and the planner's solution (Ramsey Optimal

Monetary Policy). The optimal rule features no interest rate smoothing, a strong response to inflation, and a limited reaction to output. Our findings demonstrate the critical role of monetary policy in shaping the welfare impact of redistributive shocks. We further compare these welfare effects to those of an agricultural productivity shock and show that the steady-state level of redistribution significantly affects the relative costs of redistribution-driven fluctuations. We find that non-optimised rules lead to significantly higher welfare costs than optimised simple rules.

In the third chapter, we study the interactions between informality, underdeveloped financial markets and fiscal consolidation by developing a two-sector, two-agent medium-scale NK-DSGE model that allows public expenditure and private consumption to be either substitutes or complements. While there is a large literature that tries to understand the effects of fiscal consolidation in AEs, there is a relatively small literature on fiscal consolidation in EMDEs. We find that greater informality dampens the reduction in public debt from a contractionary fiscal policy shock. We find tax-based shocks to exhibit greater decline in debt at the cost of a greater contraction in output than spending-based shocks. Our analysis suggests that a fiscal consolidation shock can be expansionary when private consumption and public spending exhibit moderately-high substitutability consistent with the literature on expansionary fiscal consolidations.

Chapter 1

Introduction

1.1 Motivation

Emerging market and developing economies (EMDEs) have certain characteristics that distinguish them from advanced economies (AEs). They have weaker law enforcement, underdeveloped financial markets, greater reliance on uncompetitive or public sector banks for sources of finance, weaker fiscal capacity and reliance on seigniorage for revenues, restrictive regulatory frameworks, greater pressures of fiscal dominance and consequently a lower credibility of the monetary authority. These make fiscal-monetary policy coordination difficult.

EMDEs are vulnerable to external shocks such as trade disruptions and global price shocks, are susceptible to large exchange rate movements in the presence of capital flows, susceptible to sudden stops (Ghate & Kletzer 2016) and have sovereign spreads sensitive to world interest rate (Johri et al. 2022). Unlike AEs, capital flows are destabilising and amplify economic cycles (as discussed in Frankel (2010)). Volatile fiscal policy in terms of spending and deficits increases uncertainty for monetary authorities and complicates coordination.

In terms of policy, while monetary policy transmission is weaker in EMDEs due to weaker links with external financial markets, less competitive formal financial sectors, liquidity-constrained money markets, thinly-traded bond markets and sector-dependent stock markets size of the agriculture sector,[1] the presence of a large share of economic activity outside the ambit of taxation makes the conduct of fiscal policy challenging.[2] Figure 1.1 shows the average levels of informal sector share in official GDP and employment outside the formal sector from the *Informal Economy Database, ILO* by region[3]. World Development Indicators show that the average share of value added by agriculture, forestry and fishing between 1990-2024 was 27.24% for low-income countries, 10.84% for middle-income countries and 1.50 for high-income countries.

[1]See Mishra et al. (2016) for evaluation of monetary policy transmission in India.

[2]As raising taxes in the formal sector leads to diversion of economic activity (Dellas et al. 2024), governments in EMDEs engage in financial repressions to raise resources (Reinhart & Sbrancia 2015) which lower the supply of credit and may results in unconventional monetary policy having counterproductive effects (Ankit Kumar et al. 2025).

[3]This is based on the estimates of shadow economy in Medina & Schneider (2019) using the multiple indicator-multiple cause approach

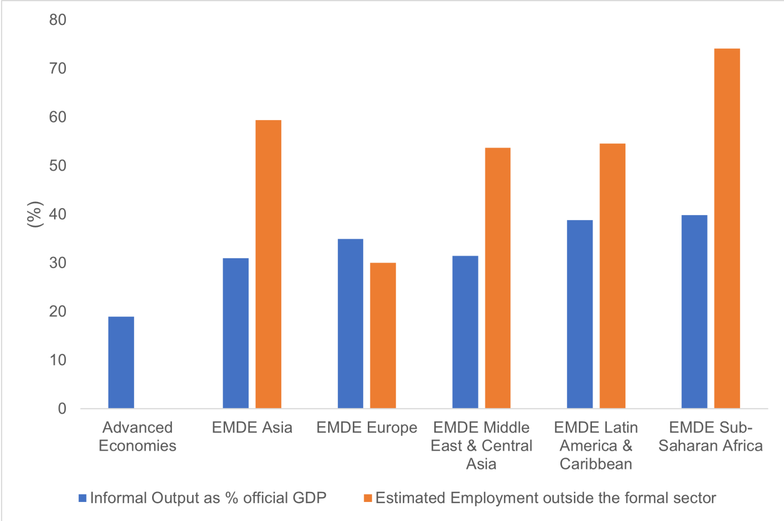


Figure 1.1: Average Informal output and employment (2000-2020) (%)

Source: ILO Informal Economy Database (2021) & IMF classification (2025)

Given the substantial share of the population employed in weather-dependent agriculture, governments in EMDEs frequently implement extensive policy interventions—particularly in the form of producer and consumer subsidies. These measures aim to promote rural economic development, reduce reliance on agricultural exports, shield vulnerable populations from the adverse effects of domestic and global commodity price volatility, and enhance food security for low-income households. Thus, the presence of a large agricultural sector has implications for the conduct of fiscal policies and renders the monetary transmission weaker in EMDEs. [4].

In this thesis, we examine the implications of three structural characteristics of EMDEs (e.g. large agricultural sectors, informality in production and the presence of rule-of-thumb agents) for key macroeconomic aggregates. We analyse the distributional effects of policy interventions in the agricultural sector and their welfare implications. We examine fiscal consolidation in economies

[4]See Amaglobeli et al. (2024) for details on agricultural price subsidies

with large informal sectors. These features pose challenges for monetary and fiscal policy transmission, policy coordination and macroeconomic stabilization under inflation targeting. We examine these issues within a comprehensive analytical framework using a two-sector two-agent NK-DSGE (2S-TANK) setup. The subsequent sections present an overview of the research questions, the methodology adopted, and summarize the key findings of the study.

1.2 Redistributive Policy Shocks and Monetary Policy in a Model with Heterogeneous Agents

EMDEs are characterized by a high reliance on agriculture for both output and employment. Governments in these economies frequently intervene in agricultural markets to ensure an assured market for producers and to maintain availability, affordability, and accessibility of food for consumers. Such interventions aim to protect vulnerable populations from food-price volatility—arising from domestic and global supply shocks—while guaranteeing remunerative prices for farmers. These policies typically involve the procurement of staples and their redistribution at subsidized rates through public distribution systems (PDS).

In this paper, we model these interventions as policy shocks. While prior work, such as Ghate et al. (2018) has focused on the procurement aspect of government intervention, the procurement and redistribution mechanisms have not been incorporated into a dynamic general equilibrium framework. Other studies, including Pourroy et al. (2016), Ginn & Pourroy (2019), and Ginn & Pourroy (2022), have examined agricultural interventions as food-price subsidy shocks, whereas Chakraborty et al. (2025) compares the effects of input subsidies and minimum support prices for staple crops. Our approach builds on this literature by explicitly modelling the dual objectives of market stabilisation and food security in a dynamic setting.

The main methodological contribution of our framework is that we extend the two-agent New Keynesian, i.e., TANK-DSGE framework of Debortoli & Gali (2017) to two sectors (agriculture and manufacturing) in a tractable way. We estimate the model using Bayesian methods following Schorfheide (2000) and Fernández-Villaverde & Rubio-Ramírez (2004). In our setup, the agriculture sector is perfectly competitive, while the manufacturing sector exhibits nominal rigidities. We study the transmission of a supply-side shock (agricultural productivity shock), a demand-side shock (monetary policy shock) and a combined shock (the redistributive policy shock) and evaluate the role of two agents and two sectors in driving the results. In our model, consumer heterogeneity interacts with inter-sectoral dynamics to determine the differential response of rich and poor consumption, and therefore aggregate demand to shocks.

We find that a positive agricultural productivity shock leads to a decline in inflation, an increase in the output gap, a rise in both poor and rich consumption, and higher welfare. We define welfare in the model to explicitly depend on aggregate consumption. In contrast, a procurement and redistributive policy shock causes higher inflation, an increased output gap, greater consumption by the poor, and higher overall consumption in the economy, even though such shocks raise inflation and lead to a decline in the consumption of the rich. Because of the redistributive effect, the rise in poor consumption makes aggregate consumption rise. We find that in models with two sectors, the presence of a flexible price sector creates a large deflation in the economy in response to a contractionary monetary policy shock. We find that a higher share of agricultural employment lowers the effectiveness of monetary policy.

1.3 Welfare Consequences of Redistributive Policy Shocks

In this chapter we compute the welfare costs of reditsributive policy shocks described in Chapter 1. We compute consumption-equivalent welfare gains following Lucas (1987) and Schmitt-Grohe & Martin Uribe (2007) to calculate the amount of steady-state consumption that agents would like to forego to avoid volatility induced by these shocks. We compute welfare based on two criteria - the planner's solution (*Ramsey Optimal Monetary Policy*) and optimal simple rules (*OSR*). We compare optimised and non-optimised rules to the planner's solution. To get a relative perspective, we compare the welfare costs for an agricultural productivity shock.

Our results indicate that the welfare costs of redistributive policy shocks are relatively modest. Wealthier households are willing to forgo between 0.0096% and 0.0120% of their steady-state consumption to eliminate such shocks, whereas poorer households would sacrifice between 0.0161% and 0.0350% for the same outcome. We also find that redistributive shocks impose higher welfare costs than agricultural productivity shocks. The optimised simple policy rule for managing redistributive shocks prescribes no interest-rate smoothing or output-gap stabilisation but a strong response to inflation. In contrast, non-optimal monetary policy responses to redistributive policy shocks magnify welfare losses for both types of households. Notably, the utilitarian Ramsey planner does not identify full inflation stabilisation as optimal.

1.4 Informality and Fiscal Consolidation

The COVID-19 pandemic led to a resurgence of interest in ensuring fiscal sustainability. Reducing sovereign debt requires fiscal consolidation policies. How should the government achieve this? While there is consensus that spending-based shocks are less distortionary (Alesina & Ardagna (2010), Alesina et al. (2019a), and Alesina et al. (2019b)), and it may even be self-financing in the absence of a monetary policy response (DeLong et al. (2012)) for advanced economies, the empirical results for Emerging Market and Developing Economies are mixed. While Dellas et al. (2024) finds tax-based consolidations to lead to a decline in economic activity and a further increase in tax rates, Carrière-Swallow et al. (2021) finds tax-based and spending-based fiscal consolidations to have a similar impact on output. While most studies find spending-based consolidations to be contractionary, Dave et al. (2021) shows *expansionary fiscal consolidations* to hold in a small open economy (SOE) real business cycle model when public and private goods are perfect substitutes in consumption.

This chapter examines the impact of informality on the effectiveness of fiscal consolidation shocks. We motivate our models with evidence that countries with larger informal sectors have a slower rate of reduction of debt-output ratios. We build a two-sector TANK model and highlight the mechanism behind the impact of spending and tax-based fiscal consolidation shocks on the economy. Our results corroborate the findings of Alok Kumar (2023) and Colombo et al. (2024), who find that the presence of larger informal sectors impedes fiscal consolidations. We find that capital income tax shocks are more effective in lowering the debt-output ratio, but are more contractionary consistent with the results of the AEs and some evidence for EMDEs. Capital income tax shocks lead to an expansion of the informal sector and resource allocation towards the less-productive sector. In contrast, spending-based consolidations raise investment in both sectors. We show that fiscal consolidation may not be contractionary when public and private consumption are substitutable. The advantage of our 2S-TANK framework is that it allows us to trace out the consumption responses of Ricardian and hand-to-mouth agents. This is suggestive of fiscal consolidation having a differential impact on different types of agents.

1.5 Summary

My thesis makes several important contributions. First, I contribute to a small but growing literature on monetary-fiscal interactions in EMDEs with a large informal sector. Because the analysis is conducted using an NK-DSGE framework, the insights obtained are relevant for the macroeconomic framework under inflation targeting. Second, I evaluate the macroeconomic effects of sector-specific fiscal policy shocks by extending the NK-DSGE model to include two sectors and two agents. This is done in a tractable way. Third, my thesis contributes to a growing literature on business cycle analysis in EMDEs, and the policy insights would be useful to policymakers in Central Banks in countries with a large informal sector.

Chapter 2

Redistributive Policy Shocks and Monetary Policy in a Model with Heterogeneous Agents

[1]

2.1 Introduction

Governments in many emerging market and developing economies (EMDEs) routinely intervene in their agricultural markets. Higher food security norms, for instance, require an increase in the redistribution of agricultural output to the poorest population in a country. Other interventions involve the procurement and redistribution of food to minimise food price volatility in the wake of domestic (e.g., poor rainfall) or external (e.g., global commodity price) shocks.

[1] This chapter is joint work with Chetan Ghate (ISI Delhi) and Debdulal Mallick (Deakin University, Melbourne). This paper is forthcoming in *Journal of Money, Credit and Banking* DOI: 10.1111/jmcb.70025.

There are many examples of these types of interventions. In 2013, India enacted a new National Food Security Act (NFSA) under the umbrella of a new "rights-based" approach to food security. The Act legally entitles "up to 75% of the rural population and 50% of the urban population to receive subsidized food grains" under a Targeted Public Distribution System.[2] i.e., about two-thirds of the population is legally entitled to receive food grains at highly subsidized prices under the new act. The ostensible goal is to smooth the purchasing power of poor populations that are food insecure. The National Food Authority (NFA) in the Philippines is mandated to purchase and distribute rice and other commodities. In response to the rise in global grain prices in the last quarter of 2007, the Philippine government increased funding to support its Economic Resiliency Program, which included the expansion of the rice production enhancement initiative known as "Ginintuang Masaganang Ani". The total fiscal cost of the NFA rice subsidy jumped to 0.6% of GDP in 2008 compared to 0.08% of GDP in 2007 (Balisacan et al. 2010). In Bangladesh, the government has intervened in food markets for several years in order to reduce price fluctuations and procure rice for safety net programs (Hossain & Deb 2010). To ensure food security in Indonesia in 2008, the Indonesian government, through its BULOG operational strategy doubled the amount of rice distributed to cover all poor families under the RASKIN program through targeted market operations requested by local governments. Regular rice distribution for the poor was achieved by increasing domestic rice procurement. BULOG's heavy procurement added to demand, helping farmers maintain prices at a profitable level (Saifullah 2010). The Korean government also motivates its agricultural policy for food security reasons based on self-sufficiency (Beghin et al. 2003).

[2]See https://nfsa.gov.in/portal/NFSA-Act

Interventions such as the enactment of a new NFSA with wider coverage, or surprise government interventions when there are large price shocks in food commodities, such as the world rice price crisis of 2008, have two salient features. First, they typically imply higher procurement and redistribution of food commodities by the government to households. This raises the food subsidy to the household. Second, such interventions are conducted at a relatively high frequency, i.e., several times within a year. We refer to frequent interventions by the government in agriculture markets as redistributive policy shocks.[3] The main research questions that this chapter addresses is: how should monetary policy respond to redistributive policy shocks? What is the impact of redistributive policy shocks on the sectoral and aggregate dynamics of inflation and rich and poor consumption? The novel part of our analysis is that we allow for government intervention in the agriculture market in a way that captures the essence of procurement and redistribution style interventions in EMDEs.

We build a two-sector (agriculture and manufacturing) two agent (rich and poor) New Keynesian DSGE model. Our theoretical model builds on earlier work by Debortoli & Gali (2017), Aoki (2001), and Ghate et al. (2018). The main methodological contribution of our framework is that we extend the two agent New Keynesian, i.e., TANK-DSGE framework of Debortoli and Gali to two sectors (agriculture and manufacturing) in a tractable way. On the production side, the agriculture sector is perfectly competitive with flexible prices while the

[3]Redistributive policy is often viewed as countercyclical: procurement rises and redistribution falls in periods of high agricultural output (e.g., bumper crops), while procurement declines and transfers increase during adverse shocks such as droughts or floods. Under this interpretation, fiscal policy acts primarily as an automatic stabiliser rather than as an independent source of demand. Exploring the transmission mechanisms of various shocks in the presence of countercyclical redistributive policy requires careful modelling of the buffer stocks and is left for future work. As the minimum support price (MSP) is announced at the beginning of the cropping season in India, it influences farmers' production and crop-choice decisions ex ante (See Shoumitro Chatterjee et al. (2024), and `https://www.pib.gov.in/PressReleasePage.aspx?PRID=2177219&reg=3&lang=2`), implying that procurement policy also has forward-looking and demand-creating effects. We therefore model redistributive policy as an exogenous policy shock.

manufacturing sector is characterized by monopolistic competition and sticky prices. As in Debortoli and Gali, we assume that there are two types of agents, rich and poor. Rich agents are Ricardian and buy one period risk free bonds. Poor agents are assumed to be rule of thumb consumers. Both types of households consume both types of goods. To provide the subsidized agriculture good to the poor, the government imposes a lump sum tax on the rich and uses the proceeds to procure agricultural output from the open market. It then re-distributes a fraction of the procured agriculture good to the poor. Higher redistribution and procurement, by leading to a higher subsidy of the agriculture good to the poor leads to a larger reduction in the poor's market expenditures on the agriculture good. Further, we assume that rich agents have a higher intertemporal elasticity of substitution (IES) of consumption compared to the poor which affects their labour supply decisions differentially in response to changes in the real wage.[4] We calibrate the model to India, an economy subject to frequent government interventions in the agriculture market.[5] From the impulse response functions (IRFs), we identify the transmission mechanism of agricultural productivity shocks, redistributive policy shocks, and monetary policy shocks to sectoral inflation rates, the economy wide inflation rate, and consumption of rich and poor agents. We compare our results to a variety of benchmarks that emerge as special cases from our framework: a two sector representative agent NK framework along the lines of Aoki, a one sector two agent NK DSGE model along the lines of Debortoli and Gali, and the simple one sector one agent NK

[4]In Debortoli and Gali, all agents have the same intertemporal elasticity of substitution. Our assumption is driven by estimates of different intertemporal elasticity of substitution parameters for rich and poor households from Indian household data. See Atkeson & Ogaki (1996). Our assumption is consistent with the DSGE literature on the macroeconomic evaluation of LSAPs (large scale asset purchase programs), where the intertemporal elasticity of substitution across households is assumed to be different. See Chen et al. (2012).

[5]India is an EMDE with a large agriculture sector and has less reliance on imports for meeting its food security needs - closer to our closed economy model.

model in Gali (2015).[6] This allows us to isolate the impact of demand side factors (consumer heterogeneity) and supply side factors (multiple sectors) in determining sectoral and aggregate inflation rates, and rich and poor consumption in response to these shocks. We show that a positive agricultural productivity shock leads to a decline in inflation, a rise in the output gap, a rise in both poor and rich consumption, and higher welfare. We define welfare in the model to explicitly depend on aggregate consumption, as is standard in the literature. In contrast, a procurement and redistributive policy shock leads to higher inflation, a higher output gap, higher consumption of the poor and higher aggregate consumption in the economy, even though such shocks raise inflation, and there is a decline in consumption of the rich. Because of the redistributive effect, the rise in poor consumption makes aggregate welfare rise. Compared to the Aoki model, since the poor receive a fraction of their agriculture consumption for free (via the redistributive shock) and spend a higher share of their income on the agriculture good compared to the rich, the market demand for the agriculture good is less, and so the inflationary impact of a procurement and redistributive policy shock is much lower in our model compared to the Aoki model (where there is no redistribution). In an extension of the model, we show that our results on the rise in welfare because of a procurement and redistributive policy shock are robust to assuming i) non-homothetic preferences, and ii) labour immobility across sectors.

A recent focus in the monetary policy literature explores the impact of monetary policy in the presence of consumer heterogeneity (see McKay et al.

[6] Both productivity shock and procurement and redistributive policy shock IRFs are benchmarked only to the Aoki model since Aoki has two production sectors while both Debortoli and Gali and Gali (2015, Chapter 3) have a single sticky price manufacturing sector. In the case of Debortoli and Gali, their framework assumes incomplete markets, ours has complete markets. Parameter restrictions that yield their model can therefore be seen as an approximation of their framework.

2016, Kaplan et al. 2018, Auclert 2019, and Broer et al. 2020). As in this research, we ask how heterogeneity matters for whether monetary policy responses to shocks raise aggregate welfare or not? Why is it important to take into account heterogeneity? In our model consumer heterogeneity interacts with rich inter-sectoral dynamics to determine the differential response of rich and poor consumption, and therefore aggregate demand to shocks. We therefore compare our two-sector TANK model under a contractionary monetary policy shock with the simple NK framework in Gali (2015, Chapter 3), the Aoki model, and Debortoli and Gali. In models with two sectors (our model and Aoki's) the presence of a flexible price sector creates a large deflation in the economy in response to a monetary tightening by the monetary authority. This is because a rise in the nominal interest rate leads to the inter-temporal substitution of consumption, as in the standard NK model, which causes a reduction in aggregate demand and a decline in the aggregate price level and inflation. This decline becomes more pronounced when there is a flexible price sector in addition to a sticky price sector. Since the shock is of one period, agricultural inflation returns to the steady state in the next period. Manufacturing inflation, however, recovers, gradually, because of the sticky price assumption in all models. Crucially, in our model and Aoki's model, real interest rates increase by less, and therefore rich and poor consumption falls be less compared to Debortoli and Gali and the simple NK model. The decline in aggregate consumption, therefore, is also less in our model and Aoki's model compared to the simple NK model and Debortoli and Gali. In all cases, consumer heterogeneity interacts with rich intersectoral dynamics to determine the general equilibrium responses to a variety of shocks.

An interesting insight from our analysis is that when the employment share of the manufacturing sector rises, output adjusts more compared to an economy with a higher share of the agriculture/flexible price sector, and the effectiveness of monetary policy is comparatively more. Our model therefore provides a rationale for why monetary policy is ineffective in economies with a large agriculture sector.

Our two sector-two agent NK framework builds on the seminal work by Gali & Monacelli (2005), Aoki (2001), and Debortoli & Gali (2017). The main difference with respect to these papers is that Gali and Monacelli (2005) consider an open economy framework, whereas we consider a closed economy framework. In Aoki (2001) there are two production sectors, a flexible price agriculture sector that is perfectly competitive, and a sticky price manufacturing sector that is monopolistically competitive. The production side of our model is similar to Aoki's model. However, Aoki's model has a single representative agent. In our model, we allow for two types of agents, rich (Ricardian) and poor (rule of thumb) with different intertemporal elasticities of substitution in consumption and different budget constraints. Another difference with respect to Aoki (2001) is that the government in our model taxes rich agents, procures grain from the agriculture sector, and redistributes the agriculture good to poor agents. In Aoki's framework there is no government intervention.[7]

Debortoli & Gali (2017) build a DSGE model in which agents are Ricardian/rich and rule of thumb/poor. They show that a tractable TANK model provides a good approximation to study the impact of aggregate shocks to aggregate variables in a baseline HANK (Heterogenous agent New Keynesian) model. In Debortoli & Gali (2017), there is however only one production sector (sticky price sector). The main methodological contribution of our work is to

[7]Gali et al. (2007) use a two-agent framework (rule of thumb and Ricardian) to account for evidence on government spending shocks, but their focus is on fiscal policy, not monetary policy.

extend the two agent-one sector framework of Debortoli and Gali to two sectors in a tractable way.

This chapter builds on previous work in Ghate, Gupta, Mallick (2018), or GGM. In GGM, there are three production sectors (grain, vegetables, and manufacturing). In that framework, all three sectors are monopolistically competitive, with the agriculture sector having flexible prices. The manufacturing sector is the sticky price sector. In the current framework, there are two production sectors (agriculture, manufacturing). Unlike GGM, the agriculture sector is just characterized by a grain sector which is assumed to be perfectly competitive. Like GGM, the manufacturing sector is the sticky price sector. In GGM, there is a single representative agent, i.e., it is a RANK (Representative Agent New Keynesian) model. Our model has two types of agents.[8] Like GGM however, our model illustrates how the terms of trade between agriculture and manufacturing is central to the transmission of monetary policy changes to aggregate outcomes.

We build on a growing literature on heterogeneous agent New Keynesian (HANK) models. The main methodological contribution we makes is to merge a two sector production structure along the lines of Aoki with a TANK framework along the lines of Debortoli and Gali to understand the impact of redistributive policy shocks and its implications for monetary policy using a tractable New Keynesian DSGE framework.

[8]In the current framework, we do not model minimum support prices as we did in GGM. Our focus is to study the impact of redistributive policy shocks on rich-poor consumption and sectoral and aggregate inflation dynamics, and monetary policy setting in this context.

2.2 The Model

The model has two sectors: agriculture (A) and manufacturing (M). The A-sector is characterized by perfect competition and flexible prices, and produces a single homogeneous good. The M-sector is characterized by monopolistic competition and staggered price setting.[9] We consider an economy populated by two distinct types of households: poor (P) and rich (R). The fraction of households that are rich is exogenously given and denoted by μ_R. The rest $(1-\mu_R)$ are poor. The poor and rich can either work in the A sector or the M sector, i.e., there is perfect mobility of labour across sectors. Poor households are assumed to be rule of thumb (or hand to mouth consumers) and do not have bond holdings. Rich households are forward-looking Ricardian consumers and hold bonds. The rich households own the firms and also supply labour to their own firms, and so they have both dividend and labour income. The poor households only supply labour to the firms owned by the rich, and so their only income is labour income.

Like GGM, the government procures grain in the open market. It does this by imposing a lump-sum tax on the rich and uses the proceeds to procure/buy A-sector output from the market at the market price.[10] It then redistributes a fraction of the procured A good to poor households. Hence, redistribution goes to the poor households, rather than any particular sector. The rich households also have higher incomes than the poor since the poor households only have labour income, whereas rich households have labour and dividend income.

Following Atkeson & Ogaki (1996), who show that the IES in consumption

[9] The manufacturing sector can also be termed as the "non-agriculture" sector. The names are not crucial. What is crucial is that one sector is a flexible price sector, and the other is a sticky price sector.

[10] It is important to note that the seller of the A good can be either poor or rich. As the agriculture sector is perfectly competitive and exhibits flexible prices, we are agnostic about who owns the agricultural firms.

rises with wealth in Indian data, we assume that the poor have a lower IES than the rich. This means that the poor are less willing to substitute consumption across time periods. This allows labour responses of the rich and poor to differ for a given change in the real wage (Chen et al. 2012).

2.2.1 Households

All households are assumed to have identical preferences.[11] At time 0, a household of type K $(= R, P)$ maximizes its expected lifetime utility given by

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[U\left(C_{K,t}\right) - V\left(N_{K,t}\right)\right] \tag{2.1}$$

where $C_{K,t}$ is a consumption index, and $N_{K,t}$ is labour supply. The subscript $K \in \{R, P\}$ specifies the household type. A household of type K derives utility from consumption, $C_{K,t}$, and disutility from supplying labour, $N_{K,t}$. $\beta \in (0, 1)$ is the discount factor. The period utility function is specified as:

$$U\left(C_{K,t}\right) = \frac{C_{K,t}^{1-\sigma_K}}{1-\sigma_K}, \tag{2.2}$$

$$V\left(N_{K,t}\right) = \frac{N_{K,t}^{1+\varphi}}{1+\varphi}, \tag{2.3}$$

where σ_K and φ, respectively, are the inverse of the IES for consumer type K, and the inverse of the Frisch labour supply elasticity, which is assumed to be the same for both types of households. Consumption of both rich and poor households depend on goods consumed from both sectors and follow Cobb-Douglas indices of agriculture (A) and manufacturing (M) consumption and is

[11] All derivations for the model in Sections 2 and 3 are in the Technical Appendix.

given by:

$$C_{K,t} = \frac{C_{K,A,t}^{\delta_K} C_{K,M,t}^{1-\delta_K}}{\delta_K^{\delta_K} (1-\delta_K)^{1-\delta_K}}; \text{ for } K = R \text{ and } P, \tag{2.4}$$

where $\delta_K \in [0,1]$ is the share of income spent on agricultural goods by the K^{th} type of agent. Consumption in the manufacturing sector is a CES aggregate of a continuum of differentiated goods indexed by $j \in [0,1]$,where $P_{M,t}(j)$ is the price level of the j^{th} variety of the M-sector good, i.e., $C_{K,M,t} = \left(\int_0^1 C_{K,M,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right)^{\frac{\varepsilon}{\varepsilon-1}}, \varepsilon > 1.$[12]

Rich households maximize utility given in equation (2.1) subject to the following intertemporal budget constraint

$$\int_0^1 \left[P_{M,t}(j) C_{R,M,t}(j)\right] dj + P_{A,t} C_{R,A,t} + E_t\{Q_{t+1} B_{t+1}\}$$
$$\leq B_t + W_t N_{R,t} - T_{R,t} + Div_t, \tag{2.5}$$

where Q_{t+1} is the stochastic discount factor, B_{t+1} are the nominal payoffs in period $t+1$ of the bonds held at the end of period t, $T_{R,t}$ is the lump-sum tax paid to the government, and Div_t is the dividend income distributed to households by monopolistically competitive firms. Labour is assumed to be completely mobile across sectors, with the nominal wage rate given by W_t. We assume that the A sector produces a single homogeneous good, whose price is $P_{A,t}$.

To model a procurement-redistribution style intervention in an EMDE, the government in every period procures the agriculture good at the open market price, $P_{A,t}$. Part of the procured agriculture good is rebated back to each poor household as a subsidy, $C^S_{P,A,t}$, while the remaining portion is put into a buffer

[12]The demand functions for goods within manufacturing varieties are

$$C_{K,M,t}(j) = \left(\frac{P_{M,t}(j)}{P_{M,t}}\right)^{-\varepsilon} C_{K,M,t}$$

for $K = R$ and P.

stock.[13] Of the total consumption of the agriculture good by the poor household, $C_{P,A,t}$, a fraction, λ_t, is subsidized (it is given for free). That is, $C^S_{P,A,t} = \lambda_t C_{P,A,t}$ The remaining fraction, $(1-\lambda_t)$, of $C_{P,A,t}$ is purchased from the open market ($C^O_{P,A,t}$), which implies

$$C^S_{P,A,t} + C^O_{P,A,t} = C_{P,A,t}. \tag{2.6}$$

Poor households are assumed to be rule of thumb consumers, and maximize their current utility (2.1) subject to the following (static) budget constraint

$$\int_0^1 \left[P_{M,t}(j) C_{P,M,t}(j)\right] dj + P_{A,t} C^O_{P,A,t} \leq W_t N_{P,t}, \tag{2.7}$$

where $P_{A,t}C^O_{P,A,t}$ denotes the nominal value of open market purchases of the agriculture good done by the poor. The poor agent derives utility from the amount of the agricultural good consumed, while the expenditure depends only on a fraction, $1-\lambda_t$, of the quantity consumed. It is easy to see that equation (2.7) can be rewritten as

$$\int_0^1 \left[P_{M,t}(j) C_{P,M,t}(j)\right] dj + P_{A,t}(1-\lambda_t) C_{P,A,t} \leq W_t N_{P,t}. \tag{2.8}$$

Hence, the proportional quantity subsidy can be interpreted as a price subsidy. We define: $P'_{A,t} = (1-\lambda_t)P_{A,t}$, which is the effective price of the agricultural good paid by the poor agent.

Optimal allocations

Optimal consumption allocations by the rich for A and M goods are given, respectively, by

[13] An equivalent interpretation is that non redistributed procured output is wasted, or *thrown into the ocean*. We do not endogenize buffer stock dynamics in this chapter.

$$C_{R,A,t} = \delta_R \left(\frac{P_{A,t}}{P_t}\right)^{-1} C_{R,t}, \tag{2.9}$$

$$C_{R,M,t} = (1-\delta_R) \left(\frac{P_{M,t}}{P_t}\right)^{-1} C_{R,t}, \tag{2.10}$$

where the aggregate price level is given by $P_t = P_{A,t}^{\delta_R} P_{M,t}^{1-\delta_R}$.

For poor households, consumption allocations for the A and M goods are given, respectively, by

$$C_{P,A,t} = \delta_P \left(\frac{P'_{A,t}}{P'_t}\right)^{-1} C_{P,t}, \tag{2.11}$$

$$C_{P,M,t} = (1-\delta_P) \left(\frac{P_{M,t}}{P'_t}\right)^{-1} C_{P,t}, \tag{2.12}$$

where the price index for the poor is given by: $P'_t = \{(1-\lambda_t)P_{A,t}\}^{\delta_p} P_{M,t}^{1-\delta_p}$. Because of the policy, λ_t, it is important to note that the rich and poor face different price indices.

Using the fact that $C_{R,M,t}(j) = \left(\frac{P_{M,t}(j)}{P_{M,t}}\right)^{-\varepsilon} C_{R,M,t}$ and the demand functions in (2.9) and (2.10) implies that the budget constraint for the rich can be rewritten as:

$$P_t C_{R,t} + E_t\{Q_{t+1}B_{t+1}\} \leq B_t + W_t N_{R,t} - T_{R,t} + Div_t. \tag{2.13}$$

For the poor, using equations (2.11) and (2.12) implies

$$P'_t C_{P,t} \leq W_t N_{P,t}, \tag{2.14}$$

where $C_{R,t}$ and $C_{P,t}$ denote the consumption indices (over the agriculture good and manufacturing good) of the rich and poor households, respectively. As seen in equation (2.14), the impact of subsidizing the agriculture good for poor households reduces the effective price of the consumption basket to $P_t^{'}$.

The solutions to maximizing equation (2.1) subject to equation (2.13) for the rich and equation (2.14) for the poor yield the following optimality conditions:

$$1 = \beta E_t \left[\left(\frac{C_{R,t+1}}{C_{R,t}} \right)^{-\sigma_R} \frac{P_t}{P_{t+1}} R_t \right], \tag{2.15}$$

$$\frac{W_t}{P_t} = \frac{N_{R,t}^{\varphi}}{C_{R,t}^{-\sigma_R}} \text{ for the rich,} \tag{2.16}$$

$$\frac{W_t}{P_t^{'}} = \frac{N_{P,t}^{\varphi}}{C_{P,t}^{-\sigma_P}} \text{ for the poor,} \tag{2.17}$$

where $R_t = \frac{1}{E_t\{Q_{t+1}\}}$ is the gross nominal return on the riskless one-period bond.

Terms of trade

Terms of trade between the agriculture and the manufacturing sectors (TOT) is defined as the relative price of the agricultural good $T_t \equiv \frac{P_{A,t}}{P_{M,t}}$. CPI inflation is given by $\pi_t = \ln P_t - \ln P_{t-1}$, and the sectoral inflation rates are given by as $\pi_{A,t} = \ln P_{A,t} - \ln P_{A,t-1}$ and $\pi_{M,t} = \ln P_{M,t} - \ln P_{M,t-1}$, respectively, for the agriculture and the manufacturing sectors. From the aggregate price index, CPI inflation can also be written in terms of TOT as

$$\pi_t = \delta_R \pi_{A,t} + (1 - \delta_R)\pi_{M,t} = \delta_R \Delta T_t + \pi_{M,t}. \tag{2.18}$$

Sectoral aggregates

We define aggregate agriculture consumption as a weighted average of rich and poor agriculture consumption:

$$C_{A,t} = \mu_R C_{R,A,t} + (1-\mu_R) C_{P,A,t}. \tag{2.19}$$

The total amount of redistributed grain and the consumption subsidy to the poor is given by:

$$(1-\mu_R) C^S_{P,A,t} = \phi_t Y^P_{A,t}, \tag{2.20}$$

where the government redistributes a fraction, $\phi_t \in [0,1]$, of procured goods, $Y^P_{A,t}$, to the poor. Substituting out for $C_{P,A,t}$ from (2.11) yields

$$\underbrace{C_{A,t}}_{\text{Total Ag. Con}} = \underbrace{\mu_R \delta_R \left(\frac{P_{A,t}}{P_t}\right)^{-1} C_{R,t}}_{\text{Con. by Rich}} + \underbrace{(1-\mu_R)\delta_P \left(\frac{P'_{A,t}}{P'_t}\right)^{-1} C_{P,t}}_{\text{Con. by Poor}} \tag{2.21}$$

This implies

$$C_{A,t} = \mu_R \delta_R T_t^{-(1-\delta_R)} C_{R,t} + (1-\mu_R)\delta_p \left\{(1-\lambda_t) T_t\right\}^{-(1-\delta_p)} C_{P,t}. \tag{2.22}$$

Likewise, $C_{M,t} = \mu_R C_{R,M,t} + (1-\mu_R) C_{P,M,t}$ which implies

$$C_{M,t} = \mu_R (1-\delta_R) T_t^{\delta_R} C_{R,t} + (1-\mu_R)(1-\delta_P) \left\{(1-\lambda_t) T_t\right\}^{\delta_p} C_{P,t}. \tag{2.23}$$

These last two equations imply that total agriculture and manufacturing consumption depend on rich and poor consumption, and the TOT.

2.2.2 Firms

In the manufacturing sector, there exists a continuum of firms, each denoted by an index $j \in [0,1]$. Every firm produces a distinct good $Y_{M,t}(j)$ using a linear production technology, characterized by the production function $Y_{M,t}(j) =$

$A_{M,t}N_{M,t}(j)$. We assume that productivity shocks are the same across firms and follow an AR(1) process,

$$\log A_{M,t} - \log A_M = \rho_M \left(\log A_{M,t-1} - \log A_M\right) + \varepsilon_{M,t}$$

where $\varepsilon_{M,t} \sim i.i.d(0, \sigma_M)$. The nominal marginal costs are common across firms and are given by $MC_{M,t} = (1+\tau_M)\frac{W_t}{A_{M,t}}$, where τ_M is the employment subsidy given to manufacturing production. Real marginal cost is written as:

$$mc_{M,t} = \frac{MC_{M,t}}{P_{M,t}} = (1+\tau_M)\frac{W_t}{P_t}T_t^{\delta_R}\frac{1}{A_{M,t}}. \tag{2.24}$$

Let $Y_{M,t} = \left(\int_0^1 Y_{M,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right)^{\frac{\varepsilon}{\varepsilon-1}}$, where $\varepsilon > 1$. Output demand is given by $Y_{M,t}(j) = \left(\frac{P_{M,t}(j)}{P_{M,t}}\right)^{-\varepsilon} Y_{M,t}$. The labour supply allocation in the manufacturing sector is obtained as:

$$N_{M,t} = \int_0^1 N_{M,t}(j)\, dj = \frac{Y_{M,t}}{A_{M,t}} Z_{M,t}, \tag{2.25}$$

where $Z_{M,t} = \int_0^1 \left(\frac{P_{M,t}(j)}{P_{M,t}}\right)^{-\varepsilon} dj$ represents the price dispersion term. Equilibrium variations in $\ln \int_0^1 \left(\frac{P_{M,t}(j)}{P_{M,t}}\right)^{-\varepsilon} dj$ around perfect foresight steady state are of second order. Given that the agriculture sector is characterized by flexible price and perfect competition, we can write the sectoral aggregate production as:

$$Y_{A,t} = A_{A,t}N_{A,t}, \tag{2.26}$$

where the productivity shock follows an AR(1) process,

$$\log A_{A,t} - \log A_A = \rho_A \left(\log A_{A,t-1} - \log A_A\right) + \varepsilon_{A,t}, \tag{2.27}$$

where $\varepsilon_{A,t} \sim i.i.d(0, \sigma_A)$. Nominal marginal costs in the agriculture sector are given by $MC_{A,t} = \frac{W_t}{A_{A,t}}$.[14]

[14]The linear specification of the production function makes the marginal products completely determined by exogenous productivity shocks. We assume a decreasing returns to scale production function to break the

Price setting in the manufacturing sector

Price setting follows Calvo (1983), and is standard in the literature. Firms adjust prices with probabilities $(1-\theta)$ independent of the time elapsed since the previous adjustment. The inflation dynamics under such price setting is

$$\pi_{M,t} = \beta E_t\{\pi_{M,t+1}\} + \kappa \widetilde{mc}_{M,t}, \tag{2.28}$$

where $\kappa = \frac{(1-\beta\theta)(1-\theta)}{\theta}$, and $\widetilde{mc}_{M,t}$ is the deviation of the real marginal cost in the manufacturing sector from its natural rate (to be defined later).

2.2.3 Government procurement

In each period, the government procures $Y^P_{A,t}$ amount of agricultural output at the market price $P_{A,t}$ using the tax receipts from the rich and redistributes a fraction ($\phi_t \in [0,1]$) of procured goods to the poor.[15] The redistributed amount is given by $\phi_t Y^P_{A,t}$. The agricultural sector output is the sum of consumption and the amount accumulated by the buffer stock

$$Y_{A,t} = C_{A,t} + (1-\phi_t)Y^P_{A,t}, \tag{2.29}$$

where the total consumption of the agricultural good $C_{A,t}$ consists of the total amount consumed (by both the rich and poor). A procurement shock is given by an AR(1) process,

$$\ln Y^P_{A,t} - \ln Y^P_A = \rho_{Y^P_A}(\ln Y^P_{A,t-1} - \ln Y^P_A) + \varepsilon_{Y^P_{A,t}}, \tag{2.30}$$

where $\rho_{Y^P_A} \in (0,1)$ and $\varepsilon_{Y^P_{A,t}} \sim i.i.d(0, \sigma_{Y^P_A})$. Re-distributive policy shocks, captured by changes in ϕ_t, capture sudden increases in the *fraction* of procured

proportionality between real wages and terms of trade. See Section A.3 in the Appendix for Impulse Response Analysis for a single-period redistributive policy shock.

[15]Please note that when P is superscript, it refers to procurement. When it is subscript, it refers to the poor.

grain re-distributed to the poor, and are given by the following AR(1) process,

$$\ln \phi_t - \ln \phi = \rho_\phi(\ln \phi_{t-1} - \ln \phi) + \varepsilon_\phi, \tag{2.31}$$

where $\rho_\phi \in (0,1)$ and $\varepsilon_\phi \sim i.i.d(0, \sigma_\phi)$. Higher redistribution and procurement, by leading to a higher subsidy of the agriculture good to the poor from equation (2.20), therefore leads to a larger reduction in the poor's expenditures on the agriculture good.[16]

2.3 Equilibrium Dynamics

2.3.1 Market Clearing

Market clearing is given by the following equations:

$$C_t = \mu_R C_{R,t} + (1-\mu_R) C_{P,t} \left(1-\lambda_t\right)^{-(1-\delta_p)} T_t^{\delta_p - \delta_R} \left(1-(1-\delta_p)\lambda_t\right), \tag{2.32}$$

$$N_t = N_{A,t} + N_{M,t}, \tag{2.33}$$

$$Y_{M,t} = C_{M,t}, \tag{2.34}$$

$$Y_t = C_t + T_t^{1-\delta_R} Y_{A,t}^P (1-\phi_t), \tag{2.35}$$

$$Y_t = T_t^{1-\delta_R} Y_{A,t} + T_t^{-\delta_R} Y_{M,t}, \tag{2.36}$$

$$\mu_R T_{R,t} = P_{A,t}\left[(1-\phi_t) Y_{A,t}^P + (1-\mu_R) C_{P,A,t}^S\right] = P_{A,t} Y_{A,t}^P, \tag{2.37}$$

[16] See also Technical Appendix 7.3.

and equation (2.29). Equation (2.32) corresponds to aggregate consumption by both rich and poor households obtained by adding nominal values of agriculture and manufacturing consumption, weighted by their respective masses, μ_R, and $1 - \mu_R$ in the population (which is normalized to 1), and deflating by the price index. Both the policy, λ_t, and the TOT, T_t, are seen to affect aggregate consumption positively.[17] The labour market clearing condition is given by equation (2.33). The agriculture market clearing condition is given by equation (2.29). The manufacturing goods market clearing condition is given by equation (2.34). The aggregate goods market clearing condition is given by equation (2.35), which can be written in terms of T_t as in equation (2.36). Equation (2.37) is the government budget constraint, which equates lump sum taxes collected from the rich to the nominal value of redistribution $((1 - \mu_R)P_{A,t}C^S_{P,A,t})$ and the fraction of procured output that goes towards buffer stock accumulation $((1 - \phi_t)P_{A,t}Y^P_{A,t})$.

2.3.2 Log-linearization

We relegate a discussion and derivation of the steady state and complete log-linearized model to the Technical Appendix. What is of interest here are the log-linearized expressions for $\widehat{C}_{P,t}$ and $\widehat{C}_{R,t}$, as these give the differential impact on consumption of the poor and rich from a variety of shocks. Log-linearization of the aggregate market clearing condition (equation (2.35)) gives

[17] Comparative statics suggest that higher redistribution (higher λ, holding T constant) lowers the effective price index of the poor agent. This leads to a positive income effect. Holding λ constant and raising T leads to higher consumption, as a higher terms of trade has a positive impact on output, from equation (2.36).

$$\begin{aligned}\widehat{Y}_t &= c\widehat{C}_t + (1-c)\left[(1-\delta_R)\widehat{T}_t + \widehat{Y}^P_{A,t} - \left(\frac{1}{1-\phi}\right)\widehat{\phi}_t\right] \\ &= \left(\frac{1-\mu_A}{1-\bar{\delta}}\right)\widehat{C}_t + \left(\frac{\mu_A-\bar{\delta}}{1-\bar{\delta}}\right)\left[(1-\delta_R)\widehat{T}_t + \widehat{Y}^P_{A,t} - \left(\frac{1}{1-\phi}\right)\widehat{\phi}_t\right]\end{aligned} \tag{2.38}$$

where c is the steady state consumption share in output and is defined in equation (A.42). Log-linearization of aggregate consumption, C_t, in equation (2.32) gives

$$\begin{aligned}\widehat{C}_t = s_R\widehat{C}_{R,t} + (1-s_R)\Bigg\{&\Big(1-\lambda_p\tau\Big)\widehat{C}_{P,t} + \lambda_p\tau\left(\frac{\widehat{\phi}_t}{\phi} + \widehat{Y}^P_{A,t}\right) \\ &+ \left[\delta_p - \delta_R + \lambda_p\tau(1-\delta_p)\right]\widehat{T}_t\Bigg\}\end{aligned} \tag{2.39}$$

where s_R is the steady consumption share of the rich households, $\lambda_p = \frac{\delta_P\lambda}{1-\delta_P\lambda}$, and $\tau = \frac{\lambda(1-\delta_p)}{1-\lambda(1-\delta_p)}$.[18] Log linearizing the first-order conditions (equations (2.16) and (2.17)) for the rich and poor households give

$$\widehat{W}_t - \widehat{P}_t = \varphi\widehat{N}_{R,t} + \sigma_R\widehat{C}_{R,t} \tag{2.40}$$

and

$$\widehat{W}_t - \widehat{P}_t = \varphi\widehat{N}_{P,t} + \sigma_P\widehat{C}_{P,t} - \frac{\delta_p}{1-\lambda}\hat{\lambda}_t + (\delta_p - \delta_R)\widehat{T}_t. \tag{2.41}$$

The log-linearized consumption of the poor, $\widehat{C}_{P,t}$, is given by

$$\widehat{C}_{P,t} = \frac{\sigma_R}{\sigma_P + \lambda_p}\widehat{C}_{R,t} + \frac{\lambda_p}{\sigma_P + \lambda_p}\left[\frac{\widehat{\phi}_t}{\phi} + \widehat{Y}^P_{A,t}\right] - \left\{\frac{\delta_p - \delta_R - \lambda_p(1-\delta_p)}{\sigma_P + \lambda_p}\right\}\widehat{T}_t. \tag{2.42}$$

Note that $\widehat{C}_{P,t}$ is increasing in the redistribution shock, $\widehat{\phi}_t$, the steady state deviation of procurement, $\widehat{Y}^P_{A,t}$, and is affected negatively by the steady state

[18] We assume that the share of rich in employment is equal to the share of rich in the population $0 < \mu_R < 1$, i.e., $N_{R,t} = \mu_R N_t$ and $N_{P,t} = (1-\mu_R)N_t$. This implies that $\widehat{N}_{R,t} = \widehat{N}_{P,t} = \widehat{N}_t$ for all t.

deviation of the TOT, $\widehat{T}_t$. An increase in procurement and redistribution induces a "redistribution-effect" which raises consumption of the poor because it provides subsidized goods for consumption. A rise in the consumption of the rich increases consumption of the poor because of our assumption that the labour supply of the rich and poor are constant fractions of total labour supply. The TOT exerts a negative impact on consumption as a higher relative price of the agriculture good makes the consumption basket of the poor more expensive. This induces the poor to buy less agricultural output. If both the rich and poor households have the same IES, i.e., $\sigma_R = \sigma_P$, $\delta_p = \delta_R$, and there is no redistributive policy, i.e., $\lambda = 0$, then $\widehat{C}_t = \widehat{C}_{R,t} = \widehat{C}_{P,t}$.

Log linearization of the Euler equation (2.15) for the rich households around zero inflation in the steady state gives

$$\widehat{C}_{R,t} = E_t\{\widehat{C}_{R,t+1}\} - \frac{1}{\sigma_R}\left[\widehat{R}_t - E_t\{\Pi_{t+1}\}\right] \tag{2.43}$$

Substituting $\widehat{C}_{P,t}$ in equation (2.42) into (2.39), solving for $\widehat{C}_{R,t}$, and substituting the resulting expression for $\widehat{C}_{R,t}$ in equation (2.43), gives us the Euler equation in terms of aggregate consumption, $\widehat{C}_t$, as

$$\begin{aligned}\widehat{C}_t &= E_t\{\widehat{C}_{t+1}\} - \Phi^{-1}\left[\widehat{R}_t - E_t\{\Pi_{t+1}\}\right] \\ &\quad - \Psi E_t\left\{\frac{\Delta\widehat{\phi}_{t+1}}{\phi} + \Delta\widehat{Y}^P_{A,t+1} + \{(1-\delta_p) + (\delta_p - \delta_R)\, z\}\, \Delta\widehat{T}_{t+1}\right\}\end{aligned} \tag{2.44}$$

where

$$\Phi = \frac{\sigma_R(\sigma_P + \lambda_p)}{s_R(\sigma_P + \lambda_p) + (1 - s_R)\sigma_R(1 - \lambda_p\tau)}, \tag{2.45}$$

$\Psi = \frac{\lambda_p(1-s_R)(1+\sigma_P\tau)}{\sigma_P+\lambda_p}$, and $z = \frac{\sigma_p+\lambda_p-(1-\lambda_p\tau)}{\lambda_p(1+\sigma_p\tau)}$. With $\sigma_R = \sigma_P$, $s_R = 1$, and $\lambda = 0$, equation (2.44) becomes the standard Euler equation for homogenous households.

2.3.3 Gap Variables

Define $\widehat{X}_t^N$ as the deviation of $\ln X_t$ under flexible prices from the steady state, i.e., $\widehat{X}_t^N = \ln X_t^N - \ln X$. Also, define the gap of a variable as $\widetilde{X}_t = \widehat{X}_t - \widehat{X}_t^N$. Then, the dynamic IS equation (DIS) is given by:

$$\begin{aligned}\widetilde{Y}_t &= E_t\left\{\widetilde{Y}_{t+1}\right\} - c\Phi^{-1}\left[\widehat{R}_t - E_t\{\Pi_{t+1}\} - \widehat{R}_t^N\right] \\ &\quad - \left[(1-\delta_R)(1-c) + \Psi c\left\{(1-\delta_p) + (\delta_p - \delta_R)z\right\}\right] E_t\left\{\Delta\widetilde{T}_{t+1}\right\},\end{aligned} \tag{2.46}$$

where $\widehat{R}_t^N$ is the real natural interest rate[19] and is given by

$$\begin{aligned}\widehat{R}_t^N &= -\Big[\Psi\Phi(1-\Lambda^{-1}\Phi) + \varphi(1-c)\Lambda^{-1}\Phi\Big]E_t\Big\{\Delta\widehat{Y}_{PA,t+1}\Big\} \\ &\quad - \Big[\frac{\Psi\Phi}{\phi}(1-\Lambda^{-1}\Phi) - \Lambda^{-1}\Phi\varphi(1-c)\Big(\frac{1}{1-\phi}\Big)\Big]E_t\Big\{\Delta\widehat{\phi}_{t+1}\Big\} \\ &\quad + \Phi\Lambda^{-1}E_t\Big[\varphi\Delta\widehat{A}_{t+1} + \Delta\widehat{A}_{M,t+1}\Big] \\ &\quad + \Phi\Big[\Psi(1+\Lambda^{-1}\Phi)\big(1-\delta_p + (\delta_p-\delta_R)z\big) \\ &\qquad + \Lambda^{-1}\Big\{(1-s_R)\varphi c(\delta_p\tau + \delta_p - \delta_R) - \delta_R\Big\}\Big]E_t\Big\{\Delta\widehat{T}_{t+1}^N\Big\}\end{aligned} \tag{2.47}$$

The NKPC (New Keynesian Phillips Curve) in terms of manufacturing sector inflation, the consumption gap, and the TOT gap is given by,

$$\begin{aligned}\pi_{M,t} &= \beta E_t\{\pi_{M,t+1}\} + \kappa\Lambda\widetilde{C}_t + \kappa\Big[\delta_R - (1-s_R)\varphi c(\delta_p\tau + \delta_p - \delta_R) \\ &\qquad - \Psi\Phi\big(1-\delta_p + (\delta_p-\delta_R)z\big)\Big]\widetilde{T}_t\end{aligned} \tag{2.48}$$

We can also express the NKPC in terms of aggregate inflation and the output gap,

$$\begin{aligned}\pi_t &= \beta E_t\{\pi_{t+1}\} + \frac{\kappa\Lambda}{c}\widetilde{Y}_t \\ &\quad + \kappa\Big[\delta_R - (1-s_R)\varphi c(\delta_p\tau + \delta_p - \delta_R) - \Psi\Phi(1-\delta_p + (\delta_p-\delta_R)z) \\ &\qquad - (1-\delta_R)\left(\frac{\mu_A - \bar{\delta}}{1-\mu_A}\right)\Big]\widetilde{T}_t + \delta_R\Delta\widetilde{T}_t - \beta\delta_R E_t\{\Delta\widetilde{T}_{t+1}\}.\end{aligned} \tag{2.49}$$

[19] See derivation in the appendix A.1.4. $\Lambda = \varphi c + \Phi$

Equations (2.46), the Dynamic IS curve, and (2.49), the New Keynesian Phillips curve, summarize the non-policy block of the economy in our two sector two agent framework.

How do these equations differ compare to the simple NK model in Gali (2015) with a single agent and a single sticky price sector? There are three key differences between the current framework and such a benchmark. The first difference is that there are two sectors which implies that the terms of trade, T_t, appears in the NKPC and the DIS. The second difference is that we have two types of agents (i.e., $s_R \neq 1$) who have different IES's ($\sigma_R \neq \sigma_P$), and in general, different shares of agriculture in consumption ($\delta_R \neq \delta_p$). The third difference is that there is (steady state) procurement and redistribution in the current framework, i.e., $\mu_A - \bar{\delta} > 0$, and $\lambda > 0$. When $\mu_A - \bar{\delta} > 0$, this implies that the employment share and consumption share in agriculture diverge i.e., $c = \frac{C}{Y} = \frac{1-\mu_A}{1-\bar{\delta}} < 1$. Hence, $\mu_A - \bar{\delta} > 0$ drives a wedge between consumption and production in the aggregate economy.[20]

2.3.4 Monetary Policy Rule

Monetary policy follows a simple Taylor rule with the nominal interest rate as a function of aggregate inflation and the economy wide output gap as in Anand et al. (2015) and Ginn & Pourroy (2019). We use a standard generalization of

[20]Suppose $s_R = 1$, $\mu_A = \delta_R = \delta_p = 0$ $(which\ implies\ \bar{\delta} = 0)$, $\sigma_R = \sigma_P$, and $\lambda = 0$. Then equation (2.46) is given by:

$$\widetilde{Y}_t = E_t\left\{\widetilde{Y}_{t+1}\right\} - \frac{1}{\sigma_R}\left[\widehat{R}_t - E_t\{\Pi_{t+1}\} - \widehat{R}_t^N\right],$$

where $\widehat{R}_t^N = \frac{\sigma_R(1+\varphi)}{\varphi+\sigma_R} E_t\left[\triangle \hat{A}_{M,t+1}\right]$, which is the DIS equation in the simple NK model as in Gali (2015). Further, the New Keynesian Phillips Curve in equation (2.49) is given by:

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \kappa(\varphi + \sigma_R)\widetilde{Y}_t$$

which is the NKPC in the simple NK model, where $\pi_t = \pi_{M,t}$ and $\widetilde{Y}_t = \widetilde{Y}_{M,t}$.

Taylor (1993):

$$R_t = R_{t-1}^{\phi_r} \pi_t^{(1-\phi_r)\phi_\pi} \widetilde{Y}_t^{(1-\phi_r)\phi_y}. \tag{2.50}$$

The log-linearized version of the Taylor rule shows that

$$\hat{R}_t = \phi_r \hat{R}_{t-1} + (1-\phi_r)\phi_\pi \pi_t + (1-\phi_r)\phi_y \widetilde{Y}_t, \tag{2.51}$$

i.e., the nominal interest rate, $\hat{R}_t$, depends on its lagged value, $\hat{R}_{t-1}$, aggregate inflation's deviation from its target, π_t, and the aggregate output gap, $\widetilde{Y}_t$. This closes the model.

2.4 Quantitative Analysis

We evaluate the model using a Bayesian approach, as is standard in empirical macro research (see Schorfheide (2000), Fernández-Villaverde & Rubio-Ramírez (2004)). In the Indian context, Bayesian estimation has been used to estimate the structural parameters of a NK DSGE models with an agriculture sector (Ginn & Pourroy 2019). We supplement the estimated parameters in our analysis with some calibrated parameters, as described below.

2.4.1 Data

We use Indian time series data for the 1994 (Q2) - 2019 (Q4) period. Our variables include Gross Domestic Product at 2011-12 prices, Private Final Consumption Expenditure at 2011-12 prices, average daily wage rates for men (in Rs), persons employed in agriculture and manufacturing, total factor productivity in agriculture and manufacturing, inter-sectoral TOT, consumer price inflation, procurement and off-take of rice and wheat.[21] The variable selection, data

[21] Sectoral employment data (in 1000s) are taken from the employment (EMP) series while sectoral total factor productivity and intersectoral TOT are computed using total factor productivity growth rate of value added ($TFPG_{va}$) and Value Added (VA) series from India KLEMS database 2021. The Wage rate is calculated as

sources and frequency are described in Table 2.1.[22]

Description	Source	Frequency
GDP at 2011-12 Prices	National Account Statistics	Quarterly
PFCE at 2011-12 Prices	National Account Statistics	Annual
Average daily wage rates	Wage Rates in Rural India	Quarterly
Persons employed in Agriculture	INDIA KLEMS 2021	Annual
Persons employed in Manufacturing	INDIA KLEMS 2021	Annual
TFP in Agriculture	INDIA KLEMS 2021	Annual
TFP in Manufacturing	INDIA KLEMS 2021	Annual
Terms of Trade	Calculated	Annual
CPI	National Statistics Office	Monthly
Interest Rate	RBI- DBIE	Quarterly
Procurement of rice and wheat	RBI-DBIE	Annual
Redistribution of rice and wheat	RBI-DBIE	Annual

Table 2.1: Data Sources for Bayesian Estimation

2.4.2 Calibration Parameters

Our analysis includes the following calibrated variables, as shown in Table 2.2. Following J. V. Gabriel et al. (2012), we set the discount factor (β) = 0.9832, the measure of price stickiness for manufacturing goods (θ) = 0.75, and the elasticity of substitution between varieties of manufacturing goods (ϵ) = 7.01. We set the steady state employment share in agriculture (μ_A = 0.48) using data from the 68^{th} round of Employment and Unemployment Survey (National Sample Survey

the weighted average of agricultural and non-agricultural wage rates for men (in Rs), with weights being the employment shares. Data on agricultural and non-agricultural wages are taken from Wage Rates in Rural India, and interest rate (3-month T-bill data) have been taken from the *Database on Indian Economy, RBI*. Procurement and redistribution of rice and wheat (in Lakh (100,000) tonnes) have been taken from Table 27: Public Distribution System – Procurement, Off-take and Stocks RBI's Handbook of Statistics on the Indian Economy, 2018-2019 n.d.

[22]We have used access to NFSA as the defining criterion of the poor agents. Due to the absence of percentile/quantile-wise time-series data on consumption, we are unable bifurcate aggregate consumption into rich and poor.

2011a). The population share of the rich is the percentage of the population not receiving food grains under the NFSA 2013. Using population estimates from the Census of India (2011) we find (μ_R = 0.3279). The expenditure share of agriculture for the rich (δ_R = 0.3527), and the poor (δ_P = 0.4807), are determined by the share of cereals and cereal substitutes in total expenditures net of expenditures on services, durable goods, vegetables, fuels (see the Data Appendix for details).

Variable	Notation	Value	Source
Discount factor	β	0.9823	J. V. Gabriel et al. (2012)
Population share of rich	μ_R	0.3279	Calculated by Authors
Steady state employment share in agriculture	μ_A	0.48	Calculated by Authors
Expenditure share of agriculture - Rich	δ_R	0.3527	Calculated by Authors
Out of pocket Expenditure share of agriculture - Poor	δ_P	0.4807	Calculated by Authors
Elas. of Subs. between varieties of $M-$good	ε	7.01	J. V. Gabriel et al. (2012)
Measure of price stickiness (M)	θ	0.75	J. V. Gabriel et al. (2012)

Table 2.2: Calibrated Parameters

We use previous literature with two-agent or two-sector model structures to inform our priors. We use the study by Anand & Prasad (2010) to determine the Frisch elasticity of labour supply (φ) to be 3. We follow Anand & Prasad (2010) in calibrating values for persistence and the standard deviation of food and non-food productivity shocks. In particular, we use the prior that the agricultural and manufacturing shocks have persistence of $\rho_A = 0.25$, $\rho_M = 0.95$, respectively, and standard errors of $\sigma_A = 0.03$ and $\sigma_M = 0.02$, respectively. We use Atkeson & Ogaki (1996) to determine the IES for both agents ($\frac{1}{\sigma_R} = 0.8$ and $\frac{1}{\sigma_P} = 0.5$). Following Banerjee et al. (2020), we fix the interest rate smoothing parameter to be $\phi_r = 0.66$, inflation stabilization coefficient to be $\phi_\pi = 1.2$ and the output gap stabilization coefficient $\phi_y = 0.5$.

2.4.3 Estimation Method

The annual series are converted to quarterly series using natural cubic spline interpolation. The variables (except interest rate, inflation and productivity shocks) are detrended using the Hodrick-Prescott filter. The Bayesian estimation is based on the adaptive Metropolis–Hastings algorithm. The prior distributions of the estimated parameters are reported in Columns (4) and (5) in Table 2.3, and the Posterior distributions are summarized in Columns (6)-(9) in the same Table. Table 2.3 summarizes the prior distributions of the estimated parameters, and the mean and standard deviations of the posterior distributions. We use the means of the posterior distributions to study the impulse response functions (IRFs) of the relevant macroeconomic variables.

2.4.4 Impulse response analysis

Our IRF analysis focuses on: (i) a shock to agricultural productivity (supply shock) (ii) procurement and redistribution (demand side shock) and (iii) monetary policy (demand shock). We discuss the estimated mechanisms of these shocks. The IRFs of each shock are benchmarked against a one agent two sector version of our model along the lines of Aoki.[23] This allows us to highlight the importance of having rich and poor agents and redistributive policy shocks to interact in the model. We also compare the transmission mechanism in our 2S-TANK model and compare it to the IRFs in (i) a simple NK model la Gali (2015, Chapter 3), (ii) Aoki, and (iii) Debortoli and Gali. Throughout the IRF analysis, our focus is

[23]To generate the Aoki model as a special case of our model, the following parameter restrictions are imposed: $\mu_R = s_R = 1$, $\delta_p = \delta_R$, $\lambda = 0$, $\mu_A = \delta_R$, $\sigma_R = \sigma_P$, and an arbitrarily small value of $\phi = 1.000 * 10^{-25}$. For single agent models in the IRFs (Aoki's model and the simple NK model), we have exogenously imposed that $C_P = 0$ as there is no poor agent in these models.

	Parameter	Density	Prior Distribution		Posterior Distribution			
			Mean	Std Dev	Mean	Std Dev	95% interval	
s_R	SS Rich cons. share	IG	0.50	0.01	0.417	0.005	0.406	0.427
σ_R	Inverse of IES Rich	IG	1.25	0.14	1.142	0.132	0.897	1.407
σ_P	Inverse of IES Poor	IG	2	0.23	1.888	0.223	1.469	2.343
λ	SS share of subsidy in $C^P_{A,t}$	IG	0.2	0.01	0.259	0.003	0.253	0.264
ϕ	SS share of procured A good redistributed	B	0.8	0.06	0.804	0.056	0.686	0.903
φ	Inverse of Frisch elasticity of labour supply	IG	3	0.73	2.434	0.464	1.674	3.522
	Monetary Policy							
ϕ_r	Interest rate smoothing	IG	0.66	0.09	0.99	0.003	0.994	1.005
ϕ_π	Weight on inflation gap	IG	1.2	0.4	1.051	0.354	0.580	1.966
ϕ_y	Weight on output gap	IG	0.5	0.19	0.510	0.200	0.255	1.025
	Shocks: Persistence							
ρ_{A_A}	Productivity shock in A-sector	B	0.25	0.11	0.255	0.106	0.087	0.490
ρ_{A_M}	Productivity shock in M-sector	B	0.95	0.03	0.951	0.033	0.865	0.994
$\rho_{Y^P_A}$	Procurement shock	B	0.43	0.08	0.474	0.081	0.316	0.634
ρ_ϕ	Redistribution shock	B	0.59	0.09	0.694	0.066	0.561	0.816
	Shocks: Standard Deviations							
σ_A	Productivity shock in A-sector				0.016	0.0003	0.016	0.017
σ_M	Productivity shock in M-sector				0.015	0.0001	0.014	0.015
$\sigma_{Y^P_A}$	Procurement Shock				0.0196	$1.16\text{x}10^{-5}$	0.0196	0.0196
σ_ϕ	Redistribution Shock				0.011	0.001	0.011	0.014
σ_v	Monetary Policy				0.009	0.0001	0.009	0.010

(1) Note: 95% credible interval is reported in Columns (8)-(9)
(2) distributions include Beta (B), Inverse Gamma (I), Std Dev for standard deviation.
(3) Inverse Wishart is used as the conjugate prior for the covariance matrix (identity matrix as scale matrix and d.o.f. = 100) of a multivariate normal distribution with unknown mean and covariance matrix.

Table 2.3: Bayesian Estimation: Prior and Posterior Distributions

on understanding how these shocks affect sectoral and aggregate inflation rates, consumption of rich and poor agents, and resource allocation across sectors.

We allow for the procurement wedge to be positive, i.e. $\mu_A - \bar{\delta} > 0$, and $\lambda > 0$.[24] Also, since $\delta_p > \delta_R$, this implies that the share of agriculture consumption by the poor (out of total poor consumption) exceeds the share of agriculture consumption by the rich (out of total rich consumption) which influences the impact effect of the shock on poor and rich agricultural consumption.

Transmission of a single period positive productivity shock in the A-sector

We first describe what happens in our (2-sector TANK) model. This corresponds to the red dash-dotted line in Figures 2.1a-2.1c. A positive productivity shock raises output and causes deflation in the agriculture sector (P_A falls). The TOT, T, falls. The price effect dominates the productivity effect of the shock, leading to a reduction in nominal wages. However, the aggregate price index falls by more than the nominal wage, leading to an increase in the real wages on impact. The income effect of real wage dominates the substitution effect, leading to an increase in consumption and a reduction in labour supply by both agents. As T falls, the manufacturing good becomes relatively expensive, resulting in a reduction in the demand for the manufacturing (M) good. This leads to a decline in the demand for the manufacturing (M) good by both agents. Manufacturing output and employment declines.[25] While aggregate output increases, the output gap falls.[26] There is a deflation in the manufacturing sector consistent with the

[24] We drop subscripts (t) and hats from variables for the following discussion to economize on notation. The IRFs for variables however, should be interpreted as their log deviations.

[25] In the case of Aoki, there is a much greater increase in demand for the agricultural good, inducing an increase in employment in the agriculture sector.

[26] This happens because while output increases, the natural level of output increases even more. Under flexible prices, the decline in demand (in response to the agricultural productivity shock) would have resulted in lower manufacturing sector prices and, therefore, relatively higher manufacturing output.

negative output gap. Aggregate inflation falls because inflation in both sectors fall.[27]

The decline in inflation and output gap induces the monetary authority from the Taylor rule, equation (2.51), to cut nominal interest rates. Real rates also fall since prices are sticky, which induces a rise in the consumption of rich households, $C_{R,}$, owing to the intertemporal substitution effect. From equation (2.42), it is apparent that the impact of poor household consumption, C_P, depends positively on C_R and the terms of trade. Overall, C_P rises, leading to aggregate consumption, C, to rise. In sum, a positive agriculture productivity shock leads to a rise in both poor and rich consumption, aggregate consumption, lower sectoral inflation rates, and lower aggregate inflation.

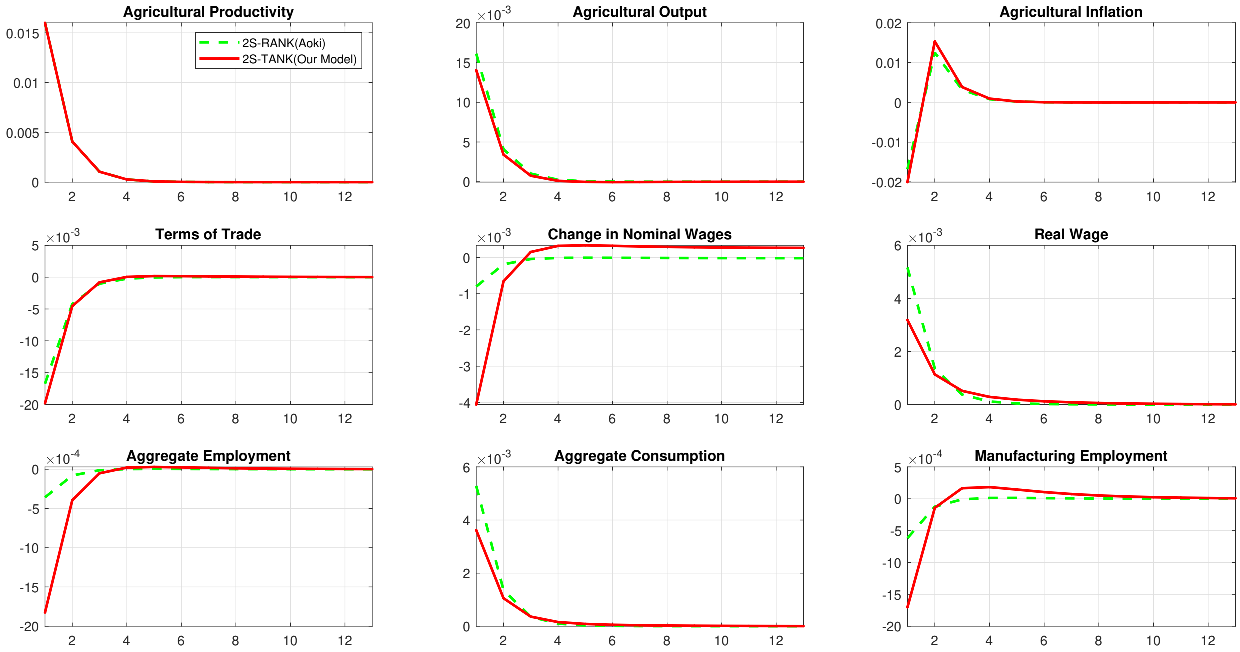
Distributional Impact Both the rich and the poor benefit from higher real wages because of a positive productivity shock. This induces both sets of households to increase their consumption of both the manufacturing and agriculture good. However, the decline in the TOT (P_A falls relative to P_M) induces both the rich and poor to increase their demand of the agriculture good comparatively more because of the inter-good substitution effect. However, poor consumption increases less relative to rich consumption, suggesting that the rich gain more than the poor, shown by the falling poor-rich consumption ratio.

Transmission of a single period redistributive policy shock

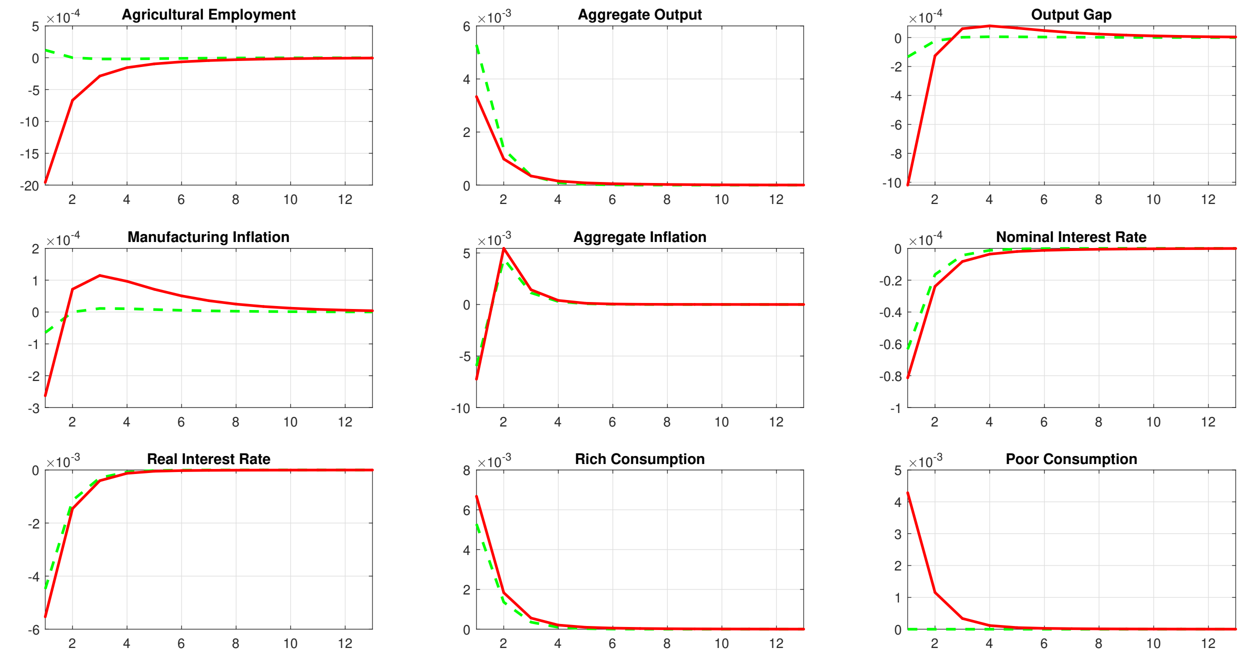
As before, a redistributive policy shocks refers to a procurement and redistributive shock.[28] We first describe what happens in our (2 sector TANK) model. This corresponds to the red dash-dotted line in Figures 2.2a-2.2c. A procurement

[27] Modelling a countercyclical redistributive policy would weaken the deflationary impact of a positive agricultural productivity shock.

[28] We use these terms inter-changably.

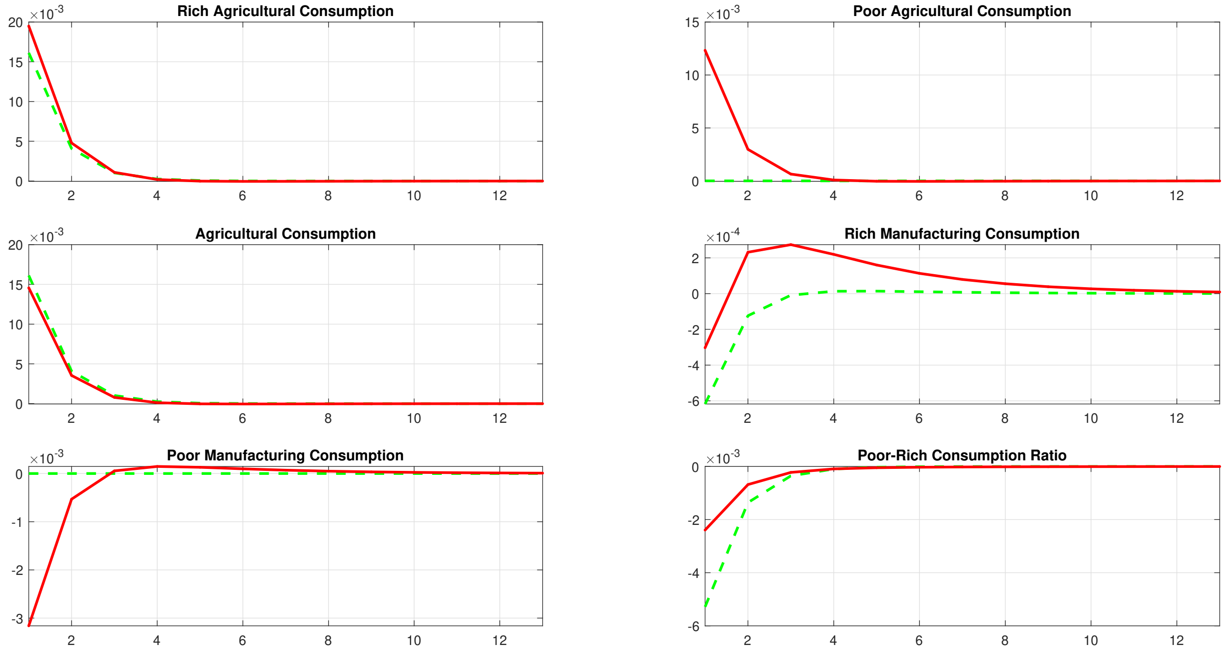


(a) Impact of single-period positive agriculture productivity shock



(b) Impact of single period positive agriculture productivity shock

Figure 2.1: Impact of single period positive agriculture productivity shock



(c) Distributional impact of single period positive agriculture productivity shock

Figure 2.1: Impact of single period positive agriculture productivity shock

and redistribution (which are orthogonalized) shock acts like a demand shock to the economy.[29] On impact, a procurement and redistributive policy shock leads to higher demand for agricultural output, Y_A, higher P_A and therefore, higher π_A. This leads to an *increase* in the TOT, T. For the supply of the agriculture good to increase with no change in productivity, employment in the agriculture sector, N_A, must go up on impact. In order to attract labour to the agriculture sector, nominal wages in the agriculture sector must rise. With sticky prices in the manufacturing sector, equilibrium in labour markets (the same nominal wage in both sectors) means that economy wide real wages rise.[30]

As before, a rise in the real wages has two competing effects: income and

[29]The reason why we consider them simultaneously is because the government's desire to increase procurement is driven by its desire for higher redistribution.

[30]This is broadly in line with research on the Indian National Food Security Act in 2013 which shows that changes in the generosity of the Public Distribution System led to higher wages, suggesting that labour market effects of social transfers bestow important additional effects in terms of benefits for the poor. See Baylis et al. (2019).

substitution effects. The income effect states that a rise in the real wages (income) of an agent would lead to greater consumption of both consumption and leisure (C rises, N falls) while the substitution effect states that a rise in real wages makes leisure relatively more expensive and hence leisure should fall and consumption should rise (C rises, N rises). The rich agent's consumption is governed by a third effect - the inter-temporal consumption substitution effect, which states that an increase in the real interest rate will induce agents to save today and consume tomorrow, i.e., substitute today's consumption for future consumption.

As the poor agents do not have access to financial markets, they cannot smooth their consumption over time.[31] The redistributive policy shock lowers the effective price of the poor agent's basket. More precisely, it lowers the price of the agricultural good paid by the poor agents to $P_A(1-\lambda)$ which turns out to be lower than P_M. This leads to an increase in C_P, $C_{P,A}$ and a decrease in $C_{P,M}$.[32]

As π_A is positive and current and future marginal costs of production are positive, manufacturing and aggregate inflation are positive on impact. Under flexible prices, manufacturing prices increase in response to higher real wages. This causes a greater reduction in manufacturing output relative to the flexible price level of output, leading to a positive output gap. Given this, central banks must raise nominal interest rates. With sticky prices, real interest rates also rise on impact. Given our parameters, we find that C rises leading to higher welfare,

[31]Motivated by consumption inequality in India, Lahcen & Gomis-Porqueras (n.d.) (2019) build a monetary model with endogenous credit market participation where the poor, because they do not have access to financial services, smooth their consumption by saving through fiat money. They find that the transmission of monetary policy changes quite a bit with this feature. We hope to take up this extension in a separate paper in the future.

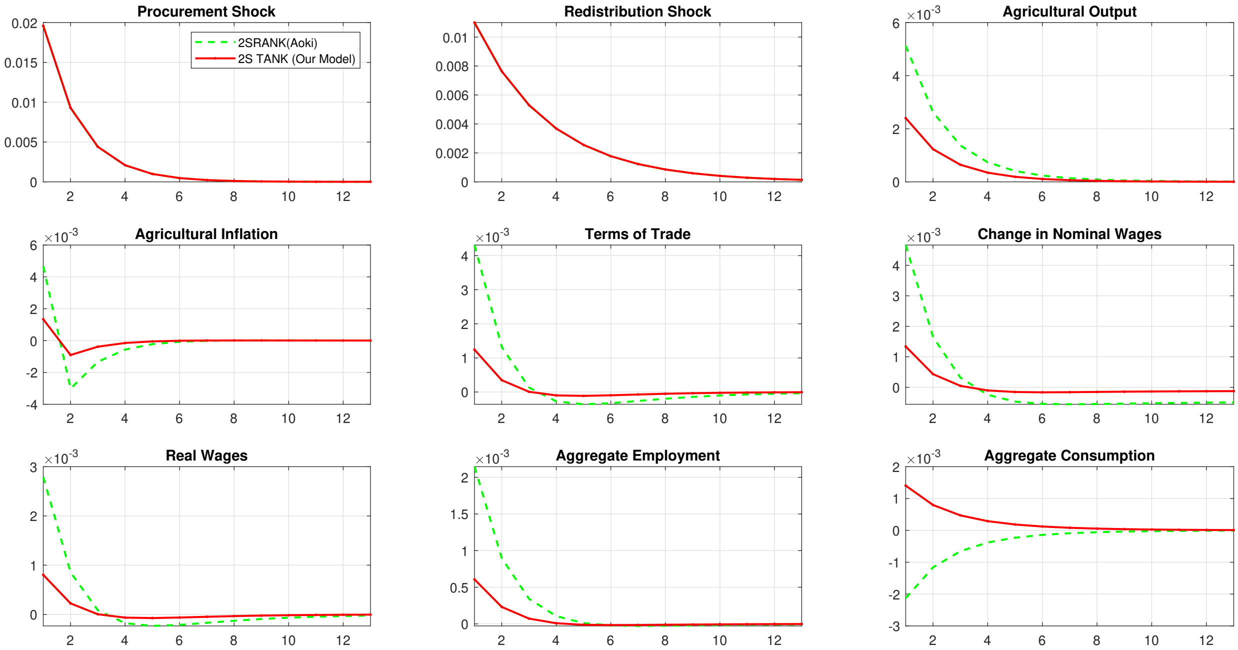
[32]When we only do a procurement shock and set $\lambda = 0$, *both* C_P and C_R fall. Thus, the redistributive effect determines the poor agent's consumption.

even though monetary policy has tightened the interest rate.

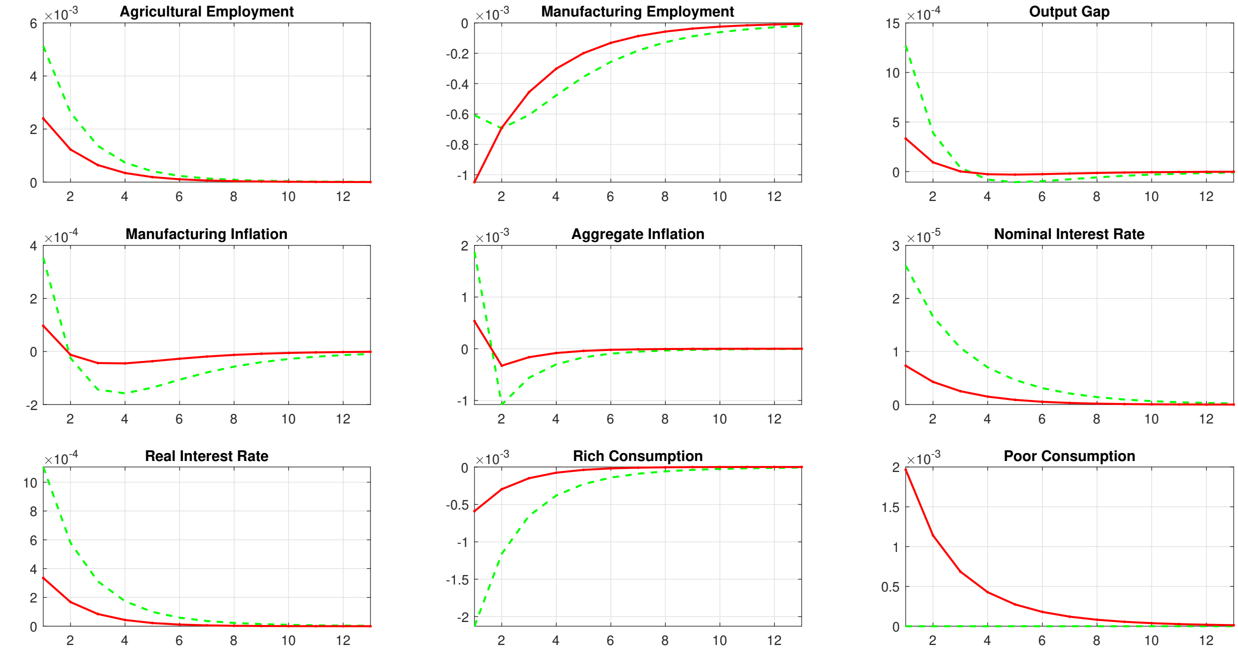
Distributional Impact As can be seen in Figure 2.2c, consumption of both agriculture and manufacturing goods by the rich fall because of intertemporal substitution. However, a rise in poor agriculture consumption on impact leads to a rise in overall agriculture consumption. Poor manufacturing consumption however also falls because $P_A(1-\lambda)$ is lower than P_M. Unlike the previous case, C_P rises relative to C_R despite the central bank tightening interest rates.

Compared to Aoki's model (green dashed line), there are interesting differences.[33] In the Aoki model, all agents are rich (Ricardian) and do not have access to subsidized consumption of the agriculture good. Employment in our model, like before, is lower compared to Aoki because of the presence of poor agents who have a lower IES. The difference in the expenditure share of the agriculture good by the poor, δ_p, plays an important role on the rich-poor consumption dynamics. Since the poor receive the redistributed agricultural good for free, their demand for market purchases of the agriculture good are lower (Figure 2.2a). In addition, $\delta_p > \delta_R$, and so the redistributed agricultural good induces a lower demand for agricultural good consumption by the poor from the market. As a result, aggregate demand for agricultural output is lower, and the impact effect of a procurement and redistributive shock on agricultural output in our model is less compared to the Aoki model. Correspondingly, a procurement and redistributive shock leads to lower inflation on impact in our model compared to Aoki's model. As a result, the corresponding rise in the real interest rate from the Taylor rule is lower in our model which implies that the decline in rich consumption is lower in our model compared to Aoki. Importantly, because of

[33] We have imposed $\mu_A > \delta_R$ to generate these IRFs. Since Aoki's model has a single agent, there is no redistribution, and therefore no redistributive policy shock in his model. The only shock therefore is a procurement shock, which generates the impulses given by the green dashed line.

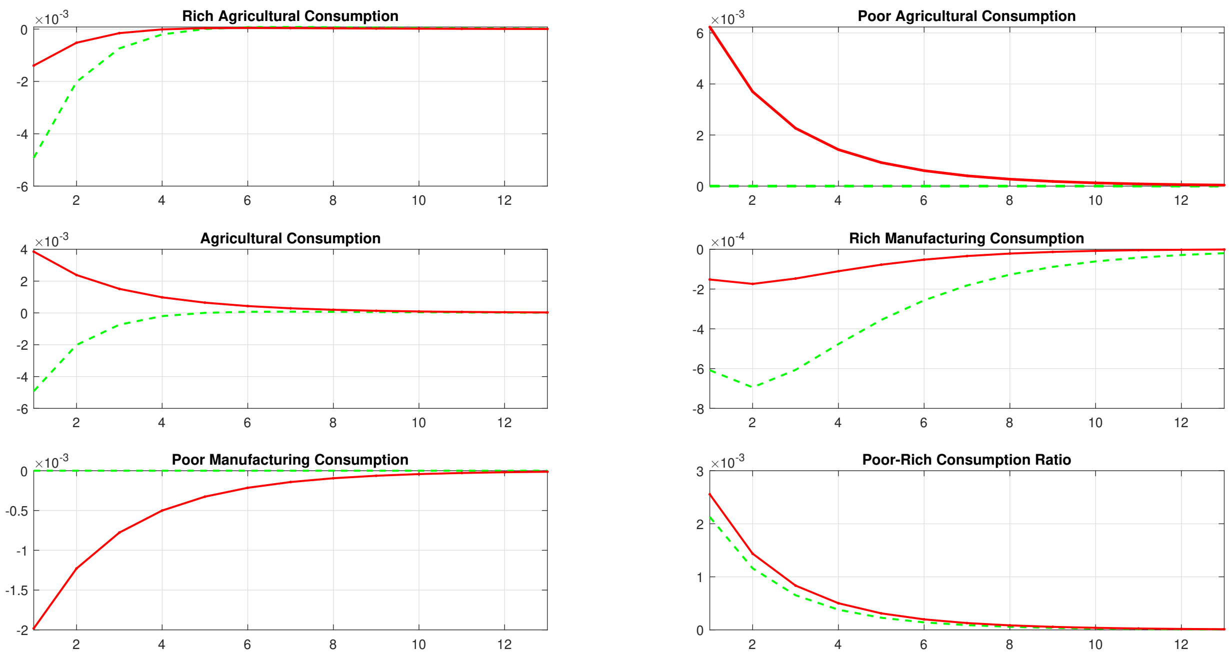


(a) Impact of single period redistributive policy shock on macroeconomic aggregates



(b) Impact of single period redistributive policy shock on macroeconomic aggregates

Figure 2.2: Impact of single period positive procurement and redistributive policy shock



(c) Distributional impact of single period positive procurement and redistributive policy shock

Figure 2.2: Impact of single period positive procurement and redistributive policy shock

the redistributive shock, poor consumption rises in our model, off-setting the decline in rich consumption, and raising aggregate welfare.

Transmission of a single period monetary policy shock

We consider a single period, contractionary monetary policy shock, which increases the nominal interest rate. This exercise is included to emphasize how our two sector TANK model (red dash-dotted line) leads to a muted impact (less monetary transmission) compared to a variety of benchmarks - the simple NK model (magenta dotted-circle line), Aoki (green-dashed line), and Debortoli and Gali (blue dash-triangle line).[34] Crucially, we show that monetary policy has

[34]To generate IRFs for 2 agents and 1 sector along the lines of Debortoli and Gali, we have imposed $\delta_R = \delta_p = \lambda = \mu_A = 0; \phi = 1.0000 * 10^{-25}$; steady state values of $Y_A = C_A = C = Y = Y_M = 1$. Note that the steady state value of $Y_M = 1$ since under the above values, $\bar{\delta} = 0$. We have retained the values of s_R, μ_R, σ_R, and σ_P as in our 2 sector TANK framework listed in Table 1. For the simple NK model, we impose the additional restrictions: $s_R = \mu_R = 1$, and $\sigma_R = \sigma_P = 1.142$, to generate the IRFs for this benchmark. As a preliminary check, we verify that the model dynamics for the simple NK model generated here has IRFs for a contractionary monetary policy

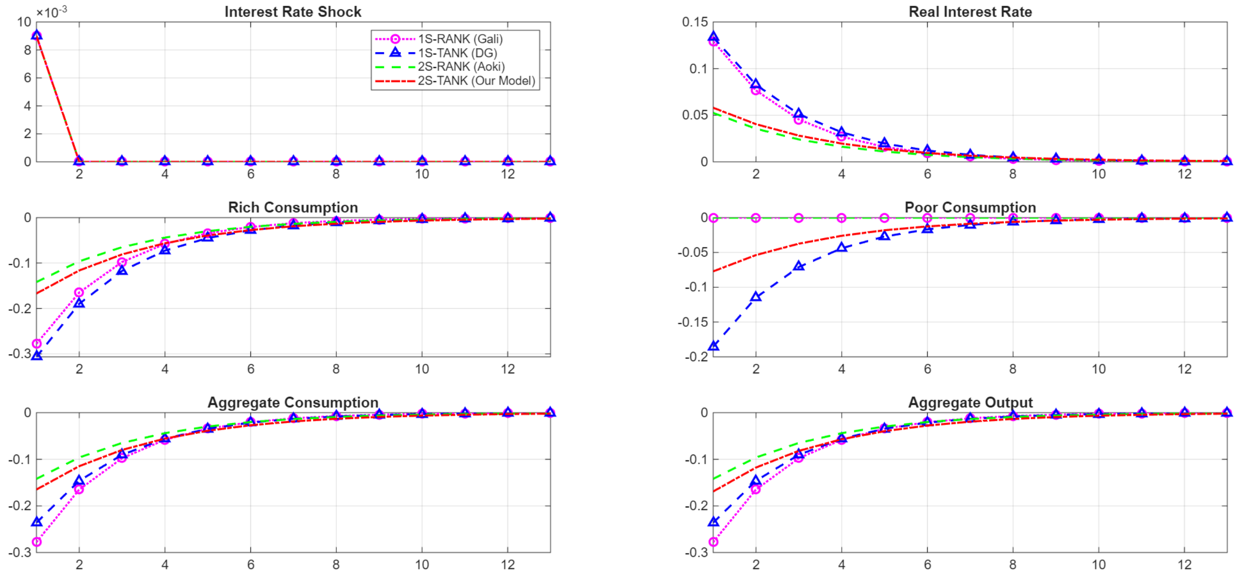
both output effects *and* redistributive effects. Our basic insight is that the model dynamics are more influenced by having two sectors, i.e., adding a flexible price sector, rather than the demand side, i.e., having poor agents, when there is a monetary policy shock.

As in the previous cases, we first discuss the effect of a monetary policy shock on our 2 sector TANK model (red dash-dotted line) in Figures 2.3a-2.3c. In response to a rise in the nominal interest rate the real interest rate rises, leading to inter-temporal consumption substitution by the rich. The reduction in aggregate demand causes a reduction in prices in both sectors, with the magnitude being greater in the agricultural sector due to flexible prices. As the interest rate shock is for a single period, agricultural inflation returns to its steady state value in the next period, while the manufacturing sector inflation recovers gradually. Thus aggregate inflation falls by more on impact but recovers quickly (owing to the flexible price sector) as compared to the one sector models in this analysis. As a result, the real interest rates rises less in our two sector TANK economy This leads to a reduction in the terms of trade, T, and thus a smaller reduction in C_P relative to C_R.

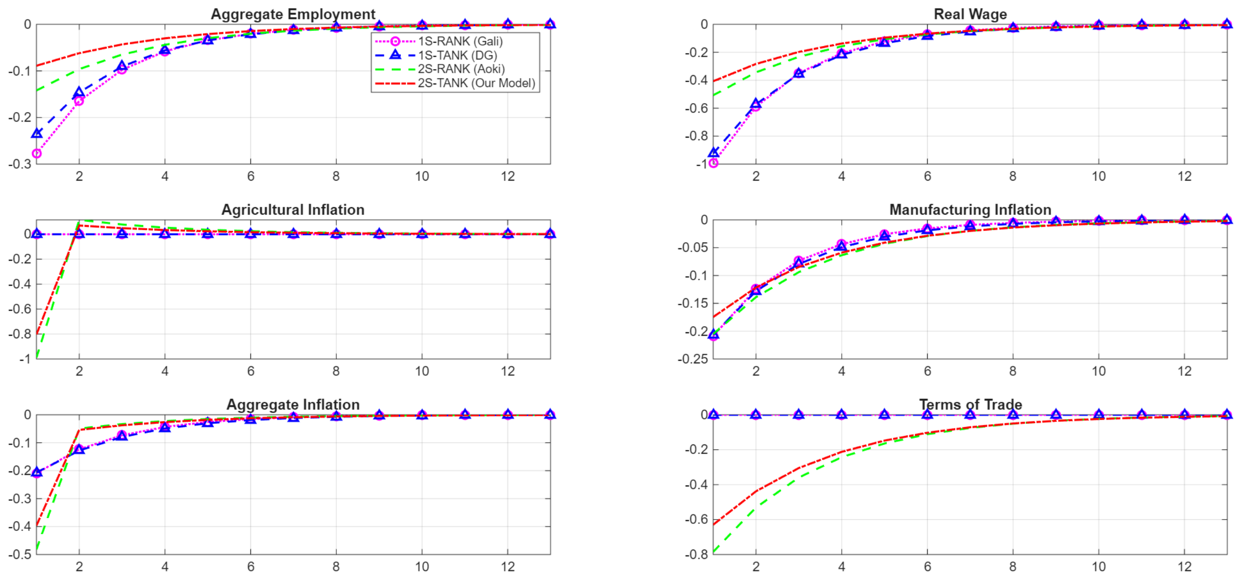
In the current scenario, where there is no government intervention in the agriculture market, aggregate output is the same as aggregate consumption, and so on impact, Y, must fall from its steady state value. For the supply of the output to decline, less goods must be produced and hence employment, N, should fall on impact. This is ensured by lower real wages, which fall on impact.

In the two sector TANK economy, as the terms of trade falls in response to a monetary tightening, the agricultural good is relatively cheaper and

shock that are consistent with Gali (2015, Chapter 3, page 69).



(a) Impact of single period contractionary monetary policy shock on macroeconomic aggregates

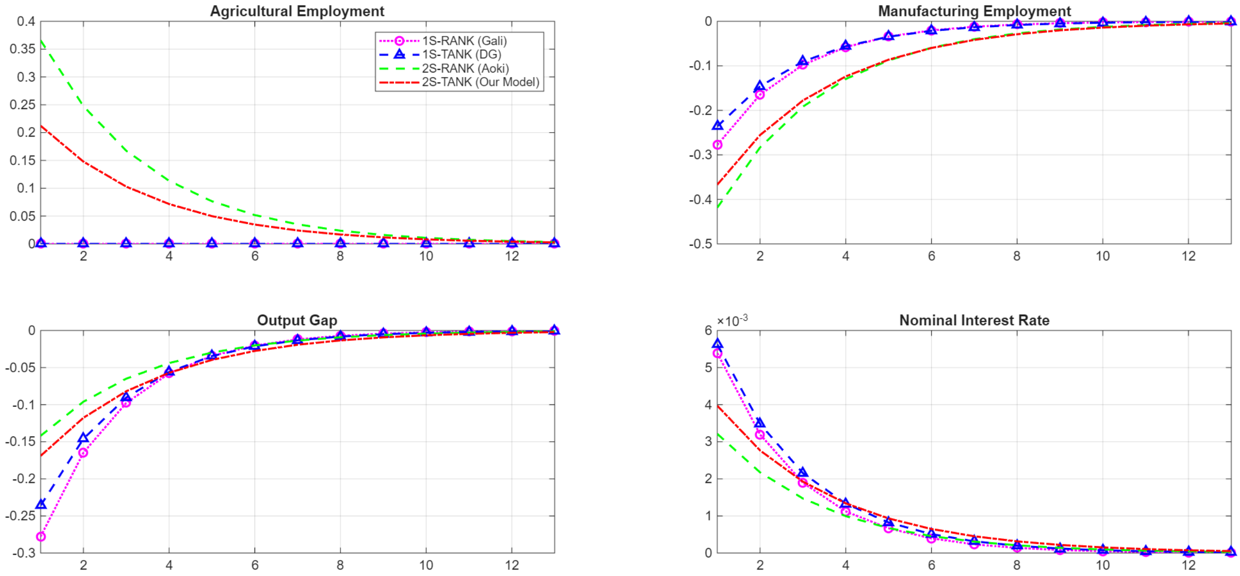


(b) Impact of single period contractionary monetary policy shock on macroeconomic aggregates

Figure 2.3: Impact of single period contractionary monetary policy shock

hence demand for the agricultural (flexible price) good increases while for the manufacturing (sticky price) good falls (inter-good substitution effect). Consequently N_A rises on impact, and therefore, N_M falls.

Distributional Impact A contractionary monetary policy shock leads to a reduction in aggregate consumption in all models, although the magnitude of reduction is



(c) Distributional impact of single period contractionary monetary policy shock

Figure 2.3: Impact of single period contractionary monetary policy shock

smaller in the two-sector models (ours and Aoki's model). This happens because of the smaller increase in the real interest rate due to the presence of a flexible price sector.[35] However, as the output gap adjusts more sluggishly, the real interest rate and aggregate consumption take longer to reach their steady state values in the two sector TANK model. Further, in the two agent models (our model and Debortoli and Gali), $C_R < C < C_P < 0$. In the single agent models (Aoki's model and the simple NK model), $C_R = C_P = C < 0$.

As mentioned above, the presence of a flexible price sector in our model and Aoki's model creates a large deflation in the economy because of the contractionary monetary policy shock. Since the shock is of one period, aggregate inflation returns to the steady state in the next period in both our model and the Aoki model. Manufacturing inflation, however, recovers, gradually, because of the sticky price sector in all the models. The rise in the nominal

[35]We would expect transmission to be weaker in TANK models as a fraction of agents cannot smooth their consumption, but the effect of the negative terms of trade lowers their consumption.

interest rate leads to the intertemporal substitution of consumption, as in the standard NK model, which causes a reduction in aggregate demand and a decline in the aggregate price level in all models. However, in our model and Aoki's model, due to the presence of a flexible price sector, real interest rates increase by less, and therefore rich consumption falls by less compared to Debortoli and Gali and the simple NK model. As a result, poor consumption also falls by less from equation (2.42). The decline in aggregate consumption is also less in our model and Aoki's model.

Since the contractionary monetary policy shock reduces the terms of trade, the agriculture good is relatively cheaper compared to the manufacturing good and hence demand for the agriculture good (flexible price) increases while for the manufacturing good (sticky price) falls. This leads to a rise in agricultural employment, and a decline in manufacturing employment on impact in both our model and Aoki's model.

Role of Demand Heterogeneity and Multiple Sectors in Monetary Policy Transmission
Introducing demand heterogeneity alters the economy-wide intertemporal elasticity of substitution. In a representative agent model, the intertemporal elasticity is $\frac{1}{\sigma_R}$, in two-agent models, the aggregate consumption dynamics are governed by $\frac{1}{\Phi}$, where Φ is defined in equation (2.45). Since $\sigma_P > \sigma_R$ causes $\Phi > \sigma_R$, the effective intertemporal elasticity is lower in a TANK model, i.e., changes in real interest rates have a smaller impact on output. DIS becomes flatter. Consequently, a contractionary monetary policy shock in a TANK model generates a smaller decline in output relative to the representative-agent benchmark.

As the responsiveness of aggregate demand to the real interest rate is governed by the intertemporal elasticity, introducing multiple production sectors does not mechanically alter the slope of the DIS curve. However, sectoral structure affects the natural rate of output and marginal cost dynamics through terms-of-trade adjustments. These mechanisms shift the position of the NKPC but do not change its slope unless price-setting frictions or the mapping from output to marginal cost are modified.

Finally, since redistribution alters the aggregation of marginal utilities across agents and therefore the effective curvature parameter Φ, the slope of the DIS in our TSTANK model is influenced by the redistribution parameter λ. By changing the economy-wide intertemporal elasticity of substitution, redistribution modifies the responsiveness of aggregate demand to movements in the real interest rate. Hence, the effects in our model operate through both the demand channel (via intertemporal substitution) and the supply channel (via relative price and marginal cost movements).

2.5 Extensions

To verify the robustness of our results, we consider three extensions. First, to gain insights on the effectiveness of monetary policy in economies with large agriculture sectors, we vary the employment shares to see whether the effectiveness of monetary policy is higher in economies where the employment share in the agriculture sector is smaller.[36] In the second extension we allow for

[36]For these extensions, we only do comparisons with our baseline 2S-TANK model.

non-homothetic preferences. Finally, we study the implications of redistributive policy shocks in a scenario where labour is immobile across sectors.

First, we consider the case of a contractionary monetary policy shock, which cools down the economy as in Figure 2.4. When the employment share in the agriculture sector is high and proxies the value in some poor countries (e.g. Nepal, $\mu_A = 65\%$), compared to an advanced economy, where the share of agricultural employment is much lower (e.g. South Korea, $\mu_A = 5\%$), the impact effect on the output gap is much less (see magenta dotted line versus blue dashed line). This can be seen in Figure 2.4 in the Technical Appendix. Aggregate output declines by more in the less agriculture-intensive-employment economy when there is a contractionary monetary policy shock. The impact effect on inflation is also more muted when the share of agriculture employment is smaller in the economy. This shows that when the share of the manufacturing sector rises, output adjusts comparatively more, and the effectiveness of monetary policy is comparatively more. This insight applies to all EMDEs with large agriculture sectors, and offers a possible explanation for why monetary policy is ineffective in such economies.

For non-homothetic preferences, we allow for subsistence consumption in agriculture for the poor. In their optimization, this changes the consumption index given in equation (2.4) to

$$C_{P,t} = \frac{(C_{P,A,t} - C_{P,A}^{subs})^{\delta_P} C_{P,M,t}^{1-\delta_P}}{\delta_P^{\delta_P} (1-\delta_P)^{1-\delta_P}} \tag{2.52}$$

where $C_{P,A}^{subs} > 0$ is the subsistence level of agriculture consumption of the poor.[37] Adding subsistence consumption of the agriculture good leads to an

[37]For simplicity, we assume that the subsidy to the poor is equal to the subsistence level of agriculture consumption.

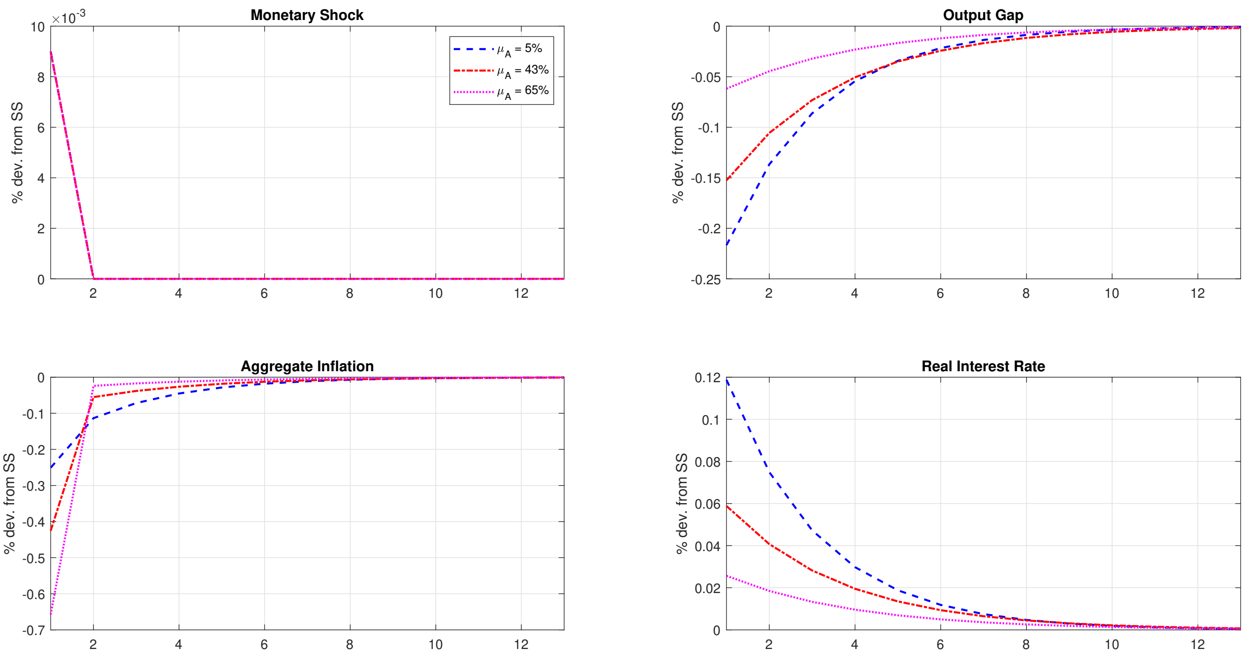


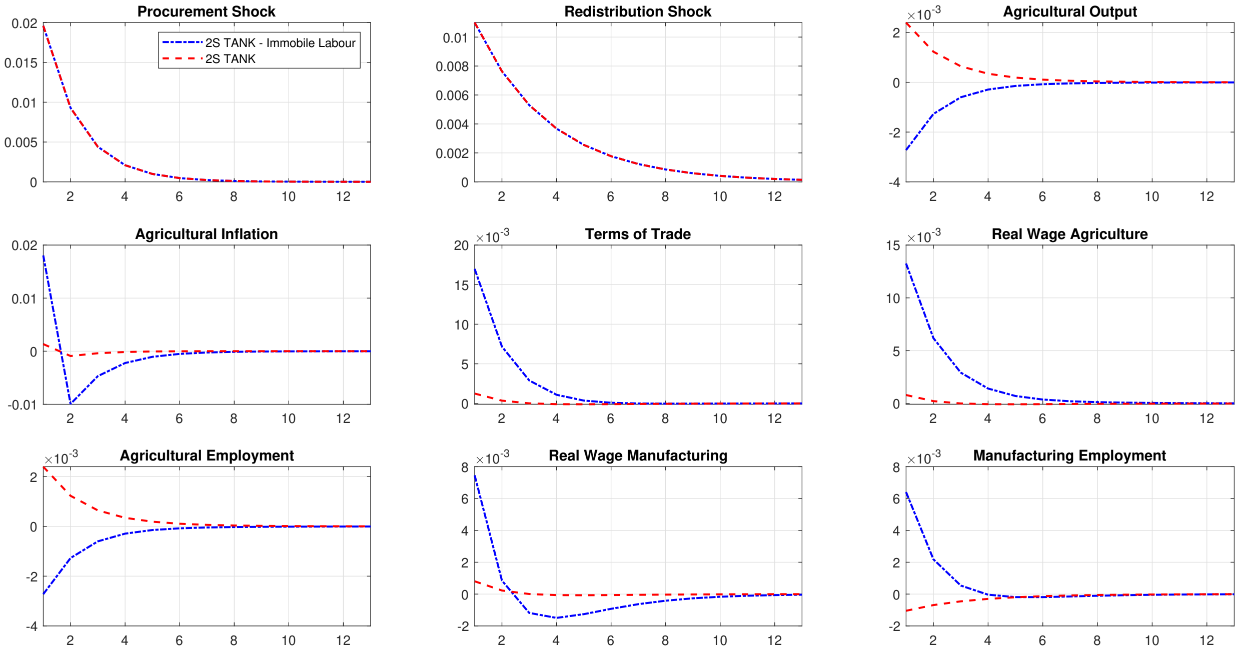
Figure 2.4: Impact of single period monetary policy shock for $\mu_A = 5\%$, $\mu_A = 43\%$, $\mu_A = 65\%$

increase in the steady state consumption of the agriculture good, and therefore an increase in the total quantity of the agriculture good consumed and produced.[38] The only change in the log-linearized model is in the steady state values. In fact, model simulations show that log deviations from the steady state are qualitatively similar, although the impact effect from the shocks are higher in the model with the standard index (given in equation (2.4)) because of lower steady state values.[39]

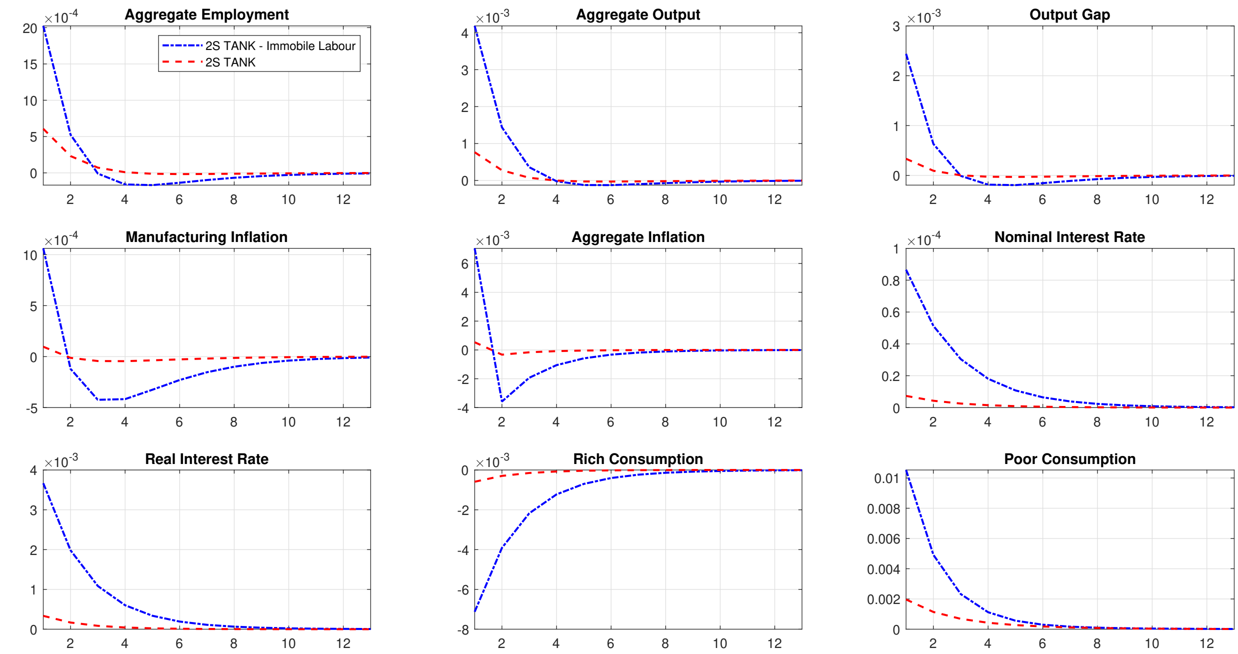
Finally, we allow labour to be completely immobile. The results are in Figures 2.5a-2.5c. We assume that the poor work in the agriculture sector, and the rich in the manufacturing sector. This leads to sector specific real wages,

[38]Non-homothetic preferences implies that the elasticity of substitution between the agriculture good and the manufacturing good is no longer unity. Rather, it depends on $C^{subs}_{P,A}$. Also changes in income lead to changes in expenditure shares of the agriculture and the manufacturing good even with a constant terms of trade.

[39]These results are available from the authors on request.

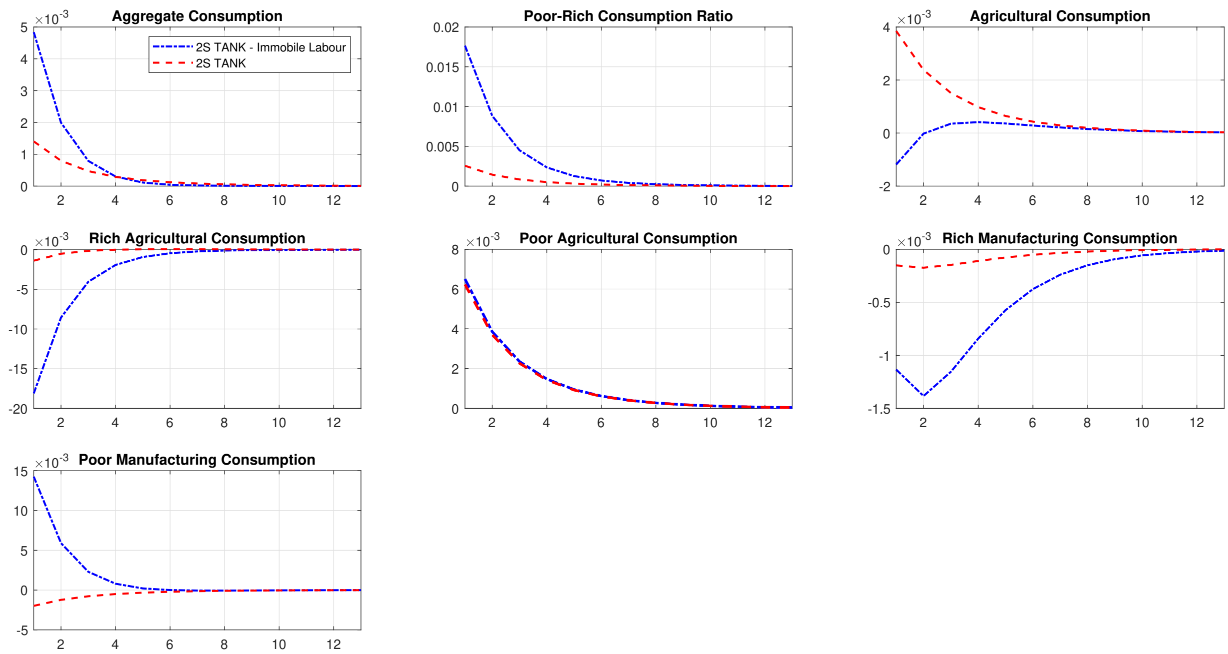


(a) Impact of single period redistributive policy shock on macroeconomic aggregates



(b) Impact of single period redistributive policy shock on macroeconomic aggregates

Figure 2.5: Impact of single period redistributive policy shock with immobile labour



(c) Distributional impact of single period redistributive policy shock

Figure 2.5: Impact of single period redistributive policy shock with immobile labour

$\frac{W_M}{P}$ in the manufacturing (M) sector, and $\frac{W_A}{P'}$ in the agriculture (A) sector. Figures 2.5a-2.5c show the IRFs benchmarked against the case (Figures 2.2a-2.2c) when labour is mobile and when labour is immobile (blue dashed line). When there is a procurement and redistributive policy shock, in order to increase the supply of the agriculture good, the real wage in the agriculture sector must increase. Because the mass of population in the agriculture sector is limited by the mass of the population who are poor (because labour is not mobile), the real wage in the agriculture sector must rise by more. Hence, a procurement and redistributive policy shock leads to a greater impact on agriculture inflation, the terms of trade, and aggregate inflation. Higher inflation with immobile labour induces the monetary authority to respond more aggressively leading to higher real interest rates. The rich agents in turn respond by increasing saving and reducing consumption of both goods (C_R falls). In contrast, the poor increase their consumption of both goods (C_P rises) and supply less labour as they gain from higher real wages and lower prices of the agricultural good on account of the subsidy. Thus agricultural employment declines. Higher demand for the manufacturing good by the poor agents dominates the reduction in demand by the rich. This causes wages in the manufacturing sector to rise (with sticky prices, real wages $\frac{W_M}{P}$ also rise) thereby leading to higher manufacturing employment[40] thereby creating a positive output gap. Aggregate output rises more compared to the baseline model.

2.6 Policy Implications

2.6.1 Redistributive Policy Multipliers

We quantify the impact of the redistributive policy shock on aggregate variables by computing present value multipliers. As our shocks are orthogonal, we are able to compute the multipliers for horizon h as:

$$\begin{aligned} PVM^X_{RPS,h} &= \frac{\mathbb{E}_t \sum_{j=0}^{h} \beta^j \left(\Delta X_{PA,t+j} + \Delta X_{\phi,t+j}\right)}{\mathbb{E}_t \sum_{j=0}^{h} \beta^j \left(\Delta Y_{PA,t+j} + \Delta \phi_{t+j}\right)} \\ &= \frac{\mathbb{E}_t \sum_{j=0}^{h} \beta^j \left(\bar{X}\widehat{X_{PA,t+j}} + \bar{X}\widehat{X_{\phi,t+j}}\right)}{\mathbb{E}_t \sum_{j=0}^{h} \beta^j \left(\bar{Y}_{PA}\widehat{Y_{PA,t+j}} + \bar{\phi}\widehat{\phi_{t+j}}\right)}, \end{aligned}$$

where, $\widehat{X_{s,t+j}}$ represents the log deviation from steady state X corresponding to shock s for horizon j. Table 2.4 presents the results.

[40] This would have induced higher manufacturing prices and a relatively lower manufacturing output in a flexible price regime.

Multiplier	Impact	Q2	Q4	Q20	Q40
Output (Y)	0.073	0.058	0.053	0.052	0.052
Agriculture Output (Y_A)	0.111	0.099	0.095	0.094	0.094
Manufacturing Output (Y_M)	−0.052	−0.052	−0.052	−0.052	−0.052
Consumption (C)	0.133	0.124	0.122	0.121	0.121
Poor consumption (C_P)	0.159	0.150	0.148	0.147	0.147
Rich consumption (C_R)	−0.071	−0.063	−0.060	−0.059	−0.059

Notes: The table reports impact and present-value multipliers following a redistributive policy shock. Present values are computed using steady-state discounting. All variables are expressed in levels by scaling log impulse responses with their respective steady states.

Table 2.4: Redistributive Policy Shock Multipliers

The output multiplier is positive but well below one: an impact multiplier of 0.07 and a long-run PV multiplier of about 0.05. This indicates that the redistributive policy generates real activity, but with limited aggregate amplification. As expected, it leads to a reallocation of activity across sectors, with agricultural output responding strongly and persistently (long-run PV ≈ 0.09) while manufacturing output contracts with a stable multiplier around -0.05. The poor exhibit large and persistent gains, while rich households exhibit a decline on account of general equilibrium effects.

2.7 Conclusion

Governments in many EMDEs routinely intervene in their agricultural markets because of changing food security norms or to minimize food price volatility. Such interventions typically involve higher procurement and redistribution of food commodities, and higher food subsidies by the government to households. This chapter asks: what is the impact of a procurement and redistributive policy shock on the sectoral and aggregate dynamics of inflation, and the distribution of consumption among rich and poor households? To address this, we build a tractable two-sector (agriculture and manufacturing) two-agent (rich and poor) New Keynesian DSGE model with redistributive policy shocks. We calibrate the model to the Indian economy. There are two novel aspects of our framework. First, we extend the framework of Debortoli and Gali to two sectors in a tractable way. Second, we allow for government intervention in the agriculture market in a way that captures the essence of procurement and redistribution style interventions in EMDEs. Our framework allows us to understand how redistributive policy shocks affect the economy, and the role of consumer heterogeneity on the welfare implications of a variety of shocks. We contribute to a growing literature on understanding the role of consumer heterogeneity in analyzing the effect of monetary policy.

We show that a procurement and redistributive policy shock leads to higher sectoral and aggregate inflation and higher aggregate consumption in the economy, even though there is a decline in the consumption of the rich. Our main result is that for an inflation-targeting central bank, consumer heterogeneity matters for whether monetary policy responses to shocks raise aggregate welfare or not. Hence, it is important to take into account consumer heterogeneity when evaluating the general equilibrium effects of monetary policy in the economy. We compare our results to a variety of benchmarks to isolate the effect of adding a flexible-price production sector or adding rule-of-thumb agents on the model's dynamics. We also show that our main results are robust to a variety of extensions. An interesting insight that we gain from our analysis is that in EMDEs with smaller agriculture sectors (larger manufacturing sectors), output adjusts comparatively more to changes in monetary policy, and therefore, the effectiveness of monetary policy is higher. This offers a possible explanation for why monetary policy is less effective in economies with large agricultural sectors.

Chapter 3

Welfare Consequences of Redistributive Policy Shocks

[1]

3.1 Introduction

In this chapter, we assess the welfare costs of redistributive policy shocks using the framework in Chapter 2. We study the welfare impacts of unanticipated increases in procurement and redistribution that are short-lived - *a redistributive policy shock*. We found in Chapter 2 that redistributive policy shocks were inflationary yet expansionary. In this chapter, we ask what are the welfare costs of such redistributive policy shocks? What is the optimal monetary policy response to the redistributive policy shock? How do the optimised simple rules compare with the Ramsey Optimal Monetary Policy (ROMP)? How do welfare costs

[1] This paper is joint work with Chetan Ghate (ISI Delhi) and Debdulal Mallick (Deakin University, Melbourne).

compare to an agricultural productivity shock? The role of public distribution of food-grains was particularly heightened during the imposition of the lockdown when there was a drastic reduction in employment and earnings.[2] Most analyses in the literature focus on assessing redistribution policies based on the costs of such policies to the government or exhibiting the impact on developmental outcomes such as food security, nutrition and income stability.

In the Indian context, there has been a widespread discussion in the literature regarding the efficiency and equity trade-off in redistribution policies in agriculture.[3] Poor targeting (Ramaswami 2005), lack of access, diversion of grain to open markets (R. Khera 2011, Gulati & Saini 2015)[4] higher distributional costs as compared to the private sector[5] (Dutta & Ramaswami 2001), low product quality and shop closures (Muralidharan et al. 2011) are a few of the reasons in favour of cash transfers. Other studies have underscored the importance of the public distribution system in lowering poverty in the rural areas and providing social protection (Jean Drèze & R. Khera 2013), providing stability for farmers' income and insulating the vulnerable sections from price fluctuations (Sinha 2015), prevented under-nutrition increased wage incomes and improved dietary diversity (Shrinivas et al. 2025).

While there has been considerable research on optimal targets for stabilising inflation and output volatility in the presence of multi-sector economies (Aoki 2001, Anand & Prasad 2010, Anand et al. 2015), the monetary policy literature on

[2]See Drèze & Somanchi (2021) for a discussion of representative surveys on the impact of pandemic-induced lockdown on earnings and food-insecurity on the informal sector-slum dwellers and migrant workers

[3]Chakraborty et al. (2025) evaluate the welfare costs of input price subsidies and minimum support price to show that removing these policies lowers the tax burden, but raises the agricultural productivity gap.

[4]Gulati & Saini 2015 estimate the leakage from PDS to be 46.7% in 2011-12. The leakage was greater in states where a larger percentage of poor resided. There have been improvements in the efficiency of operation after the enactment of the National Food Security Act. Recent estimates show a sharp reduction in leakages. Using Household Consumption Expenditure Data R. Khera (2024) shows that leakages had reduced to 22%.

[5]PEO Report N0 189 (2005) finds that a 1 rupee transfer costs the government Rs 3.65.

interventions in agricultural sector policies is much less (Ginn & Pourroy 2022, Gupta 2024). Aoki (2001) finds that a divine coincidence between stabilising inflation and output gap breaks down in the presence of two sectors and targeting sticky price inflation is optimal in a two-sector RANK economy. Other papers introduce a non-Ricardian agent in the two-sector model and show that headline inflation is optimal (Anand & Prasad 2010, Anand et al. 2015) in a two-sector TANK economy. Gupta (2024) introduces market price support as markup shocks and finds that the optimal policy is to respond to inflation and terms of trade. Though her paper models interventions in the grain market via public procurement, her analysis does not model multiple agents, which is central to the analysis for our study.

A paper that is most related to our analysis is Ginn & Pourroy (2022). They study the impact of food-price stabilisation policies using a *price subsidy*. They study the effect of world food price shocks and show that food price subsidies lower the volatility of the Consumer Price Index (CPI). They find that food-price stabilisation policies are costly and exhibit heterogeneous effects on agents. In contrast, we model redistribution in terms of *quantities* by utilising a closed economy 2-sector model with two agents developed in chapter 2, to evaluate the welfare costs of redistributive policy shocks in terms of consumption equivalents as in Lucas (1987). Though similar, the policies analysed are fundamentally different. We model redistributive policy shocks emanating from higher procurement and redistribution of grain to the poor, while they assess the role of price subsidies in the presence of world food price shocks. We find that redistributive policy shocks have a heterogeneous impact on agents and entail a small cost to the aggregate output. The chapter proceeds as follows: Section 2 describes different approaches to computing the welfare cost. Section 3 describes the framework to characterise optimal monetary policy for a redistributive policy shock. Section 4 assesses the role of steady-state redistribution on welfare cost estimates. Section 5 studies the impact of changing weights in the planner's objective function on welfare cost computations. Section 6 concludes.

3.2 Methodology

We wish to characterise the optimal monetary policy in the two-sector TANK model with redistributive policy shocks. We follow two approaches to computing the optimal monetary policy response to various shocks - we assume that the monetary authority acts like a utilitarian Ramsey planner and maximizes the weighted average intertemporal utility functions of households, subject to the private sector optimality conditions and the economy's feasibility constraints. This is called Ramsey Optimal Monetary Policy, or ROMP. Second, we compute the optimal values of Taylor Rule parameters that maximize economy-wide welfare.

It may be recalled that two types of distortions are present in standard one-sector RANK models - the presence of monopolistically competitive firms which leads to prices exceeding the marginal cost of production, and sticky prices in the manufacturing (modern) sector, leading to dispersion in prices of different varieties of sticky-price (manufacturing) sector goods, resulting in a misallocation of resources. In addition to these two, we have a third distortion-intervention in the flexible price sector in the form of steady state procurement ($Y_A > C_A$) and redistribution ($C_{P,A,t} > C^O_{P,A,t}$)[6]. We neutralize the first distortion through an employment subsidy. However, as procurement and redistribution

[6]The presence of procurement and redistribution (for the poor) breaks the link between aggregate consumption and aggregate output (and employment). Refer to Chapter 2 for details.

are noted features of emerging market economies, we wish to study the optimal monetary policy design in their presence. In an economy with interventions in the agricultural sector that are inflationary, it may not be optimal for the central bank to target full inflation stabilization.[7]

In standard NK models the optimal policy design is to perfectly stabilize inflation at the steady state level, but in the presence of a flexible price sector, the shock reflects one for one in the prices (and inflation).[8] Thus, we would expect that the planner would not be able to smooth variability in the inflation in flexible price sector and thus not be able to achieve full (headline) inflation stabilization i.e., in an economy with interventions in the agricultural sector, it may not be optimal for the central bank to target zero inflation. We assess the implications of such interventions on the design of optimal policy.

Following (Schmitt-Grohe & Martin Uribe 2007), we characterize optimal monetary policy in the 2S-TANK model of Chapter 2 with a procurement and redistribution shock by using two approaches (i) we assume that the monetary authority acts like a utilitarian Ramsey planner and maximizes the weighted average of rich and poor welfare functions (3.1) subject to the private sector optimality conditions and the economy's feasibility constraints, (ii) by computing optimal values of Taylor Rule parameters (or optimal simple rules) that maximize economy-wide welfare via minimizing the variance of inflation and the output gap.

[7] Other studies that do not subscribe to this result are Schmitt-Grohe & Martin Uribe (2007) and Khan et al. (2003). They introduce demand for money in the model and find the optimal policy to stabilise nominal interest rates rather than inflation.

[8] It is well known that the optimal policy design depends on the nature of the shock (Poole 1970) and the model setup (Woodford (2010)).

3.2.1 Ramsey Optimal Monetary Policy (ROMP)

The Ramsey-monetary authority maximizes, W_t, given by

$$W_t = \Omega W_{R,t} + (1 - \Omega)W_{P,t} \tag{3.1}$$

where $W_{R,t}$ is the lifetime welfare of the Ricardian agent and $W_{P,t}$ is the lifetime welfare of poor agents and $\Omega \in [0, 1]$ is the weight given to rich agents by the planner where $W_{K,t}$ is

$$\mathcal{W}_{K,t} = \mathbb{E}_t \left\{ \sum_{s=0}^{\infty} \beta^s U_K(C_{K,t+s}, N_{K,t+s}) \right\} \tag{3.2}$$

Equation 3.2 has a Bellman representation given by

$$W_{K,t} = U(C_{K,t}, N_{K,t}) + \beta E_t W_{K,t+1}$$

where

$$U(C_{K_t}, N_{K_t}) = \frac{{C_{K,t}}^{1-\sigma_K}}{1-\sigma_K} - \frac{{N_{K,t}}^{1+\varphi}}{1+\varphi}$$

for each $K \in \{R, P\}$. We use Dynare 5.2 to solve for the time-consistent policy under commitment, where the central bank chooses a path for the policy instrument, the nominal interest rate in order to maximise welfare in equation 3.1 subject to the equilibrium conditions specified in Chapter 2.

The model is solved using a second-order approximation around the deterministic steady state, allowing us to capture both mean and variance effects of policy on welfare. The optimal policy is derived endogenously and results in an implicit targeting rule involving inflation, the output gap, and other endogenous variables.

3.2.2 Optimal Simple Rules

As the government cannot choose the allocations that a Ramsey planner decides, we conduct welfare analysis using simple Taylor rules to see how close they can replicate the Ramsey outcomes. We study the implications of optimal policy conditional on the simple rule given by the Taylor Rule (3.3):

$$R_t = R_{t-1}^{\phi_r} \pi_t^{(1-\phi_r)\phi_\pi} \tilde{Y}_t^{(1-\phi_r)\phi_y} \epsilon_t \tag{3.3}$$

To compute optimal simple rules, a welfare-based loss function based on the second-order approximation to the lifetime utility of agents in the economy of type $K \in \{R, P\}$ is given by

$$\mathcal{W}_{K,t} = \mathbb{E}_t \left\{ \sum_{s=0}^{\infty} \beta^s U_K(C_{K,t+s}, N_{K,t+s}) \right\} \Bigg|_{x_0 = x} \tag{3.4}$$

The second-order welfare approximation takes the following form (as in Faia & Monacelli (2007), Ginn & Pourroy (2019),Ginn & Pourroy (2022) and Adjemian et al. (2011)):

$$\mathcal{W} = \mathbb{E}_{-1} \left\{ \mathcal{W}_0 \right\}_{|y_{-1} = \bar{y}} = \bar{\mathcal{W}} + \frac{1}{2} \left[g_{\sigma\sigma} \right] + \frac{1}{2} \mathbb{E} \left\{ \left[g_{uu} (u_1 \otimes u_1) \right] \right\}, \tag{3.5}$$

where $\bar{\mathcal{W}}$ denotes the welfare value at the steady-state, $g_{\sigma\sigma}$ is the second derivative of the policy function (g) with respect to the variance in the shocks, and g_{uu} the Hessian of g with respect to the shock vector u. The recursive representation of welfare is given by:

$$\mathcal{W}_{K,t} = U_K(C_{K,t}, N_{K,t}) + \beta \mathcal{W}_{K,t+1} \tag{3.6}$$

The aggregate welfare is then expressed as:

$$\mathcal{W}_t = \mu_R W_{R,t} + (1-\mu_R) W_{P,t} \tag{3.7}$$

where μ_R is the share of Ricardian of rich agents in the population, while $(1-\mu_R)$ is the fraction of poor agents who receive subsidised food grain as a part of the redistributive policy.

In this chapter, we specify the loss function to be determined by the variance of inflation and the output gap in equation 3.8.[9]

$$\mathcal{L} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \Omega_\pi \pi_t^2 + \Omega_{\widetilde{Y}} \widetilde{Y}_t^2 \right\} \tag{3.8}$$

As is standard in the literature, we set the bounds for the persistent coefficient in the Taylor Rule to be [0,0.99] [10], bounds for the coefficient on inflation and output-gap to be [0,3].

We compare the optimized simple rules with ROMP to see how well a monetary authority following OSR can implement the planner's solution.

3.2.3 Criterion

As in Schmitt-Grohé & Martín Uribe (2006) and Schmitt-Grohe & Martin Uribe (2007), we compute the expected lifetime utility conditional on the initial state being the deterministic steady state. We define the welfare measure for each agent under a monetary policy regime *a* ($V^a_{K,0}$) to be its expected lifetime utility at time 0:

[9]We follow the welfare loss function used in the literature with small-scale models having a cashless economy to perform the analysis. The literature also loss function minimization approach to determine the optimal monetary policy instrument in the analysis of monetary targeting versus inflation targeting. Singh & Subramanian (2009) compares the two for velocity and fiscal shocks and finds that the optimality of targeting instrument depends on the shock under consideration. Using a similar approach Singh et al. 2017 finds exchange rate-targeting rules to be welfare dominated by optimal money growth rules with limited asset market participation.

[10]We limit the upper bound to 0.99 to prevent introduction of singularity

$$V_{K,0}^{a} \equiv E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{{C_{K,t}^{a}}^{1-\sigma_K}}{1-\sigma_K} - \frac{{N_{K,t}^{a}}^{1+\varphi}}{1+\varphi} \right] \tag{3.9}$$

i.e., for each agent $K \in \{R, P\}$, we define the welfare measure under a monetary policy regime *a* to be its expected lifetime utility at time 0 as $V_{K,0}^{a}$.

We define the welfare measure (χ_K) to be the percentage of steady-state consumption that the household of type K is willing to forego to be as well off under the steady state as under a given monetary policy regime a. i.e., agent K would like to give up χ_K % of steady state consumption to avoid the volatility from a shock under regime a.

Thus, the consumption equivalent χ_K can be computed from:

$$\sum_{t=0}^{\infty} \beta^t \left[\frac{[(1-\frac{\chi_K}{100})C_K]^{1-\sigma_K}}{1-\sigma_K} - \frac{{N_K}^{1+\varphi}}{1+\varphi} \right] = V_{K,0}^{a} \tag{3.10}$$

This definition captures the notion that business cycles are costly and risk-averse agents would be willing to pay (in consumption units) to avoid fluctuations in consumption.

3.3 Planner's solution for shocks in the agriculture sector (ROMP)

In this section, we first compute the planner's solution (ROMP). Since there is excess procurement or equivalently, less than full-redistribution ($\phi_t < 1$), the ROMP solution is the *constrained first best*.[11] As the focus of our paper is on the welfare costs of agriculture sector interventions, we compare conditional welfare under the two policy regimes for shocks emanating from the agriculture sector

[11] We assess the sensitivity of our results to the steady-state share of redistribution ($\bar{\phi}$) in Table 3.1 by considering alternate values of steady-state redistribution ($\phi = 0.40$ and $\phi = 0.80$).

(a procurement and redistribution shock and an agricultural productivity shock (supply-side) and both shocks referring to a combination of the two. We present implied volatilities of key variables as standard deviation in percentages when a Ramsey planner maximises equation 3.1. The results are reported in Table 3.1.

We observe that the welfare costs of shocks to the flexible price sector are small. Redistributive Policy Shocks are more costly than the agricultural productivity shock as they lead to greater output gap variability. The poor have higher welfare costs as they are unable to smooth consumption over time due to the absence of savings instruments.

Low Steady State Redistribution ($\phi = 0.40$)

	Redis.Policy	Agri. Prodty	Both Shocks
Welfare Cost (%)			
χ_R	0.0050	0.0020	0.0071
χ_P	0.0132	0.0022	0.0154
Standard Deviation (%)			
Inflation	0.214	0.806	0.834
Manufacturing Inflation	0.033	0.012	0.035
Output Gap	0.137	0.057	0.149
Rich Consumption	2.617	2.354	3.520
Poor Consumption	0.329	0.400	0.518

Table 3.1: Welfare Cost and Standard Deviations under Ramsey Optimal Monetary Policy- Low steady state redistribution

Table 3.2 presents the analysis for higher steady-state redistribution ($\bar{\phi}$). We observe from Table 3.2 that raising steady-state redistribution share from $\bar{\phi} = 0.4$ to $\bar{\phi} = 0.8$ leads to higher inflation variability (0.214% versus 0.241%) because

High Steady State Redistribution ($\phi = 0.80$)			
	Redis.Policy	Agri. Prodty	Both Shocks
Welfare Cost (%)			
χ_R	0.0085	0.0019	0.0105
χ_P	0.0325	0.0015	0.0341
Standard Deviation (%)			
Inflation	0.241	0.803	0.839
Manufacturing Inflation	0.038	0.012	0.040
Output Gap	0.155	0.055	0.164
Rich Consumption	2.279	2.335	3.262
Poor Consumption	0.889	0.353	0.956

Table 3.2: Welfare Cost and Standard Deviations under Ramsey Optimal Monetary Policy- High steady state redistribution

of a procurement and redistributive policy shock. The planner, however, does not find it optimal to stabilize inflation perfectly.[12] We verify that raising the steady state redistributive share of procured output raises the amount available for consumption (because of lower buffer stock accumulation), thereby raising steady state consumption of both agents. However, an increase in ϕ increases the variability of poor agent consumption (0.329 versus 0.889). This is on account of higher inflation volatility (which leads to higher variability in the subsidy policy, λ_t). Rich consumption volatility falls with higher ϕ because the Ramsey planner raises the steady state interest rate to counteract higher inflation variability. The poor agents are more risk averse but are unable to smooth consumption. In the presence of higher inflation, they are willing to forgo a greater amount (0.0132%) of their steady state consumption than the rich (0.0050%) to avoid fluctuations in

[12]We have verified that this result applies to manufacturing productivity shock also. Core inflation and output gap are stabilised, but the standard deviation of aggregate inflation is 0.535%

consumption. When $\phi = 0.80$, the consumption equivalents increase to 0.0325% and 0.0085% respectively. The welfare cost of procurement and redistributive interventions is apparent across higher values of ϕ.

In contrast, with an agricultural productivity shock, a higher steady state redistribution lowers variability in consumption for both agents. Inflation variability falls because higher steady-state redistribution requires lower open market purchases of the agricultural good by the poor. This leads to lower consumption volatility of the poor. Thus the poor are willing to forgo a lower amount of steady state consumption to achieve stable consumption when the redistribution share is higher (0.0015% when $\phi = 0.80$ as compared to 0.0022% when $\phi = 0.40$.

When both shocks in the agricultural sector hit the economy simultaneously - a plausible scenario in the context of EMDEs - we find that inflation volatility rises marginally from 0.834 to 0.839. The output gap volatility also rises. The combined shocks lead to higher consumption volatility of the poor but lower consumption volatility of the rich, reflecting a higher steady state interest rate with $\phi = 0.8$. Compared to the each individual shock, the consumption equivalents for both agents are higher, as is to be expected.

3.4 Optimal Simple Rules for shocks in the agriculture sector (OSR)

We fix the procured amount to be 0.21[13] and report the results by varying the steady state level of redistribution from $\phi = 0.4$ to $\phi = 0.8$. The results of the

[13] This amounts to 26% of the steady state output. The average procurement share of wheat production was 27.5% in the last 5 years (excluding FY20). We use this as a proxy for the proportion of agricultural goods procured in the model.

analysis are shown in Table 3.3 and 3.4.

Panel A: Low Steady State Redistribution ($\phi = 40\%$)

OSR Rule	ϕ_r	ϕ_π	ϕ_y	Welfare Cost (%)	$\sigma_\pi(\%)$	$\sigma_{\pi_M}(\%)$	$\sigma_{\tilde{Y}}(\%)$
Redis. Policy	0	3	0	χ_R : 0.0096	0.191	0.137	0.146
				χ_P : 0.0161			
Agri. Prodty	0.2183	3	2.4310	χ_R : 0.0091	0.068	0.121	0.444
				χ_P : 0.0074			
Both Shocks	0	3	0.2844	χ_R : 0.0222	0.381	0.231	0.378
				χ_P : 0.0256			

Table 3.3: Welfare Cost and Standard Deviations under Optimal Simple Rules: low steady-state redistribution share

Panel B: High Steady State Redistribution ($\phi = 80\%$)

OSR Rule	ϕ_r	ϕ_π	ϕ_y	Welfare Cost (%)	$\sigma_\pi(\%)$	$\sigma_{\pi_M}(\%)$	$\sigma_{\tilde{Y}}(\%)$
Redis. Policy	0	3	0	χ_R : 0.0120	0.169	0.122	0.128
				χ_P : 0.0350			
Agri. Prodty	0.2176	3	2.4227	χ_R : 0.0091	0.067	0.121	0.441
				χ_P : 0.0071			
Both Shocks	0	3	0.7263	χ_R : 0.0283	0.359	0.250	0.400
				χ_P : 0.0465			

Table 3.4: Welfare Cost and Standard Deviations under Optimal Simple Rules: low steady-state redistribution share

We find that the OSR that minimizes the variances of inflation and the output gap from a procurement and redistribution shock puts the maximum weight on inflation, and no weight on interest rate persistence and the output gap, i.e., the monetary authority finds it optimal to target aggregate inflation only. Changing steady state redistribution has no impact on the optimal policy parameters (see Table 3.4), however, it does impact the variances.

Shock	Variable	ϕ	Steady State	Standard Deviation
Redis. Policy	C_R	0.4	3.206	2.589%
Redis. Policy	C_R	0.8	3.248	2.327%
Redis. Policy	C_P	0.4	0.865	0.324%
Redis. Policy	C_P	0.8	0.930	0.878%
Agri. Prodty.	C_R	0.4	3.206	3.448%
Agri. Prodty.	C_R	0.8	3.248	3.453%
Agri. Prodty	C_P	0.4	0.865	0.532%
Agri. Prodty	C_P	0.8	0.930	0.526%
Both Shocks	C_R	0.4	3.206	4.002%
Both Shocks	C_R	0.8	3.248	3.897%
Both Shocks	C_P	0.4	0.865	0.583%
Both Shocks	C_P	0.8	0.930	1.005%

Table 3.5: Comparison of Consumption with Varying Redistribution

As the shock affects the level and volatility of the share of subsidized consumption, it leads to greater volatility of consumption for poor agents (in Table 3.5). We also find that $\phi = 0.8$ leads to lower volatility of aggregate inflation, sticky price inflation and the output gap (See Table 3.4).

As higher redistribution of the procured output lowers the reliance of the poor on open market purchases, we verify that it lowers the variability of the terms of trade, sectoral and aggregate inflation, and thereby interest rates. The lower volatility of interest rates leads to lower volatility of rich consumption (from 2.589% to 2.327%, see Table 3.5). The cost of the redistributive policy is apparent in the higher consumption equivalent of the poor driven by higher poor consumption volatility because of higher variability in the subsidized share.[14].

In contrast, the positive agricultural productivity shock lowers the relative price of the agricultural commodity. As can be seen from Table 3.3 for given ϕ, it is optimal to have persistence in the interest rates, although the values of ϕ_π do not change. With these parameters ($\phi = 0.4$ and $\phi = 0.8$), there is no discernible change in the volatility of inflation, the output gap and sticky-price inflation. Rich consumption variability rises marginally to 3.453% while poor consumption volatility falls marginally to 0.526% as can be seen in Table 3.5 with $\phi = 0.8$.

We find that, under an agricultural productivity shock, the optimal response of a monetary authority should be to respond to both deviations in inflation and output gap from their targets while exhibiting persistence in the interest rate. As in the case of a procurement and redistribution shock, the monetary authority responds aggressively to deviations of inflation from its target. However, similar levels of volatility across different values of ϕ lead to similar values of consumption equivalents for the two cases.

With combined shocks, both agents's consumption is more volatile compared to the individual shocks. The consumption equivalents rise because the poor agent's consumption is more volatile (Table 3.5) and thus they are willing to forgo 0.046% of their steady state consumption to be in an economy with no interventions in the agricultural sector as compared to 0.028% by the rich. The optimal policy in this scenario is to respond aggressively to deviations of contemporaneous inflation, more aggressively to deviations in the output gap

[14]We verify that in the case of $\phi = 0.8$ the variability in λ_t, the subsidized share of food increases to 3.151% from 2.439% (corresponding to $\phi = 0.4$). Despite lower rich consumption volatility when $\phi = 0.8$, the steady state consumption of the rich rises, which increases the conditional welfare corresponding to the deterministic steady state. This leads to a higher consumption equivalent.

(0.7263 versus 0.2844), but with no interest rate persistence.

3.5 Comparison between OSR and the Planner's solution

As the focus of our paper is on interventions in the agriculture sector, we focus on optimal monetary policy under redistributive policy shocks. We use the Ramsey optimal monetary policy to be the benchmark regime and compare welfare from optimal simple rules, the estimated Taylor Rule, a simple Taylor Rule having no sensitivity to the output-gap and a standard Taylor Rule with no interest rate persistence.

Table 3.6 summarises the volatility of aggregate inflation (π), sticky-price inflation or equivalently, manufacturing sector inflation (π_M), nominal interest rates (R) and the output gap ($\widetilde{Y}$). Row 1 reports the standard deviations under a redistributive policy shock under the Ramsey regime.[15]

We find that the optimized simple rule (OSR) features a no-smoothing interest rate, an aggressive response to inflation and a muted response to output. The inflation coefficient of the optimized rule takes the largest value allowed in our search, namely $\phi_\pi = 3$.[16] As the optimized rule features no interest-rate inertia, there is no difference in the long-run impact of monetary policy.[17] We also find that the optimized rule is quite effective as it delivers welfare levels remarkably close to those achieved under the Ramsey policy, as evident by the low values of

[15]As the Ramsey planner determines the nominal interest rate through maximisation of welfare subject to the equilibrium constraints, the Taylor Rule is not applicable and the Taylor coefficients are reported as '-'. Furthermore, as it is the reference category, $\chi_R = \chi_P = 0$.

[16]Raising the upper bound to 10 increases the optimal value of ϕ_π to the new upper bound in Table B.1 in the Technical Appendix B. However, the associated changes in consumption equivalents are quantitatively very small. These findings are consistent with Schmitt-Grohé & Martín Uribe (2006), who show that while the inflation coefficient is important for determinacy, its precise value has only a limited effect on welfare.

[17]This is a result of the Taylor Rule specification and no persistence of the monetary policy shock. Relaxing these two allows for significant long-run impact of inflation on interest rates as in Schmitt-Grohe & Martin Uribe (2007).

	Optimized Parameters			Welfare Cost		Volatility (%)			
Rule	ϕ_r	ϕ_π	ϕ_y	Conditional ($\times$100)	Unconditional ($\times$100)	σ_π	σ_{π_M}	σ_R	$\sigma_{\tilde{Y}}$
Ramsey	–	–	–	$\chi_R = 0$, $\chi_P = 0$	$\chi_R = 0$, $\chi_P = 0$	0.241	0.038	0.224	0.155
Optimized	0	3	0	$\chi_R = 0.0035$, $\chi_P = 0.0024$	$\chi_R = 0.0037$, $\chi_P = 0.0027$	0.169	0.122	0.517	0.128
Non-Optimized Rules									
Bayesian	0.9	1.051	0.51	$\chi_R = 0.5140$, $\chi_P = -0.248$	$\chi_R = 0.1105$, $\chi_P = -0.006$	0.944	0.405	0.083	0.701
Simple Taylor Rule	0	1.5	0	$\chi_R = 0.0177$, $\chi_P = 0.0106$	$\chi_R = 0.0185$, $\chi_P = 0.0120$	0.384	0.261	0.586	0.298
Standard Taylor Rule	0	1.5	0.5	$\chi_R = 0.0879$, $\chi_P = 0.0514$	$\chi_R = 0.0929$, $\chi_P = 0.0587$	0.712	0.568	0.880	0.498

* Conditional and unconditional welfare costs χ^cx100 and χ^ux100, are defined as the percentage decrease in the Ramsey-optimal consumption process necessary to make the level of welfare under the Ramsey policy identical to that under the evaluated policy. Thus, a positive figure indicates that welfare is higher under the Ramsey policy than under the alternative policy.

Table 3.6: Optimal Monetary Policy for a Procurement and Redistribution Shock

χ. While the planner can achieve lower sticky price inflation ($\sigma_{\pi_M} = 0.038\%$), which is close to full core-inflation stabilisation, under OSR, aggregate inflation variability, σ_π, is lower. This is because under OSR, the monetary authority places a high weight on minimizing the variance of inflation[18].[19] The planner can achieve significantly lower volatility in the interest rates via commitment.

We compare the welfare cost under non-optimized rules as well. We find that a monetary authority following the optimal simple rule is better able to stabilise inflation and the output gap than all three non-optimized rules under consideration. A monetary authority following the estimated Taylor Rule (equation 2.50) from the Bayesian exercise in Section 2.4.3 in Chapter 2 can stabilise interest rates well but suffers on account of higher inflation and output-gap volatility. A standard Taylor Rule with an inflation coefficient of 1.5 leads to lower volatility in inflation.

The positive consumption equivalents suggest that conditional and unconditional welfare are higher under Ramsey than in alternative regimes (optimized rules, simple Taylor rule, and the standard Taylor rule).[20]. We find that consumption equivalents are substantially higher under non-optimized rules for both rich and poor households compared to OSR, implying high welfare costs associated with redistributive policy shocks when non-optimized rules are used in setting monetary policy.[21]

[18]We use a weight of 0.9 on inflation and 0.1 for output gap for computing Optimal Simple Rules in the analysis.

[19]In addition to stabilizing price and output stability, the planner has an additional goal to stabilise short-term consumption as he cares about the welfare of the poor agent.

[20]Conditional welfare is the expected utility starting from a specific initial state or shock realisation. In contrast, unconditional welfare is the expected utility over all possible future paths, averaged across the ergodic (long-run) distribution of shocks. It assumes the economy starts in its long-run steady-state.

[21]The negative consumption equivalent estimated using the Bayesian method for both conditional and unconditional welfare for the poor reflects the high steady state consumption of poor households in the Bayesian regime. This result is independent of the weights given by the planner in equation 3.1. Bayesian estimated rules lead to the most aggregate inflation volatility.

3.6 Sensitivity Analysis

In this section, we assess whether our results are sensitive to (i) the planner's relative weight on the rich agent's utility (Ω), and (ii) the weights on inflation and output gap for computing optimal simple rules.

3.6.1 Altering weights in the Ramsey planner's objective function ($\Omega \neq \mu_R$)

We compare our benchmark results of a utilitarian planner who values the welfare of both agents and assigns weights equal to their population shares to: (i) a Ricardian planner - who only values the Ricardian agents' welfare (i.e., sets $\Omega = 1$ in equation 3.1), and (ii) a Rawlsian planner - who only values the poor (i.e., sets $\Omega = 0$ in equation 3.1). The results are reported in Table 3.7. We find that placing a zero-weight on the utility of financially-constrained agents makes the planner come closer to full inflation stabilization ($\sigma_\pi = 0.129\%$) which is a superior to a monetary authority following Optimal Simple Rules (see Table 3.6, $\sigma_\pi = 0.169\%$).

Variable	Rich Welfare	Average Welfare	Poor Welfare
	$\Omega = 1$	$\Omega = \mu_R$	$\Omega = 0$
Inflation	0.129	0.241	0.353
Manufacturing Inflation	0.022	0.038	0.052
Aggregate Output	0.758	0.841	0.921
Output Gap	0.085	0.155	0.222
Rich Consumption	2.401	2.277	2.170
Poor Consumption	0.867	0.889	0.908
Employment	0.713	0.760	0.804

Table 3.7: Comparison of Standard Deviation (%) by altering the objective function for Ramsey planner

Hence, whether full inflation stabilisation would be obtained depends upon the relative preference for the rich and the poor agents.[22] Our results are in line with Mehrotra & Yetman (2014), who find a positive correlation between the share of Ricardian households and the relative volatility of output to inflation.[23]

3.6.2 Altering weight on inflation and output gap in OSR ($\Omega_\pi \neq 0.9$ and $\Omega_{\widetilde{Y}} \neq 0.1$)

In this subsection, we reverse the weighting scheme used in the monetary authority's objective function in Section 3.2.2, i.e., we set the weight on inflation to be 0.1 and the aggregate output gap to be 0.9. Table 3.9 summarises the results.

Assigning greater weight to the output gap in the monetary authority's

[22]The impulse response functions for a procurement and redistribution shock are presented in Appendix B. They show that sectoral and aggregate inflation rise by much more when the planner maximises the welfare of the poor. This is because of a shift in policy trade-offs: maintaining price stability and output stability are no longer the primary goals, but are instead balanced against the urgent need to preserve consumption for liquidity-constrained households.

[23]The ratio increased from 2.6 when $\Omega = 0$ to 5.9 when $\Omega = 1$.

objective function raises the relative importance of output stabilisation relative to inflation. This can be achieved in by having higher value of ϕ_y, lower value of ϕ_π or higher value of ϕ_r as the latter reduces the effective weight on inflation (1-ϕ_r)ϕ_π. We observe that the third does indeed take place.

($\Omega_\pi = 0.1$, $\Omega_y = 0.9$) with $\phi = 0.80$

OSR Rule	ϕ_r	ϕ_π	ϕ_y	Welfare Cost (%)	σ_π(%)	$\sigma_{\pi_M}(\%)$	$\sigma_{\tilde{Y}}$(%)
Redis. Policy	0	3	0	$\chi_R = 0.0120$	0.169	0.122	0.128
				$\chi_P = 0.0350$			
Agri. Productivity	0.7160	3	0	$\chi_R = 0.0032$	0.590	0.074	0.103
				$\chi_P = 0.0029$			
Both Shocks	0.5585	3	0	$\chi_R = 0.0156$	0.542	0.146	0.244
				$\chi_P = 0.0380$			

Table 3.9: Welfare Cost and Standard Deviations under Optimal Simple Rules Using Alternative Weights

We find that the Taylor rule parameters under modified weights don't change for a procurement and redistribution shock. Hence, the welfare costs in terms of conditional consumption equivalents (χ_R and χ_P) in Table 3.3 and Table 3.9 and volatility of sectoral inflation, aggregate inflation and aggregate output gap are identical.

However, the welfare costs in terms of conditional consumption equivalents (χ_R and χ_P) are significantly lower for agricultural productivity shocks both shocks when the monetary authority places a higher weight on the variance of the output-gap term in the objective function, indicating that it is closer to the deterministic steady state. Even though the inflation-coefficient in the OSR rule is the same in both cases, because the output-coefficient is significantly higher with $\Omega_\pi = 0.1$, we find manufacturing sector inflation and aggregate output gap to be more stable, while aggregate inflation to be more volatile. The variance of aggregate inflation is higher when $\Omega_\pi = 0.1$ in Table 3.9 than in Table 3.3, where $\Omega_\pi = 0.9$ (0.590 versus 0.067 in the case of agricultural productivity shocks and 0.542 versus 0.359 in the case of both shocks). Sectoral inflation exhibits lower volatility with $\Omega_\pi = 0.1$ (0.074 versus 0.0121 in the case of agricultural productivity shocks and 0.146 versus 0.250 in case of both shocks). The output gap is significantly less volatile with $\Omega_\pi = 0.1$ (0.103 versus 0.441 in the case of agricultural productivity shocks and 0.244 versus 0.400 in the case of both shocks). This is consistent with theory, as aggregate inflation is determined by the weighted average of inflation in the flexible price sector (agriculture) and the sticky-price sector (manufacturing). Since the sticky-price sector drives the output gap, fluctuations in the output gap influence aggregate inflation indirectly. Thus, if the monetary authority places a greater weight on output-gap stabilisation in the presence of redistributive-policy shocks, the economy would face greater volatility of aggregate inflation.

3.7 Conclusion

In this chapter, we compute the welfare costs of redistributive policy shocks and show that, although positive, they are quantitatively small. Rich households are willing to forgo $0.0096 - 0.0120\%$ of their steady-state consumption to be in a regime without such shocks, whereas poor agents are willing to forgo $0.0161 - 0.0350\%$. Hence, while the aggregate welfare effects are modest, redistributive policy shocks are more costly for poorer agents and generate larger welfare losses than agricultural productivity shocks.

The optimal simple rule for a redistributive policy shock prescribes no interest-smoothing or output gap stabilisation, and a strong response to inflation. In contrast, non-optimal monetary policy responses result in significant welfare costs for both agents in the presence of redistributive policy shocks.

When comparing the OSR to the utilitarian Ramsey planner, we find that full inflation stabilization is not optimal under the planner's solution. As the planner assigns positive weight to the hand-to-mouth agent, the Ramsey-optimal policy incorporates an additional objective of supporting current consumption. In attempting to raise the income of poorer households through higher aggregate demand, the planner moderates the interest rate response to shock-induced inflation. As a result, inflation volatility is higher under the Ramsey allocation than under the OSR. Consistent with this mechanism, increasing the weight on output-gap stabilization reduces welfare losses in consumption-equivalent terms but increases inflation volatility. Overall, our results underscore the inherent trade-off between distributional objectives and price stability when monetary policy responds to redistributive policy shocks.

Chapter 4

Informality and Fiscal Consolidation

[1]

4.1 Introduction

The COVID-19 pandemic led to a sharp and widespread increase in public debt across advanced and emerging economies, raising renewed concerns about fiscal sustainability.[2] As monetary policy space narrowed in several countries—particularly in the presence of low interest rates and binding lower bounds—fiscal policy became the primary instrument for macroeconomic stabilisation. Yet fiscal expansion in highly indebted economies involves a clear trade-off: policies that support output and employment in the short run may simultaneously worsen debt dynamics via higher borrowing requirements

[1]This paper is joint work with Chetan Ghate (ISI Delhi)

[2]See `https://www.imf.org/en/Blogs/Articles/2025/05/29/debt-is-higher-and-rising-faster-in-80-percent-of-global-economy`.

and increasing risk premia. Understanding how fiscal interventions affect both output and the evolution of public debt is therefore central to macroeconomic policy design.

The macroeconomic effects of fiscal policy have been extensively studied within New Keynesian frameworks. The optimal design of counter-cyclical fiscal interventions depends on monetary accommodation, the degree of economic slack, and the persistence of shocks (Gali & Monacelli 2008; Coenen et al. 2013). Fiscal multipliers are significantly larger when monetary policy is constrained by the zero lower bound (Christiano et al. 2011; Erceg & Lindé 2013), and they vary with the nature and duration of fiscal shocks (Coenen et al. 2012) as well as with the specific instrument employed (Cloyne et al. 2020). While some contributions argue that fiscal expansions can be partly or fully self-financing when multipliers are sufficiently large (DeLong et al. 2012), others show that persistent increases in deficits may permanently reduce output and raise debt ratios (Fatás & Summers 2018). These results highlight that fiscal policy effects are highly state-dependent.

The composition of fiscal adjustment has also received considerable attention. Empirical evidence from advanced economies suggests that expenditure-based consolidations are, on average, less contractionary than tax-based adjustments (Alesina & Ardagna 2010; Alesina et al. 2019a; Alesina et al. 2019b). However, these findings are sensitive to institutional context and monetary conditions (Erceg & Lindé 2013). A related strand of the literature shows that fiscal consolidations may be expansionary under particular conditions. Early contributions emphasise credibility and expectation effects, whereby large and credible adjustments lower interest rates and stimulate private demand (Giavazzi

& Pagano 1990). More recent DSGE analyses instead highlight structural general equilibrium mechanisms, showing that the macroeconomic effects of consolidation depend on the composition of spending cuts and on the degree of substitutability between public and private goods (Dave et al. 2021).

The transmission of fiscal policy may differ substantially in emerging market and developing economies (EMDEs).[3] Cross-country evidence indicates that fiscal multipliers are generally smaller in emerging markets than in advanced economies (Ilzetzki et al. 2013; Kraay 2012; Hory 2016). Structural characteristics—such as limited fiscal space, weaker tax capacity, and large informal sectors—further complicate fiscal adjustment (La Porta & Shleifer 2014). Informality is particularly important because it narrows the effective tax base and alters behavioural responses to taxation (Alba & McKnight 2022). When tax rates increase, labour and production may shift toward the untaxed informal sector, reducing the realised revenue gains from consolidation as observed for Greece between 2010 and 2015 (Dellas et al. 2024). In large cross-country samples, higher informality is associated with a greater likelihood of fiscal consolidation episodes, suggesting tighter fiscal constraints in such economies (Jalles et al. 2025).

A growing empirical literature documents interactions between fiscal policy and informality. Using data for Asian economies, Pham & Le (2024) show that fiscal expansions are associated with increases in both public debt and informality. Employing a narrative identification approach for Latin American and Caribbean countries, Thibault (2020) find that consolidation multipliers are

[3]While Alok Kumar (2023) and Colombo et al. (2024) find evidence of tax-based consolidations to be costlier for EMEs, Thibault (2020) and Carrière-Swallow et al. (2021) find no significant difference between tax-based and spending-based fiscal multipliers in LAC. This may be because of non-linear effects of tax changes on output (Gunter et al. 2021).

larger in economies with lower levels of informality. At the microeconomic level, higher labour income taxes induce reallocation toward informal employment, reducing average earnings and measured productivity (Esteban-Pretel & Kitao 2021; McPhail et al. 2018). Despite these findings, theoretical frameworks capable of jointly analysing public debt dynamics, fiscal instrument choice, and endogenous labour reallocation across formal and informal sectors remain limited (Junior et al. 2021, Dellas et al. 2024, Ferrara et al. 2025). Existing DSGE models incorporating informality focus primarily on business-cycle dynamics or monetary transmission (Fernández & Meza 2015; J. Horvath & Yang 2022; Leyva & Urrutia 2020; Alberola & Urrutia 2020; Colombo et al. 2019), and do not explicitly examine how informality shapes the debt effects of alternative fiscal consolidation strategies.

This chapter addresses that gap by developing a two-sector, two-agent New Keynesian (2S-TANK) closed-economy model featuring a productive formal sector and a lower-productivity informal sector that is largely disconnected from taxation and formal financial markets. The framework incorporates key stylised features of developing economies documented by La Porta & Shleifer (2014), including sizeable steady-state informality and segmented labour markets.

Within this environment, we examine three questions. First, how does informality alter the response of public debt to government spending shocks? Second, how do tax-based versus spending-based fiscal consolidations affect labour allocation between formal and informal sectors? Third, how does the degree of substitutability between public and private goods modify the debt-output trade-off, following Dave et al. (2021)? Our comparison of consolidation instruments relates to findings that reducing public investment may be particularly costly

(Stähler & Thomas 2012) and that fiscal instrument choice significantly shapes macroeconomic outcomes (Alok Kumar 2023; Anand & P. Khera 2016; Colombo et al. 2024).

By explicitly modelling labour segmentation and fiscal capacity constraints, this chapter links fiscal consolidation to endogenous labour reallocation and demonstrates how informality reshapes debt dynamics in developing economies.

The next section documents the stylised empirical patterns that motivate the model. Section 3 presents the model. Section 4 describes the parameterisation and reports the impulse responses to fiscal policy shocks. Section 5 discusses model extensions, and Section 6 concludes.

4.2 Stylised Facts

This section documents cross-country evidence linking informality to public debt dynamics and fiscal adjustment.

- **Stylised Fact 1:** Informal economic activity constitutes a substantial share of output and employment in emerging market and developing economies (EMDEs). Although the size of the informal sector has declined gradually over time, it remains significantly larger than in advanced economies (Medina & Schneider 2019).

- **Stylised Fact 2**: High levels of informality constrain tax capacity and complicate fiscal consolidation in EMDEs.

Economies with larger informal sectors tend to have higher debt-to-GDP ratios

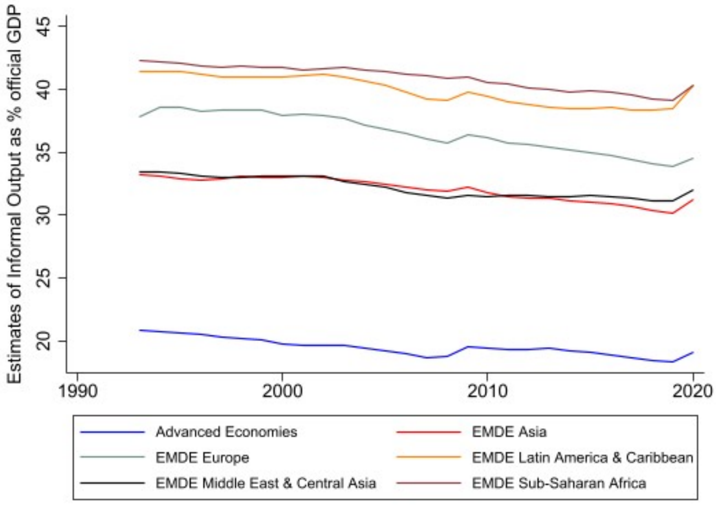


Figure 4.1: Informal output in official GDP (%)

Source: IMF World Economic Outlook (April 2025) and ILO Informal Economy Database (2021). Official output is measured by the Multiple Indicators and Multiple Causes (MIMIC) approach.

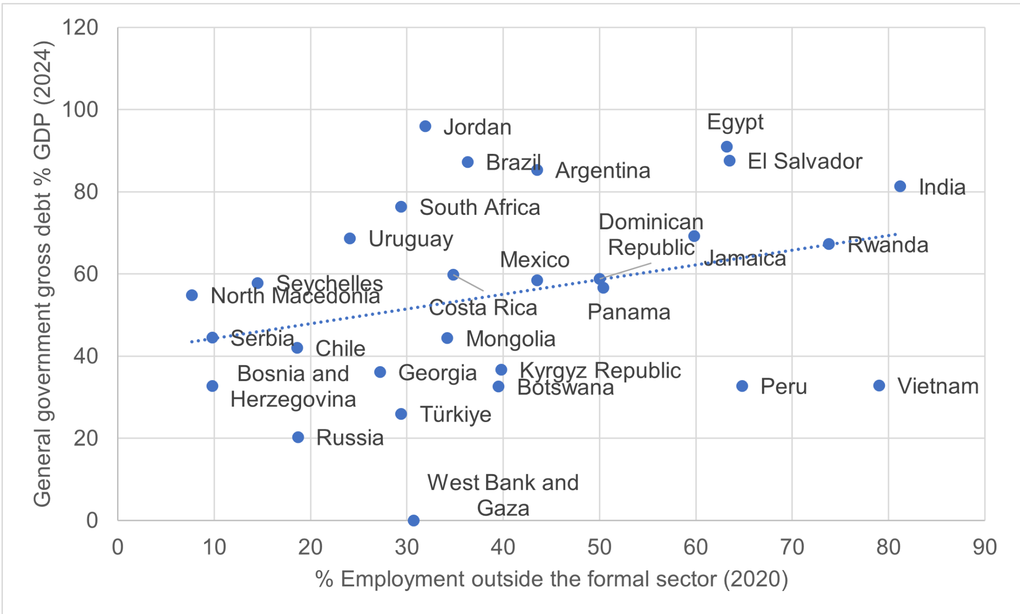


Figure 4.2: Relationship between informal employment and Government debt-GDP ratio

Source: Informal employment size based estimates from Informal Economy Database, ILO & World Economic Outlook.

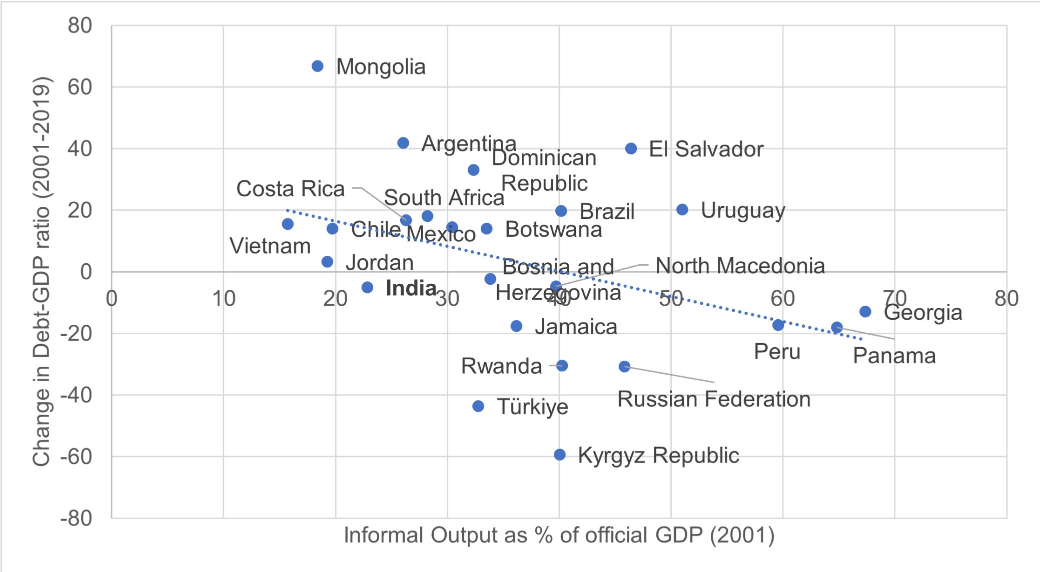


Figure 4.3: Relationship between debt reduction and informal output

Source: MIMIC-based estimates from Informal Economy Database, ILO & World Economic Outlook. Data on informal output is not available for Seychelles and West Bank and Gaza in the Informal Economy Database. Figure 4.3 illustrates a negative relationship between changes in general government debt-to-GDP ratios (2000–2019) and the share of informal output as a percentage of GDP, estimated using the MIMIC approach from the ILO's Informal Economy Database.

(see Figure 4.2) and experience smaller reductions in debt over time (as in Figure 4.3). By narrowing the effective tax base, informality limits revenue mobilization, and attempts at revenue-based consolidation may push activity into the untaxed sector, making debt stabilization more difficult.[4]

Taken together, these stylised facts point to a structural mechanism linking informality, fiscal capacity, and debt dynamics. They motivate a framework in which fiscal policy not only affects aggregate demand but also influences labour allocation across formal and informal sectors, thereby reshaping the evolution of public debt.

[4]Fiscal consolidation poses greater challenges in EMDEs compared to advanced economies. Figure C.1 in the Appendix C shows kernel density plots of the average value of deficits and by regions from 1980-2023 by region. We observe that EMDEs had steady, modest deficits between 1980–2023, signifying lower fiscal capacity. Huidrom et al. (2018) shows that an increase in fiscal space is usually accompanied by a move toward countercyclical and thus more effective fiscal policy stances.

The next section presents the model.

4.3 Model

The model economy consists of four types of agents - households, firms, government and monetary authority.

4.3.1 Households

There are two types of households in the model -Ricardian and Rule of Thumb households. Ricardian or optimising households have unrestricted access to capital and financial markets and can smooth consumption intertemporally by saving in the form of physical capital and government bonds. They decide how much formal and informal goods to consume, invest in physical capital and purchase government bonds. They are the owners of both formal and informal firms and receive dividends from both. A share $\eta \in (0,1)$ of the formal household members work in the formal sector while $1-\eta$ supply their labour to the informal sector.[5] As is standard in DSGE models, we assume that households incur disutility from working. We assume that the disutility from working in the informal sector is greater than working in the formal sector for Ricardian households.[6]

In contrast to the Ricardian households, the Rule of thumb agents are liquidity

[5]This assumption allows us to match the first order moments well. We relax this assumption in Section 4.5.1.

[6]Informal jobs are frequently characterised by irregular or contractual arrangements, which not only result in job insecurity but also tend to be less respected within communities. Workers in the informal sector may lack formal job titles, career advancement opportunities, and the social recognition that comes with stable, formal employment. This can lead to a sense of marginalisation and lower self-esteem, as informal work is often perceived as less prestigious or even as a "last resort" compared to formal sector positions. These social factors—combined with the absence of legal protections and benefits—reinforce the notion that working in the informal sector is associated with greater disutility than formal employment. Zhou et al. (2024) finds negative impacts on psychological well-being for China, while Martínez & Zafra (2025) find that informal workers experience more negative emotions such as worry, depression, and anger and have lower job satisfaction. They find that workers Informal workers in Cali, Colombia, exhibit lower life and job satisfaction compared to formal workers.

constrained, i.e., they consume their labour earnings every period. Thus, they are also referred to as hand-to-mouth agents and represented as H. They decide on how much formal and informal goods to consume and supply labour to the informal sector. The fraction of the hand-to-mouth agent is set to $\omega \in (0, 1)$, while the remaining fraction $1 - \omega$, represents the share of Ricardian households in the economy, denoted by R. Both (R and H) agents receive a lump sum transfer from the government. We assume that both agents derive utility from *effective consumption* and disutility from working. Consumption for both agents is a composite of the private good and public consumption (*effective consumption*), as in Eric M Leeper et al. (2009), Coenen et al. (2013), and Troug (2020),[7] where the private good is a composite of both the formal and informal good, as in Keller (1976).[8] A value of $e \to 0$ implies that public and private goods are perfect complements (examples include law and order, basic education, operas and movie halls) while $e \to \infty$ signifies that private and public goods are perfect substitutes. $\alpha_C = 1$ indicates that agents derive utility only from private consumption.[9]

[7]Troug (2020) uses a non-separable utility function in a 1 sector-RANK framework and introduces government consumption in utility financed by lump-sum taxes. He finds that the slope of the IS curve would be flatter when there is utility from government consumption, and public and private goods are complementary. Eric M. Leeper et al. (2017) introduces a linear additive form where $C_t^* = C_t + \alpha_G G_t$, where $\alpha_G > 0$ denotes substitutability and $\alpha_G < 0$ denotes complementarity between private and public consumption. However, effects of public consumption are independent of the level of private and public consumption. Our CES specification follows Bouakez & Rebei (2007), Sims & Wolff (2018) and improve realism.

[8]We abstract away from differences in household preferences - the consumption baskets of both households are the same i.e., preference parameters such as elasticity of substitution between public and private goods (e>0), the relative importance in the utility function ($\gamma_C \in (0, 1)$), the elasticity of substitution between formal and informal goods ($\epsilon > 1$), the relative preference for formal and informal goods ($\alpha_C \in (0, 1)$), the elasticity of substitution across varieties (σ_F & σ_I), the inverse of Frisch labour supply elasticity (ϕ) are identical for both agents.

[9]The chosen utility function implies that government consumption directly impacts private consumption in addition to the indirect wealth effect. However, it does not alter the relative choices between formal and informal consumption demands.

Ricardian Households

Ricardian households maximize their discounted lifetime utility derived from privately consumed formal (F) and informal (I) goods ($C^F_{R,t}$ and $C^I_{R,t}$, respectively), and the public good (G_t) adjusted for the dis-utility obtained from supplying labor in the formal and informal sectors ($N^F_{R,t}$ and $N^I_{R,t}$, respectively). Their optimization problem is given by:

$$\max_{\begin{Bmatrix} C^F_{R,t}, C^I_{R,t}, L^F_{R,t}, \\ L^I_{R,t}, B_{R,t}, \\ K^F_{R,t}, K^I_{R,t} \end{Bmatrix}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \log \widetilde{C}_{R,t} - \eta \chi^F_R \frac{{L^F_{R,t}}^{1+\phi}}{1+\phi} - (1-\eta)\chi^I_R \frac{{L^I_{R,t}}^{1+\phi}}{1+\phi} \right\} \tag{4.1a}$$

$$\text{where } \widetilde{C}_{R,t} = \left[\gamma_c^{\frac{1}{e}} \cdot C_{R,t}^{\frac{e-1}{e}} + (1-\gamma_c)^{\frac{1}{e}} \cdot G_t^{\frac{e-1}{e}} \right]^{\frac{e}{e-1}} \tag{4.1b}$$

$$C_{R,t} = \left[\alpha_c^{\frac{1}{\epsilon}} \cdot \left(C^I_{R,t}\right)^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha_c)^{\frac{1}{\epsilon}} \cdot \left(C^F_{R,t}\right)^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}} \tag{4.1c}$$

where ϕ is the inverse of Frisch elasticity of labour supply and $\chi^F_R, \chi^I_R > 0$ are preference parameters related to work effort.[10]

The Ricardian households maximize (4.1) subject to the budget constraint in

[10] Various assumptions with respect to labour supply are made in the literature. Colombo et al. (2022) assumes both agents supply labour to both sectors and the demand for each variety is uniformly distributed among household types. However, accounting for frictions to labour mobility in the developing-country context, we assume that only the Ricardian agent can supply labour to both sectors, but there are no frictions to setting wages. Alok Kumar (2023) and V. Gabriel et al. (2016) also assume informal sector labour supply by Ricardian agents. The former assumes greater dis-utility in working in the formal sector which is counterintuitive while the latter introduces an exogenous markup in the formal sector. We get a wage premium based on higher productivity in the formal sector.

4.2

$$\begin{aligned}(1+\tau_{C,t})\frac{P_t^F}{P_t}C_{R,t}^F + \frac{P_t^I}{P_t}C_{R,t}^I + \frac{P_t^F}{P_t}I_{R,t}^F + \frac{P_t^I}{P_t}I_{R,t}^I + \frac{B_{R,t}}{P_t} \\ \leq (1-\tau_{K,t}^F)r_{K,t}^F K_{R,t-1}^F + (1-\tau_{w,t}^F)\eta w_t^F L_{R,t}^F + (1-\eta)w_t^I L_{R,t}^I \\ + \frac{B_{R,t-1}R_{t-1}}{P_t} + r_{K,t}^I K_{R,t-1}^I + \Lambda_t^F + \Lambda_t^I - \Gamma_t\end{aligned} \tag{4.2}$$

and capital accumulation constraint (4.3) for $j \in \{F, I\}$:

$$K_{R,t}^j = (1-\delta)K_{R,t-1}^j + I_{R,t}^j \tag{4.3}$$

where P_t^F and P_t^I are the prices of formal, informal goods respectively, while P_t represents the price index of the composite good, $r_{K,t}^F > 0$ and $r_{K,t}^I > 0$ are the real returns to capital in the formal and informal sector, w_t^F and w_t^I are real wages in the formal and informal sector respectively, and $\tau_{C,t} \in (0,1)$, $\tau_{K,t} \in (0,1)$ and $\tau_{W,t} \in (0,1)$ are tax rates imposed on consumption, return to capital and labour services in the formal sector, $B_{R,t}$ is the nominal value of bonds purchased in period t. $I_{R,t}^F$ and $I_{R,t}^I$ are the investments undertaken by each Ricardian household in physical capital in the formal and informal sectors, respectively.[11] Λ_t^F and Λ_t^I are the real profits of owning the formal and informal firms, and Γ_t are real value of lump sum taxes.

We assume that consumers value variety and are willing to pay a premium for differentiated products. Thus, we assume both formal and informal good are CES aggregates of differentiated products z^j, for each type of good $j \in \{F, I\}$. The sectoral demand of good $j \in \{F, I\}$ by agent $k \in \{R, H\}$ is given by[12]:

[11] We assume that there is sector-specific capital. Since we assume no investment adjustment costs in the benchmark model, the price of the investment goods are the same as the price of the final goods.

[12] The aggregate consumption demand of sectoral goods is a weighted average of households' demands. As we assume symmetric preferences for agents, aggregate consumption is (4.4)

$$C_{k,t}^{j} = \left(\int_{0}^{1} \left(C_{k,t}^{j}(z^{j}) \right)^{\frac{\sigma^{j}-1}{\sigma^{j}}} dz^{j} \right)^{\frac{\sigma^{j}}{\sigma^{j}-1}} \tag{4.4}$$

Thus, the sectoral price index is given by:

$$P_{t}^{j} = \left(\int_{0}^{1} P_{t}^{j}(z^{j})^{1-\sigma^{j}} dz^{j} \right)^{\frac{1}{1-\sigma^{j}}} \tag{4.5}$$

and the demand for each type $C_t(z^j)$ is given by:

$$C_{t}^{j}(z) = \left(\frac{P_{t}^{j}(z^{j})}{P_{t}^{j}} \right)^{-\sigma^{j}} C_{t}^{j} \tag{4.6}$$

Optimizing conditions The Ricardian household pays a tax ($\tau_{W,t}$) and receives a social security benefit ($\tau_{S,t}$) on the income earned from the supply of labour in the formal sector. As the informal sector is 'unofficial' and is outside the tax net, no such tax/benefit is received. The Ricardian household equates its marginal value of consolidated labour income in each sector with the dis-utility of working in that sector to determine the optimal labour supply in the formal sector, as in equation (4.7) and the labour supply in the informal sector, as in equation (4.8).

$$(1 - \tau_{W,t}^{F} + \tau_{S}) w_{t}^{F} \lambda_{R,t} = \chi_{R}^{F} {L_{R,t}^{F}}^{\phi} \tag{4.7}$$

where $(1 - \tau_{W,t}^{F} + \tau_{S})$ acts as a wedge between the real wages in the formal sector and the marginal rate of substitution. Lower tax rate on formal sector wages and higher social security benefits raise the supply of labour in the formal sector.

$$w_{t}^{I} \lambda_{R,t} = \chi_{R}^{I} {L_{R,t}^{I}}^{\phi} \tag{4.8}$$

The optimality conditions for bonds ($B_{R,t}$), formal and informal capital (K_t^F and K_t^I) are given by:

$$\lambda_{R,t} = \beta \mathbb{E}_t \left[\lambda_{R,t+1} \frac{R_t}{\Pi_{t+1}} \right] \tag{4.9}$$

$$\lambda_{R,t} = \beta \mathbb{E}_t \left[\lambda_{R,t+1} \left\{ \underbrace{\Pi^F_{t+1}(1-\delta)}_{\text{Capital resale value}} + \underbrace{(1-\tau^F_{K,t+1}) r^F_{K,t+1} \left(\frac{P_t}{P^F_t} \right)}_{\text{Net capital income}} \right\} \right] \tag{4.10}$$

where $\Pi^F_t \equiv \frac{\frac{P^F_t}{P_t}}{\frac{P^F_{t-1}}{P_{t-1}}}$

$$\lambda_{R,t} = \beta \mathbb{E}_t \left[\lambda_{R,t+1} \left\{ \Pi^I_{t+1}(1-\delta) + r^I_{K,t+1} \left(\frac{P_t}{P^I_t} \right) \right\} \right] \tag{4.11}$$

where λ^R_t is the shadow price of the household's budget constraint i.e., the household equates the marginal utility cost of investing one unit of sectoral capital with the expected discounted marginal utility benefit from the next period's (undepreciated) capital value and after-tax rental income. The demands for the formal and informal goods $C^k_{R,t}$ for $j \in \{F, I\}$ are given by equation (4.12) and (4.13), respectively.

$$\lambda^R_t \cdot (1+\tau_{C,t}) \cdot \frac{P^F_t}{P_t} = (1-\alpha_C)^{\frac{1}{\epsilon}} \cdot \gamma_C^{\frac{1}{e}} \cdot C_{R,t}^{-\frac{1}{e}} \cdot \left[\gamma_C^{\frac{1}{e}} \cdot {C^I_{R,t}}^{\frac{e-1}{e}} + (1-\gamma_C)^{\frac{1}{e}} \cdot G_t^{\frac{e-1}{e}} \right]^{-1} \cdot {C^F_{R,t}}^{-\frac{1}{\epsilon}} \tag{4.12}$$

i.e., the household equates the marginal utility of consumption of the formal good to the marginal cost of purchasing the formal good, which is the shadow value of wealth times the after-tax price of the formal good.

$$\lambda^R_t \cdot \frac{P^I_t}{P_t} = (1-\alpha_C)^{\frac{1}{\epsilon}} \cdot (1-\gamma_C)^{\frac{1}{e}} \cdot C_{R,t}^{-\frac{1}{e}} \cdot \left[\gamma_C^{\frac{1}{e}} \cdot {C^I_{R,t}}^{\frac{e-1}{e}} + (1-\gamma_C)^{\frac{1}{e}} \cdot G_t^{\frac{e-1}{e}} \right]^{-1} \cdot {C^I_{R,t}}^{-\frac{1}{\epsilon}} \tag{4.13}$$

i.e., the household equates the marginal utility of consumption of the informal good to the marginal cost of purchasing the informal good, which is the shadow value of wealth times the price of the informal good, as the informal good is outside the ambit of taxation.

The price index corresponding to the household's optimization problem is given by:

$$P_t = \left[(1-\alpha_C)((1+\tau_{C.t})P_t^F)^{1-\epsilon} + \alpha_C (P_t^I)^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}}$$

and aggregate inflation is given by $\Pi_t = \frac{P_t}{P_{t-1}}$

$$\Pi_t^{1-\epsilon} = (1-\alpha_C).\left\{(1+\tau_{C.t})\Pi_t^F.\frac{P_{t-1}^F}{P_{t-1}}\right\}^{1-\epsilon} + \alpha_C\left\{\Pi_t^I.\frac{P_{t-1}^I}{P_{t-1}}\right\}^{1-\epsilon} \tag{4.14}$$

Rule of thumb Households

H agents are excluded from the financial and formal sector labour markets by assumption. They choose the amount of sectoral consumption ($C_{H,t}^F$ and $C_{H,t}^I$) and labour hours in the informal sector ($L_{H,t}^I$) by maximizing utility (in equation (4.15)) subject to income earned from working in the informal sector and lump sum taxes in every period.

The household of type H solves

$$\max_{\{C_{H,t}^F, C_{H,t}^I, L_{H,t}^I\}} \left\{\log \widetilde{C}_{H,t} - \chi_H \frac{{L_{H,t}^I}^{1+\phi}}{1+\phi}\right\} \tag{4.15a}$$

$$\text{where } \widetilde{C}_{H,t} = \left[\gamma_c^{\frac{1}{e}} \cdot C_{H,t}^{\frac{e-1}{e}} + (1-\gamma_c)^{\frac{1}{e}} \cdot G_t^{\frac{e-1}{e}}\right]^{\frac{e}{e-1}} \tag{4.15b}$$

$$C_{H,t} = \left[\alpha_c^{\frac{1}{\epsilon}} \cdot \left(C_{H,t}^I\right)^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha_c)^{\frac{1}{\epsilon}} \cdot \left(C_{H,t}^F\right)^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}} \tag{4.15c}$$

subject to

$$(1+\tau_{C,t})\frac{P_t^F}{P_t}C_{H,t}^F+\frac{P_t^I}{P_t}C_{H,t}^I=\frac{W_t^I}{P_t}L_{H,t}^I-\Gamma_t \tag{4.16}$$

where Γ_t represent lump-sum taxes to the financially unconnected households.[13] The optimal consumption of the H households for the formal and informal goods are governed by equations (4.17) and (4.18), respectively:

$$\lambda_t^H\cdot(1+\tau_{C,t})\cdot\frac{P_t^F}{P_t}=(1-\alpha_C)^{\frac{1}{\epsilon}}\cdot\gamma_C^{\frac{1}{e}}\cdot C_{H,t}^{-\frac{1}{e}}\cdot\left[\gamma_C^{\frac{1}{e}}\cdot {C_{H,t}^I}^{\frac{e-1}{e}}+(1-\gamma_C)^{\frac{1}{e}}\cdot G_t^{\frac{e-1}{e}}\right]^{-1}\cdot {C_{H,t}^F}^{-\frac{1}{\epsilon}} \tag{4.17}$$

$$\lambda_t^H\cdot\frac{P_t^I}{P_t}=(1-\alpha_C)^{\frac{1}{\epsilon}}\cdot(1-\gamma_C)^{\frac{1}{e}}\cdot C_{H,t}^{-\frac{1}{e}}\cdot\left[\gamma_C^{\frac{1}{e}}\cdot {C_{H,t}^I}^{\frac{e-1}{e}}+(1-\gamma_C)^{\frac{1}{e}}\cdot G_t^{\frac{e-1}{e}}\right]^{-1}\cdot {C_{H,t}^I}^{-\frac{1}{\epsilon}} \tag{4.18}$$

i.e., the H household equates the marginal utility of consumption of the formal and informal goods to the marginal cost of purchasing the respective good in equations (4.17) and (4.18), respectively. As for the R agents, the marginal costs are measured as the shadow value of wealth times the price of the respective good inclusive of taxes.

The H agent chooses the labour supply to equalize real wages and the disutility of supplying labour. The optimality condition for supplying labour is given by:

$$\frac{W_t^I}{P_t}\lambda_{H,t}=\chi_H {L_{H,t}^I}^{\phi} \tag{4.19}$$

4.3.2 Firms

Both sectors are characterised by monopolistic competition, i.e., a continuum of intermediate-good firms produce differentiated products on a unit interval in each

[13] Note that we have assumed that both households pay the same lump-sum taxes. $\Gamma_t < 0$ implies a transfer.

sector.[14] The final sectoral output is a Dixit and Stiglitz aggregate of intermediate goods. The production function of a firm producing variety $z^j \in [0,1]$ in sector $j \in \{F, I\}$ is given by:

$$Y_t^j(z^j) = A_t^j (K_t^{Dj}(z^j))^{\alpha_j} (L_t^j(z^j))^{1-\alpha_j} \tag{4.20}$$

where A_t^j is the sector-specific productivity shock, $Y_t^j(z^j), K_t^{Dj}(z^j), L_t^j(z^j)$ are the sector-specific output, capital and labour employed in the firm producing the variety z^j in sector j, respectively.

The final good is given as a CES aggregate:

$$Y_t^j \equiv \left(\int_0^1 \left(Y_t^j(z^j) \right)^{\frac{\sigma^j - 1}{\sigma^j}} dz^j \right)^{\frac{\sigma^j}{\sigma^j - 1}} \tag{4.21}$$

for $z^j \in [0,1]$, where σ^j is the elasticity of substitution between varieties in sector $j \in \{F, I\}$. We assume that each intermediate goods firm, z, maximizes discounted real profits ($\Lambda_t^j(z)$) subject to the production function (equation (4.20)) and the demand for it's variety (equation (4.21)) and incurs an increasing and convex cost while adjusting prices from the previous period (following Rotemberg (1982)). The price adjustment cost is measured in terms of its sectoral output as:

$$\text{Price adjustment cost} = \frac{\varphi^j}{2} \left(\frac{P_t^j(z^j)}{P_{t-1}^j(z^j)} - 1 \right)^2 P_t^j Y_t^j \tag{4.22}$$

[14]The existence of monopolistic competition can be tested by having differentiated varieties of goods or positive markups. As data on product characteristics are not available in *Annual Survey of Unincorporated Sector Enterprises*, we are unable to infer product differentiation directly. Ideally, we could estimate markups based on market shares as in Brooks et al. (2021). This paper follows Loecker & Warzynski (2012) and De Loecker et al. (2016) and requires a firm-level panel data for estimation. Due to the absence of a firm-level panel dataset for the I sector firms, we could use the approach as in Sivadasan (2009) and Santanu Chatterjee et al. (2021). De Ridder et al. (2024) uses financial data of firms to estimate markups; however, this approach can be used only to estimate the dispersion of markups, not the average level of markup. Monopolistic competition has been assumed for both sectors in few papers Anand & P. Khera (2016), V. Gabriel et al. (2016)in the Indian context.

As Ricardian households are owners of firms, the firms' optimisation problem is given as:

$$\max_{\{P_t^j(z^j), L_t^j(z^j), K_t^{Dj}(z^j)\}} \mathbb{E}_t \sum_{s=0}^{\infty} Q_{t,t+s} \left[\frac{P_t^j(z^j)}{P_t} Y_t^j(z^j) - mc_t^j(z^j) Y_t^j(z^j) - \frac{\varphi^j}{2} \left(\frac{P_t^j(z^j)}{P_{t-1}^j(z^j)} - 1 \right)^2 \frac{P_t^j Y_t^j}{P_t} \right]$$

$$\text{s.t.} \quad Y_t^j(z) = \left(\frac{P_t^j(z^j)}{P_t^j} \right)^{-\sigma^j} Y_t^j$$

$$Y_t^j(z^j) = A_t^j (K_t^{Dj}(z^j))^{\alpha^j} (L_t^j(z^j))^{1-\alpha^j}$$

where $Q_{t,t+s} = \beta . \frac{\lambda_{R,t+s}}{\lambda_{R,t}}$ is the stochastic discount factor of the R agents, $mc_t^j(z^j)$ is the real marginal cost incurred by the firm producing variety z^j in sector $j \in \{F, I\}$.

$$(1 + \tau_S^j) w_t^j = (1 - \alpha^j) \frac{P_t^j}{P_t} \left(\frac{Y_t^j}{L_t^j} \right) \tag{4.23}$$

$$r_{K,t}^j = \alpha^j \frac{P_t^j}{P_t} \left(\frac{Y_t^j}{K_t^{Dj}} \right) \tag{4.24}$$

where w_t^j and r_t^j are the real wages and rental rates of capital in sector j. Firms hire labour and capital until the value of the additional unit of output produced (in terms of the composite good) is equal to the marginal cost to the firm adjusted for the price level of the composite good. The optimal demands for labour and capital are given in equations (4.23) and (4.24), respectively.[15]

The price-setting equation is given by:

$$\left(\Pi_t^j - 1 \right) \Pi_t^j = \frac{1}{\varphi^j} \left(1 - \sigma^j + \sigma^j mc_t^j \right) + \mathbb{E}_t \left[Q_{t,t+1} \Pi_{t+1}^j \left(\Pi_{t+1}^j - 1 \right) \frac{Y_{t+1}^j}{Y_t^j} \cdot \frac{\Pi_{t+1}^j}{\Pi_{t+1}} \right]$$

[15] $\tau_S^F = \tau_S$ while $\tau_S^I = 0$ as there are no social-security benefits in the informal sector.

where

$$Q_{t,t+1} = \beta \mathbb{E}_t \frac{\lambda_{R,t+1}}{\lambda_{R,t}}$$

is the stochastic discount factor of the R agents. Thus, in a two-sector model, the inflation rate depends on the cost of price adjustment, current and future real marginal costs of production and relative prices.

4.3.3 Monetary Authority

The monetary authority sets the nominal interest rate using a simple Taylor Rule:

$$R_t = \bar{R}^{1-\phi_R} R_{t-1}^{\phi_R} \Pi_t^{\phi_\Pi} e^{v_t} \tag{4.25}$$

where Π_t is the aggregate inflation in the economy, $\rho_R \in [0, 1)$ is the degree of persistence in the Taylor Rule, ρ_π measures the inflation sensitivity of the nominal interest rate and monetary policy shock $v_t \sim N(0, \sigma^2)$.

In our setup, aggregate inflation is determined by equation (4.14).

4.3.4 Government

The government receives revenues from taxing capital deployed in the formal sector at $\tau^F_{K,t}$, formal labour supply at $\tau^F_{W,t}$, and consumption of the formal good at $\tau_{C,t}$, lump-sum taxes Γ_t and new issuance of one-period risk-free bonds. Government expenditures include the amount spent on government consumption G_t, and the repayments of bonds issued in the previous period (interest payments). We assume that government consumption is determined exogenously, the issuance of debt is determined from equation (4.26), and lump sum taxes adjust from the steady state level by deviation of the actual debt-output ratio from a target (steady state). The government budget constraint is given by[16]:

$$G_t + (1-\omega)R_{t-1}\frac{B_{t-1}}{P_t} = \tau_{C,t}\frac{P_t^F}{P_t}C_t^F + \tau_{W,t}^F w_t^F L_t^F + (1-\omega)\tau_{K,t}^F r_{K,t}^F K_t^{DF} + (1-\omega)\frac{B_t}{P_t} + \Gamma_t. \tag{4.26}$$

We assume that there is some persistence in fiscal policy measures, i.e., government spending and tax rates are determined by their long-term value, the previous period's value and a random shock. The government procures goods exclusively from the formal sector. Government consumption follows the following AR(1) process:

$$G_t = \bar{G}^{(1-\rho_G)}.G_{t-1}^{\rho_G}.e^{\varepsilon_{G,t}} \tag{4.27}$$

where $\varepsilon_{G,t} \sim \mathcal{N}(0, \sigma_G^2)$. We assume that the tax shocks follow first-order stochastic processes, i.e., tax shock $\varepsilon_{i,t} \sim \mathcal{N}(0, \sigma_i^2)$ for $i \in \{K, W, C\}$ are given by equations (4.28)-(4.30).

$$\tau_{K,t}^F = (1-\rho_K).\bar{\tau}_K^F + \rho_K \tau_{K,t-1}^F + \varepsilon_{K,t} \tag{4.28}$$

$$\tau_{W,t}^F = (1-\rho_W).\bar{\tau}_W^F + \rho_W \tau_{W,t-1}^F + \varepsilon_{W,t} \tag{4.29}$$

$$\tau_{C,t}^F = (1-\rho_C).\bar{\tau}_C^F + \rho_C \tau_{C,t-1}^F + \varepsilon_{C,t} \tag{4.30}$$

We assume that lump-sum taxes (Γ_t) follow a pro-cyclical fiscal rule to ensure fiscal solvency. In the short-run, lump-sum taxes deviate from their average

[16] In the current setup, the government has access to six policy instruments. 3 tax instruments ($\tau_{K,t}^F$, $\tau_{W,t}^F$, $\tau_{C,t}^F$), 1 lump-sum tax to households (Γ_t), government consumption (G_t) and issuance of debt (B_{t+1})

value based on deviations of the debt-output ratio from its long-run value using a procyclical fiscal rule.

$$\Gamma_t = \Gamma_{t-1}^{\rho_\Gamma}.\left\{\bar{\Gamma}.\left(\frac{B_t}{Y_t}/\frac{\bar{B}}{\bar{Y}}\right)^{\vartheta}\right\}^{1-\rho_\Gamma} \tag{4.31}$$

4.3.5 Market Equilibrium

The formal goods market clears when formal output equals the sum of private and public consumption, firm investment, and price adjustment costs (see equation (4.33)). The informal goods market clears when informal output equals household consumption, firm investment, and the resources lost due to price adjustment (equation (4.34)).

$$\underbrace{Y_t^F}_{\text{Formal Output}} = \underbrace{(1-\omega)C_{R,t}^F + \omega C_{H,t}^F}_{\text{Private Consumption}} + \underbrace{(1-\omega)I_t}_{\text{Total Investment}} \tag{4.32}$$

$$+ \underbrace{G_t}_{\text{Public Consumption}} + \underbrace{\frac{\varphi^F}{2} Y_t^F (\pi_t^F - 1)^2}_{\text{Price Adjustment Cost}} \tag{4.33}$$

$$\underbrace{Y_t^I}_{\text{Informal Output}} = \underbrace{(1-\omega)C_{R,t}^I + \omega C_{H,t}^I}_{\text{Private Consumption}} + \underbrace{\frac{\varphi^I}{2} Y_t^I (\pi_t^I - 1)^2}_{\text{Price Adjustment Cost}} \tag{4.34}$$

The labour market is in equilibrium for both sectors. i.e., the labour demanded in the formal sector equals the labour supplied to the formal sector by the Ricardian agents,

$$L_t^F = \eta(1-\omega)L_{R,t}^F, \tag{4.35}$$

and the labour demanded in the informal sector equals total labour supply to the informal sector by both agents,

$$L_t^I = (1-\eta).(1-\omega)L_{R,t}^I + \omega.L_{H,t}^I. \tag{4.36}$$

The capital rental market clears in each sector when capital demand by intermediate goods producers equals the supply of sector-specific capital provided by Ricardian households, i.e.,

$$K_t^{DF} = (1-\omega)K_{R,t-1}^F, \tag{4.37}$$

and

$$K_t^{DI} = (1-\omega)K_{R,t-1}^I. \tag{4.38}$$

The monetary authority sets the nominal interest rate according to the policy rule, while government debt evolves according to the government budget constraint. In equilibrium, household bond holdings equal the supply of government debt, i.e.,

$$B_t = (1-\omega)B_{R,t}. \tag{4.39}$$

Aggregate GDP is determined as the total value of the output produced in the economy.

$$Y_t = \frac{P_t^F}{P_t}Y_t^F + \frac{P_t^I}{P_t}Y_t^I \tag{4.40}$$

4.4 Quantitative Analysis

4.4.1 Calibration

We calibrate the model at the annual frequency for India. India is a large emerging market economy, where historically the government expenditure-to-output ratio has been approximately 11%. Table 4.1 and 4.2 summarise the parameters and the sources, and Table 4.3 reports the persistence parameters and standard deviations of shocks used in the analysis.

We use the existing literature to set the values for most preference and technological parameters. Following the quarterly estimates of the discount factor in Anand & P. Khera (2016), we calibrate β to be 0.9762. Estimates of the responsiveness of labour supply to wages ($\frac{1}{\phi}$) vary between 0.25 and 1 (see Anand & Prasad 2010). We set the value of the inverse of Frisch elasticity from Anand & Prasad (2010) and set $\phi = 3$.

For calibrating the elasticities of substitution across different varieties $\sigma_j \in \{F, I\}$, we use the markup estimated by Pal & Rathore (2016)[17] to correspond to the formal sector. The estimated markup was 1.19, and so we calibrate $\sigma_F = 7$ to correspond to a markup of 1.17. We calibrate the corresponding parameter for the informal sector $\sigma_I = 12$ following Anand & P. Khera (2016). The literature is not very clear in identifying the elasticity of substitution between goods of the F and I sectors. A value of 8 has been used by Fernández & Meza (2015) while V. Gabriel et al. (2016) estimates a much lower value of 1.45.[18] Thus, we use a value of $\epsilon = 5$, which is lower than the degree of substitutability of varieties of individual sectors.

There are varied estimates about the share H agents (ω) in the literature. Earlier studies in the Indian context have used a value ranging from $0.10 - 0.60$.[19] The All India Debt and Investment Survey (2019) reports that approximately 84.4% of the rural population and 85.2% of the overall population aged 18

[17]They use data from the Annual Survey of Industries for 1980-2007 to estimate the markup at the 3-digit NIC level industry level for India.

[18]Their prior mean is 1.50 and standard deviation is 0.20, which could be influencing their posterior estimate.

[19]Alok Kumar (2023) estimates the share of financially constrained households to be 10%, V. Gabriel et al. (2016) estimates a value of 30% while Nandi (2020) uses 60%.

Parameter	Description	Value	Source
	Preference Parameters		
β	Discount Factor	0.97	Anand & P. Khera (2016)
σ_F	Elasticity of Substitution (F)	7	Anand & P. Khera (2016)
σ_I	Elasticity of Substitution (I)	12	Anand & P. Khera (2016)
ϕ	Inverse of Frisch Elasticity of Substitution	3	Anand & Prasad (2010)
ϵ	Inter-good elasticity of substitution (F & I)	5	Arbitrary
ω	Share of non-Ricardian (H) households	0.30	V. Gabriel et al. (2016)
η	Share of Ricardian households working in F sector	0.25	Arbitrary
γ_C	Share of Private consumption in EC	0.7	Colombo et al. (2022)
e	Inter-good elasticity of substitution (C & G)	0.5	Arbitrary
α_C	Share of Informal good in private consumption	0.50	Arbitrary
	Technological Parameters		
α_F	Capital intensity in formal sector	0.49	Alok Kumar (2023)
α_I	Capital intensity in informal sector	0.27	Alok Kumar (2023)
δ	Depreciation rate	0.10	Banerjee & Basu (2019)
φ^F	Price adjustment cost: Formal	4.05	Calculated by Authors
φ^I	Price adjustment cost: Informal	0.14	Calculated by Authors
	Steady-state parameters		
τ_C	Consumption tax rate	0.12	Middle GST Slab
τ_K	Capital income tax rate	0.08	Alok Kumar (2023)
τ_W	Labour income tax rate	0.20	Middle tax slab
τ_S	Social security contribution rate	0.12	Employer contribution to EPF
$\bar{A}_I$	Informal Sector Productivity	1	Normalization
$\bar{A}_F$	Formal Sector Productivity	1.2	Arbitrary
$\frac{\bar{G}}{\bar{Y}}$	Government consumption to GDP ratio	0.11	NAS[a]
$\frac{\bar{B}}{\bar{Y}}$	Deficit-output ratio	0.05	DBIE[b]

Table 4.1: Calibrated Parameters

[a]National Accounts Statistics
[b]Database on Indian Economy published by Reserve Bank of India

Parameter	Description	Value	Source
	Policy Parameters		
ϕ_R	Taylor Rule Parameter: Persistence	0.50	Alok Kumar (2023)
ϕ_Π	Taylor Rule Parameter: Inflation Coefficient	1.05	Alok Kumar (2023)
ϑ	Responsiveness of lump-sum tax to deviations in BY	0.1268	Alok Kumar (2023)

Table 4.2: Policy Parameters

Parameter	Description	Value	Source
	Persistence Parameters		
ρ_g	Government Spending	0.70	Author's Estimates
ρ_F	Formal Sector Productivity	0.95	Anand & P. Khera (2016)
ρ_I	Informal Sector Productivity	0.62	Anand & P. Khera (2016)
ρ_w	Labour Income Tax	0.7	Dave et al. (2021)
ρ_k	Capital Income Tax	0.6	Alok Kumar (2023)
ρ_c	Consumption Tax	0.63	Alok Kumar (2023)
	Standard Deviation		
σ_g	Government Spending	0.03	Authors Estimates
σ_F	Formal Sector Productivity	0.40	Anand & P. Khera (2016)
σ_I	Informal Sector Productivity	0.45	Anand & P. Khera (2016)
σ_w	Labour Income Tax	0.12	Dave et al. (2021)
σ_k	Capital Income Tax	0.10	Alok Kumar (2023)
σ_c	Consumption Tax	0.06	Alok Kumar (2023)

Table 4.3: Shock parameters

years and above held a bank deposit account in 2019.[20] However, the Global Findex Database 2021 finds that 78% of adults had accounts in India (including accounts in banks, credit unions, MFIs, post-office, mobile-money accounts and joint accounts with family members) while 35% of the accounts were inactive (Demirgüç-Kunt et al. 2022). Thus, we calibrate $\omega = 0.15$ in the benchmark analysis and use $\omega = 0.30$ for comparison.

We set the preference parameter governing the formal and informal consumption α_C so that it has the same weight in inflation.[21] We use the estimate of total elasticity of capital in formal production in Alok Kumar (2023) and calibrate $\alpha_F = 0.49$, while using his estimate for the capital share in informal production $\alpha_C = 0.27$. We assume the formal productivity level in the steady state $\bar{A^F} = 1.2$ and normalize the steady-state informal sector productivity $\bar{A^I} = 1$. Hence $\bar{A^F} > \bar{A^I}$. There is limited availability of recent estimates for the Rotemberg price adjustment cost parameters for EMDEs. Colombo et al. (2022) estimates the model at quarterly frequency and uses $\varphi^F = \varphi^I = 50$. Since these adjustment cost parameters are embedded in non-linear dynamic systems, they typically reflect the structure over the specific time interval for which they are estimated. Furthermore, the relationship between quarterly and annual adjustment cost parameters is not linear. Thus, we use the estimates of duration of formal and informal contracts in V. Gabriel et al. (2016) and follow the equivalence approach between Calvo and Rotemberg pricing discussed in Keen & Wang (2007) to compute price adjustment cost parameters. We assume that a typical formal sector contract has a length 4 quarters while the informal sector has a contract length of around 1.5 quarters.[22] Adjusting for annual estimation, we calculate

[20].See https://www.pib.gov.in/PressReleasePage.aspx?PRID=1753935

[21]The weight on informality is set to 70% in V. Gabriel et al. (2016) and 75% in Alok Kumar (2023).

[22]There is another estimate from Banerjee & Basu (2019) who estimate the average price duration to be 2.6

the price adjustment costs in the formal (φ^F) and informal (φ^I) sector to be 4.051 and 0.139, respectively.[23] We choose the disutility parameters $\chi_R^F, \chi_R^I, \chi_H$ to give a reasonable share of formal employment in total employment.

We set the steady-state consumption tax rate $\bar{\tau}_C = 12\%$, capital income tax rate $\bar{\tau}_K = 8\%$, labour income tax rate to correspond to the middle slab $\bar{\tau}_W = 20\%$ and the social security benefits paid to the formal sector worker by the firm $\bar{\tau}_S = 12\%$ in line with the actual rate. We use the values of persistent parameters and standard deviations of labour income tax rates from Dave et al. (2021), capital and consumption tax rate parameters from Alok Kumar (2023). As we have one-period bonds, we calibrate the value of the steady-state debt-GDP ratio to equal the average deficit-GDP ratio from 1990-2019 and set $\frac{\bar{B}}{Y} = 0.0493$. We model the cyclical component of the logarithm of Government Final Consumption Expenditure using an AR(1) process using annual data from *RBI- database for the Indian economy*. We calibrate $\rho_g = 0.705$ and $\sigma_g^2 = 0.034$.

Our model matches the empirical first-order moments with a high degree of accuracy.[24] Table 4.4 summarises the ratios of key variables from the benchmark model and their estimates from data or values reported in recent studies.[25]

months. However, that is for all India as a whole and does not distinguish between formal and informal sectors.

[23] $\varphi^F = \frac{(\sigma_F - 1)\theta_F}{(1-\theta_F)(1-\beta\theta_F)}$ where $(1 - \theta_F)$ is the probability of resetting the price.

[24] Due to the cost of nominal rigidities in the resource constraint, there is a wedge between consumption and output, because of which consumption is less volatile than output. Furthermore, the difference increases with the degree of nominal rigidity and with the size of shocks Ascari et al. (2011). Thus, we do not pursue matching second moments.

[25] We use annual data on Components of Gross Domestic Product published by RBI in the *Database of Indian Economy* to compute average values from 1990-91 to 2023-24.

Ratio	**Model**	**Data**	**Source**
Consumption-output ratio	60.0%	60.9%	NAS[1]
Investment-output ratio	29.0%	28.3%	NAS[1]
Formal Sector wage premium	2.18	2.34	Das et al. (2025)
Share of informal sector in GDP	42.7%	45%	NAS Estimates[a]
Share of formal employment	26.7%	24%	Das et al. (2025)[b]

[a]See https://www.pib.gov.in/PressReleseDetailm.aspx?PRID=2097693
[b]The estimated average percentage of employment outside the formal sector between 2010-2020 *informal employment size* in Elgin et al. (2021) is 82.6%
[a]National Account Statistics

Table 4.4: Matching key ratios from data

4.4.2 Impulse Response Analysis

We analyse the interaction between fiscal consolidation and informality. We study how the presence of a large informal sector constrains or facilitates the process of fiscal consolidation. We also study whether the nature of the public good i.e., whether the public goods enhance (complement) or offset (substitute for) the utility derived from private consumption, has a role to play in the effectiveness of fiscal consolidation.[26]

Only Private Good in Utility ($\gamma_C = 1$)

In this part of the analysis, we assume that agents derive utility only from consuming privately. The IRFs are depicted in Figures 4.4a-4.4d. We set $\gamma_C = 1$ in equations (4.1b) and (4.1c) and study the impact of a one-time reduction in the government expenditure on our model economy. As the government only consumes the goods produced in the formal sector, a reduction in G lowers the

[26]As is standard in the literature, the IRFs for inflation-aggregate and sectoral, interest rate, tax rates and debt-output ratio should be read in percentage points.

demand for the formal good Y_t^F. As changing prices is costly, the reduction in demand leads to a small decline in prices in the formal sector. As there is no direct impact on the informal sector, the relative price[27] of the informal good rises. Substitutability between the two goods leads to a contraction in demand for informal goods. Informal output Y_t^I declines. The value of the aggregate output measured by GDP decreases. A weakening of the public sector demand leads to disinflationary pressures, which result in a decline in the nominal interest rates set by the monetary authority.

As wages are flexible in both sectors, nominal wages in the F sector decrease to employ fewer workers in the F sector, and real wages (w_t^F) decline. A decline in price level results in higher real wages in the informal sector (w_t^I), leading to a contraction in demand for labour L_t^I.

Due to price stickiness, the real interest rate falls. A lower real rate encourages the Ricardians to consume more ($C_{R,t}$ rises) and work less ($L_{R,t}$ falls) by the intertemporal substitution effect. In our model, the Ricardian household has three alternative means of saving- investing in government bonds ($B_{R,t}$), and physical capital in the F and I sectors ($K_{R,t}^F$ and $K_{R,t}^I$), the real return must be the same across instruments to prevent arbitrage.[28] As the real interest on bonds has reduced, the R household must accumulate capital so that the real return from holding capital is the same as the real return from holding government bonds.

Alternatively, as lower government expenditure entails a lesser issuance of bonds, the price of the bonds rises, leading to a lower interest rate on bonds. This

[27] Ratio of Price of informal good to the aggregate price level.

[28] Investment decisions are driven by the expected return of capital in the next period, which is determined by the expected marginal product of capital and the relative price, described in equation 4.10.

leads to reallocation of savings towards investment in physical capital, leading to a higher availability of capital for production. Investment in F and I both sectors increases. A greater deployment of capital in production and a lower relative price of the F good reduces the real marginal product of capital in the F sector. As both real wages (w_t^F) and the cost of hiring capital ($r_{K,t}^F$) are lower in the F sector, real marginal costs of production decline. However, as the relative price of the I good increases due to the fiscal consolidation shock and firms engage in sectoral investment, the cost of hiring capital ($r_{K,t}^I$) increases for the I firms. In conjunction with higher real wages (w_t^I), this leads to a rise in the real marginal cost of production in the I sector. Since inflation is determined by current and future real marginal costs of production, formal sector inflation (Π_t^F) declines and the informal sector inflation (Π_t^I) increases in panel 4.4c.[29]

Non-Ricardian agents also respond to higher real wages (w_t^I) by reducing their labour supply ($L_{H,t}$). Public consumption declines, private consumption of both agents and investment in both sectors rise. Lower relative price results in higher consumption of the F good (C_t^F in panel 4.4c) and a higher collection of consumption tax revenues. However, lower employment of labour in the formal sector (L_t^F), accompanied by lower real wages (w_t^F) and real returns to capital ($r_{K,t}^F$) in the F sector (despite greater deployment of capital (K_t^F)), causes total tax revenues to decline (in panel 4.4d). A decline in the interest rate lowers the interest repayment burden, accompanied by lower public expenditure. Total expenditure decreases, debt issuance falls, and the debt-output ratio declines.

To assess the role of informality in fiscal consolidation, we increase the share of the population working exclusively in the informal sector or, equivalently,

[29] In an economy facing costs of price adjustments, inflation is affected by (i) expected future inflation, (ii) current real marginal cost, (iii) price rigidity and (iv) relative prices in the future (v) expected increase in future output. See equation (4.22).

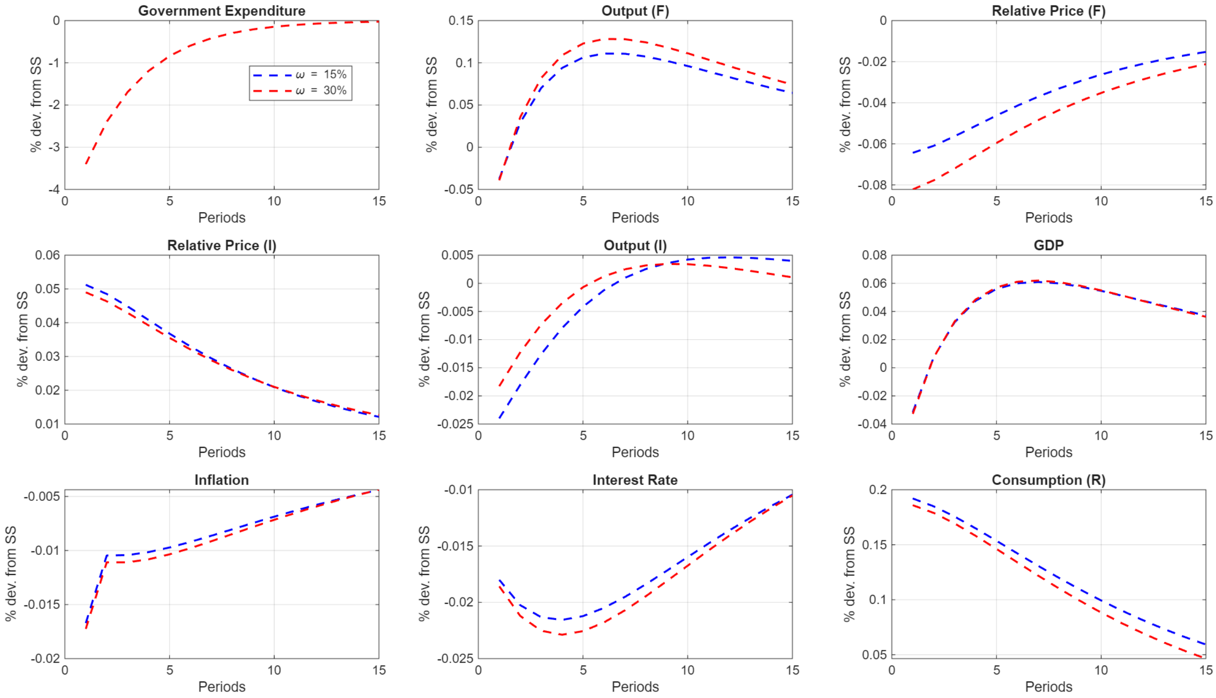
the share of financially constrained agents $\omega = 30\%$.[30] With a higher share of constrained households, a smaller share of the population can intertemporally optimise their decisions. As Ricardian households can cushion the effects of shocks by adjusting savings or reallocating consumption and savings/investment over time, the decline in demand for F sector after a negative government spending shock is larger. Labour supplied $L_{R,t}$ is similar at the time of shock, but declines by a lesser magnitude after the shock, while investment I_t^f and I_t^I increase by a greater magnitude.[31]. Thus, there is greater amount of capital used in production, leading to a greater decline in real marginal costs of production. Moreover, as sectoral output is expected to be more volatile, the incentive for firms to cut prices aggressively is higher. Thus, inflation in the F sector exhibits a greater decline in the presence of a greater share of H households.

Due to a larger decline in the relative price of the F good or equivalently, a greater increase in the relative price of the I good, the real wages do not rise as much in the I sector, leading to a larger increase in consumption by the H agents $C_{H,t}$. The decline in labour supply is subdued via the income effect.[32] This results in a larger increase in formal consumption C_t^F. With a smaller share of R agents, formal consumption rises by more, formal capital is more, and the decline in real wages and rental return on capital is more. This leads to a larger reduction in tax revenues. Accompanied by a smaller decrease in total expenditures, the decline in debt is greater with higher informality (ω). However, as the steady-state value of debt and GDP is lower, the percentage decline in the debt-GDP ratio is muted as depicted in Figure 4.4d.

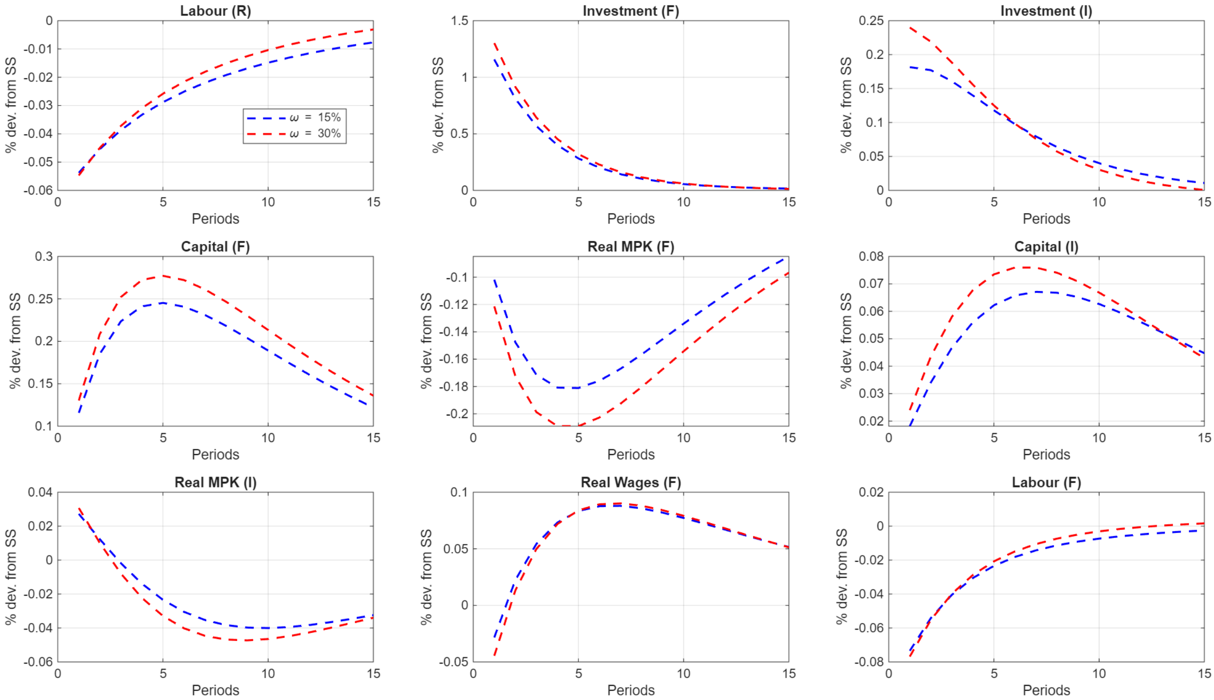
[30] Refer to the red-dashed line in Figures 4.4a-4.4d.

[31] The real marginal product of capital $r_{K,t}^F$ falls by more in F sector. In contrast, $r_{K,t}^I$ is similar. As the decline in the relative price of F good is more pronounced with a greater share of workers in the I sector, the expected price appreciation is higher. This raises investment in both sectors by more when $\omega = 30\%$

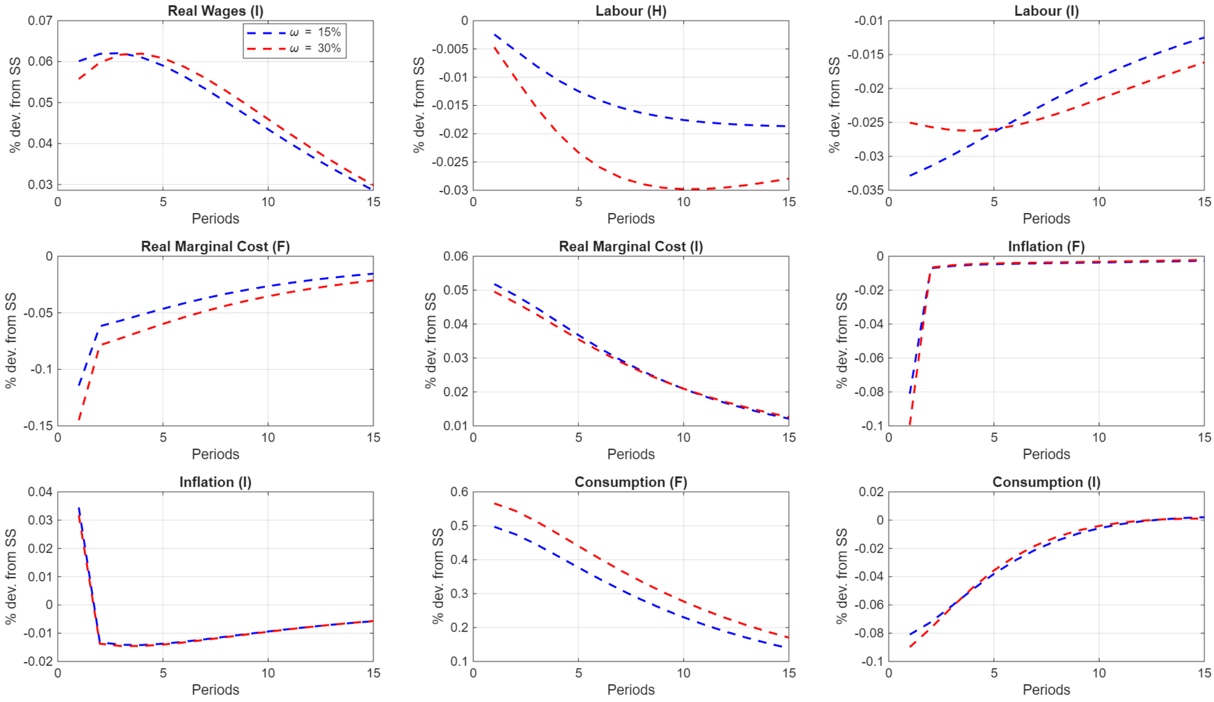
[32] This channel is supported by a smaller decrease in lump-sum taxes on account of a smaller reduction in debt-output ratio with $\omega = 30\%$.



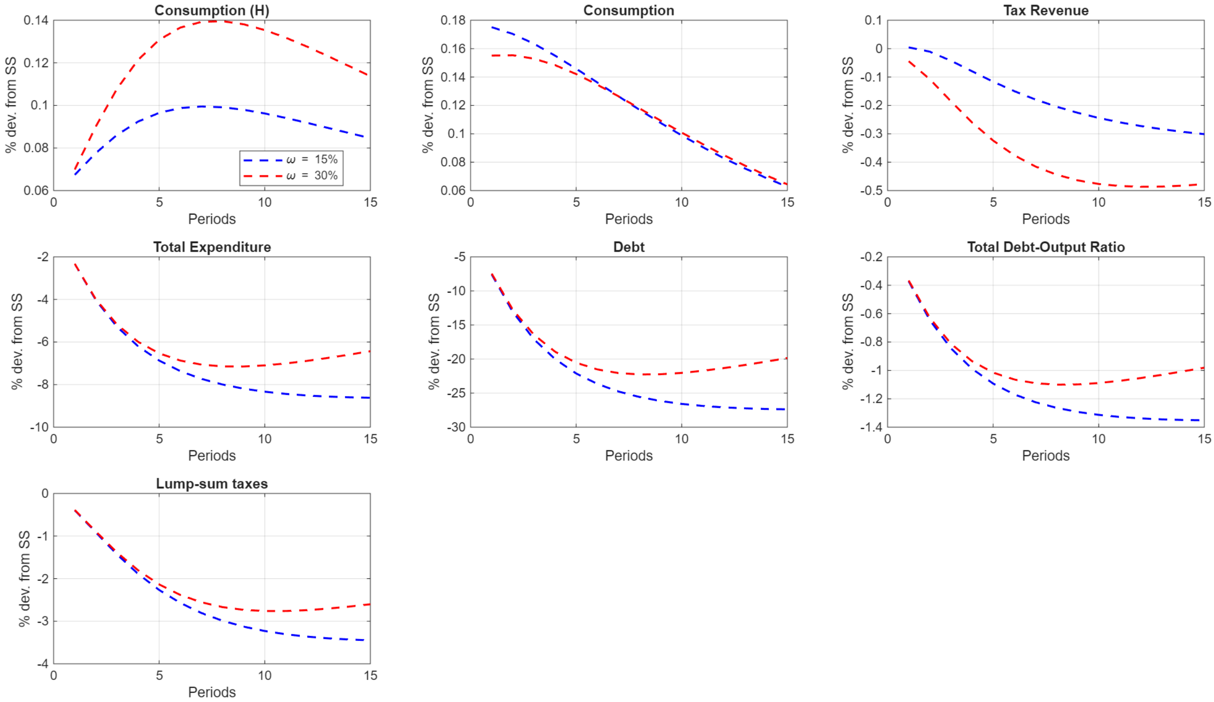
(a) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent



(b) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent



(c) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent



(d) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent

Figure 4.4: Impulse responses for a single period fiscal consolidation shock when there is no utility from public good

Thus, a fiscal consolidation crowds in private consumption and investment, but leads to a reduction in economic activity and employment in both sectors on impact. Output in the F sector recovers in the second period (owing to greater capital deployment) and expands thereafter. However, informal output recovers gradually. Aggregate GDP also declines on impact, but recovers in period 2 following the F sector output. A higher share of financially constrained agents (ω) leads to a stronger deflation in the formal sector, higher investment undertaken and formal sector output.

Private and Public Goods in Utility ($\gamma_C \neq 1$**)**

In the previous section, we saw that GDP declines in response to a reduction in G immediately after the shock. Adjustments to investment lead to the reversal of impact, and the economy overshoots the steady-state value before returning to the steady-state. Previous studies have provided evidence of 'expansionary fiscal contractions', i.e., a fiscal retrenchment leading to an increase in output growth in the short run (See Giavazzi & Pagano (1990), Dave et al. (2021) in the EME context). Dave et al. (2021) associates a positive impact of fiscal consolidation on aggregate output with 'perfect substitutability' between the public and private goods in consumption. In this section, we study whether the nature of public goods in utility (whether the public good enhances or reduces the benefits derived from private goods) can increase GDP at the time of the shock. The Impulse Response Analysis is reported in Figures 4.5a-4.5d.

Due to no reliable estimates for the elasticity of substitution between private and public goods[33] e in equation (4.1b), we vary the elasticity of substitution $e \in \{0.5, 2, 100\}$ and compare it with the benchmark scenario where public consumption provides no utility.[34] To be consistent with reality, we assume

[33]A recent paper by Dawood & Francois (2018) for 24 African countries finds private and public consumption to be Edgeworth substitutes. No such estimates are available for India.

[34]The red line represents a scenario where public and private goods are perfectly substitutable, magenta line represents the scenario where public and private goods are substitutable, blue line represents the scenario where the

private good is preferred over the public good and set $\gamma_C = 0.7$ in equation (4.1c) as in Colombo et al. (2024). The impulse response functions are presented in Figure 4.5.

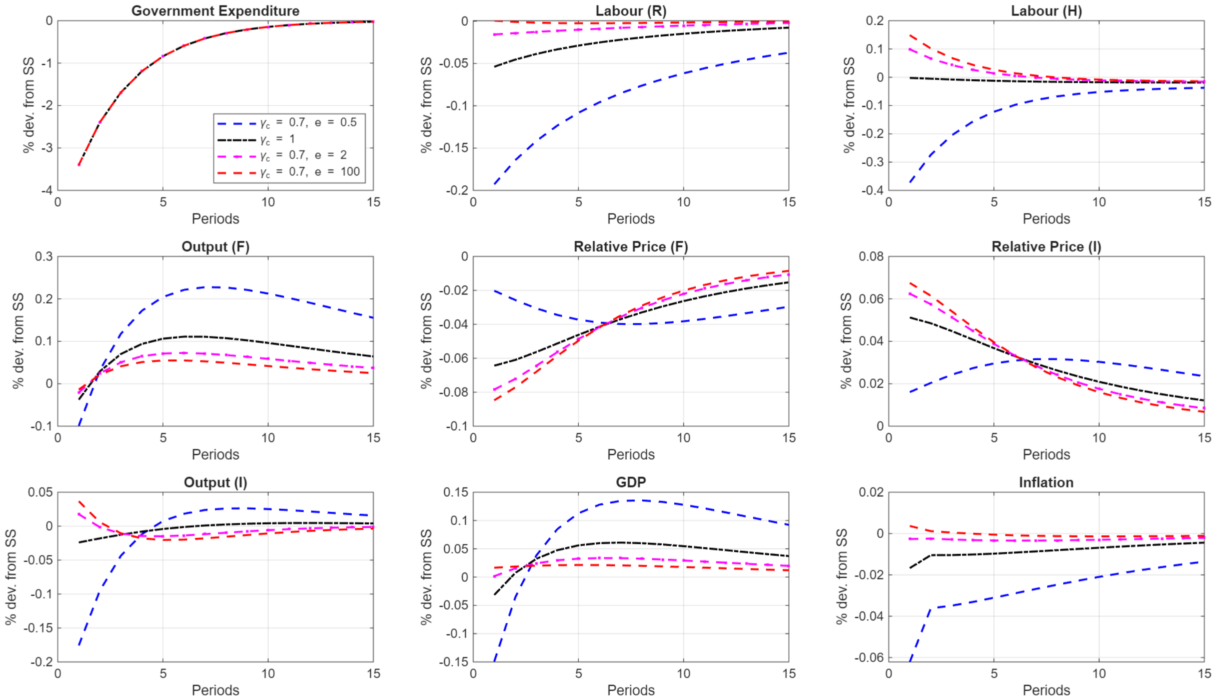
A reduction in government consumption entails a reduction in the provision of public goods. This leads to an increase in the marginal utility of total or effective consumption ($\widetilde{C}_{R,t}$) in equation (4.1a). The transmission of the fiscal consolidation depends on the substitutability between the two goods.

When private and public goods are complementary in consumption (blue line), households try to make up for this reduction in utility by raising leisure or reducing labour. As the public and private goods are consumed together by the assumption of complementarity, raising private consumption is not very rewarding. Labour supplied by both types of households ($L_{R,t}, L_{H,t}$) declines on impact, leading to a decline in sectoral outputs (Y_t^F and Y_t^I). As private goods are used in conjunction with public goods, there is a decline in demand for the goods, leading to a greater reduction in prices. In response to the deflationary shock, the monetary authority responds by lowering nominal interest rates. Ricardian agents respond by lowering labour supply and increasing consumption. As only R agents supply labour to the F sector, real wages in the F sector rise. A reduction in labour supplied by H households leads to an increase in the real wages in the I sector. Thus, the increase in real wages is greater for $e = 0.5$ than the benchmark case. As labour becomes expensive, more capital is deployed in the production process.

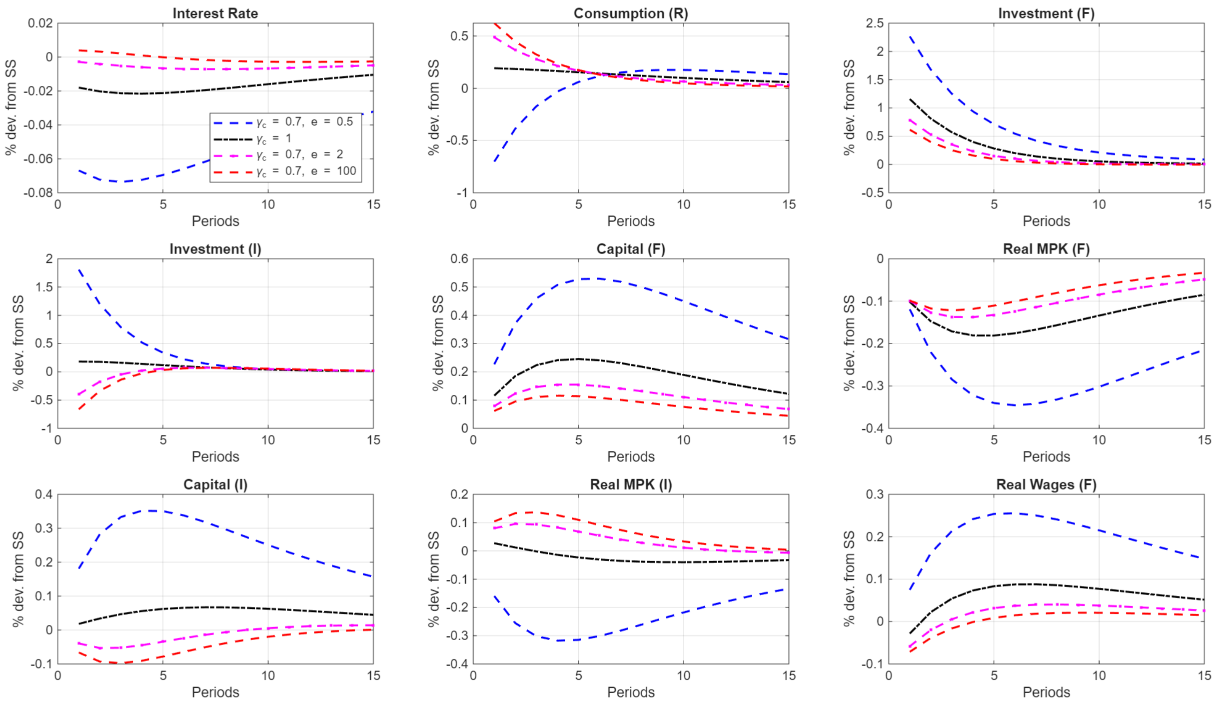
As the fiscal consolidation shock lowers inflation (is deflationary as steady state inflation is assumed to be zero), the real return on holding bonds declines.

two goods are complementary, and the black line represents no utility from the public good.

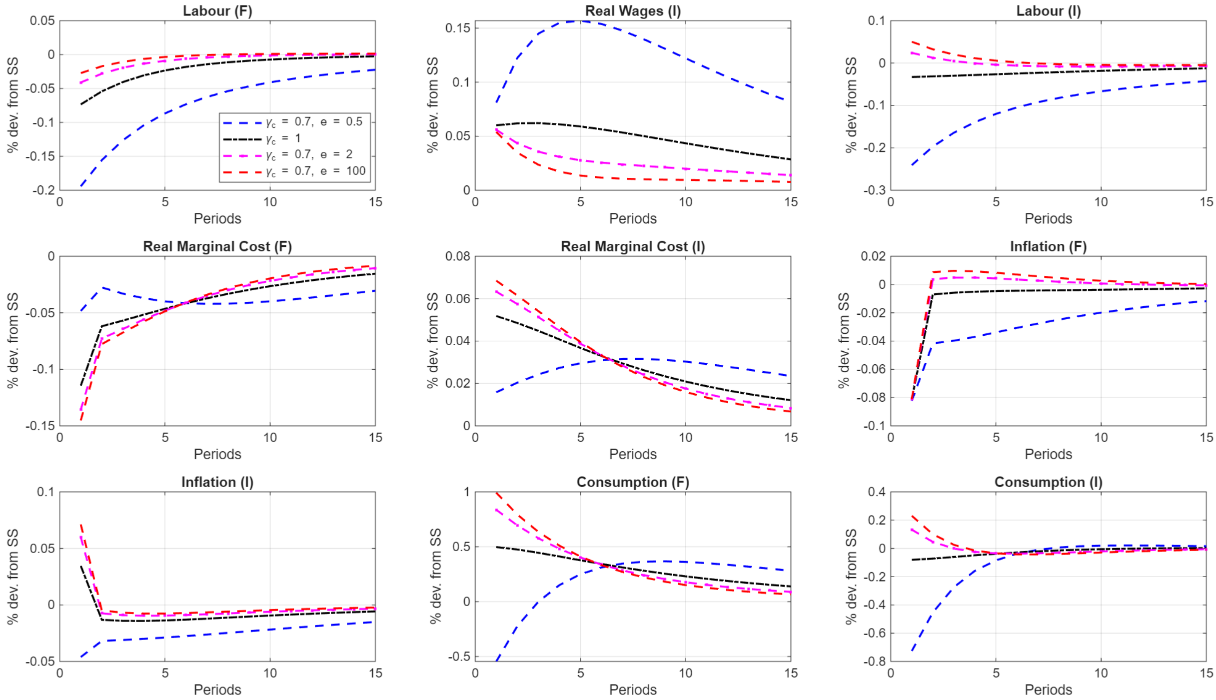
Therefore, to equalise the expected returns from different instruments, investment rises. Due to a sharper reduction in interest rates, capital employed increases by more than the benchmark case, and real marginal product of capital falls as in panel 4.5c. Higher real wages w_t^F, and a greater reduction in the real marginal product of capital $r_{K,t}^F$ lead to a muted decline marginal cost of production in the F sector, while smaller increase in real payments to capital outweigh the higher real wages in the I sector, leading to a subdued rise in real marginal cost of production in the I sector. Even though real marginal costs of production rise (for $e = 0.5$), and relative prices and sectoral demands are expected to stay muted, inflation falls in both sectors. This results in a reduction in private consumption of both agents that is spread across both goods. Thus, when public and private goods are used in conjunction (are complementary), the reduction in private consumption amplifies the impact of a reduction in G on effective consumption (See 4.5d). The R agents experience a greater reduction in effective consumption ($|\widetilde{C_{R,t}}| < |\widetilde{C_{P,t}}|$) when public and private goods are complementary in consumption.



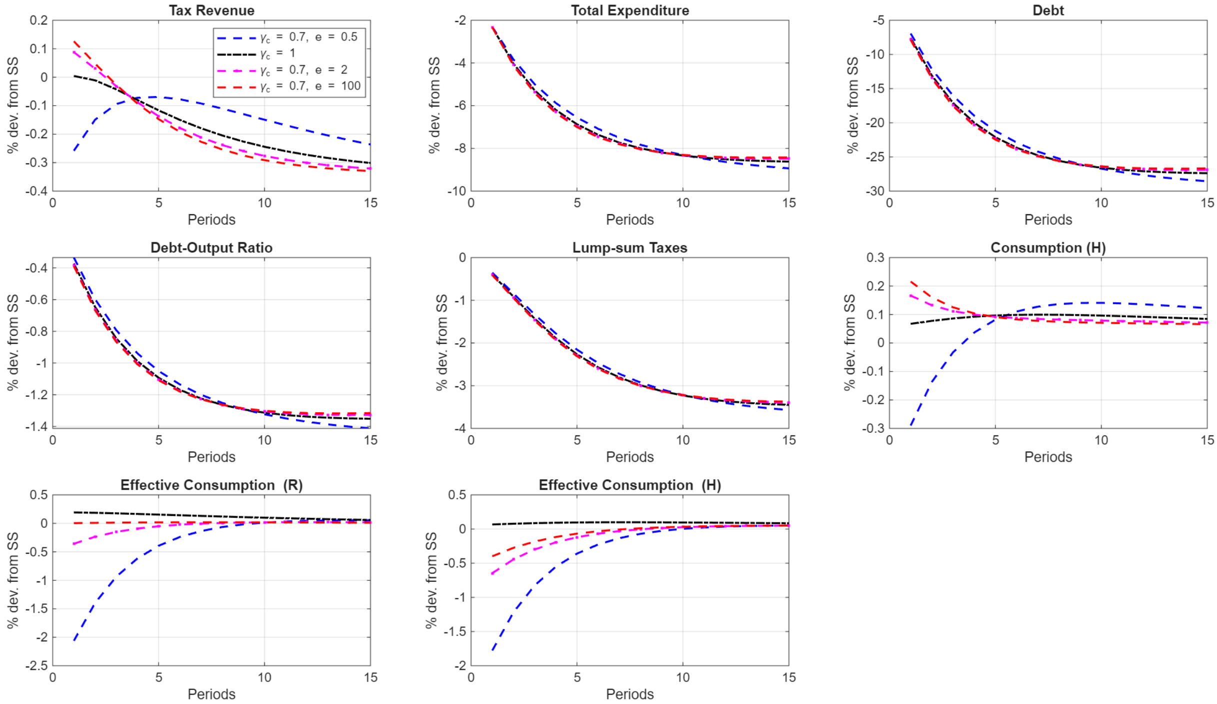
(a) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent



(b) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent



(c) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent



(d) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent

Figure 4.5: Impulse responses for a single period fiscal consolidation shock when there is no utility from public good-varying share of financially constrained agents ω

In contrast, the assumption of substitutability means that households can compensate for a reduction in public goods by consuming more privately. We have two scenarios representing imperfect and perfect substitutability in Figures 4.5a-4.5d - when $e = 2$ and $e = 100$, respectively. A reduction in the provision of public goods leads to a decline in effective consumption, resulting an increase in the marginal utility from consumption for both agents. But when public and private goods are substitutable, H agents respond by increasing labour supply. The labour supply of the R agents is determined through the interaction of income-effect, substitution effect and inter-temporal substitution effect.

As before, a reduction in fiscal consolidation leads to the I good becoming relatively expensive. With an increase in the labour supply by the H agents, who exclusively supply labour to the I sector, real wages w_t^I increase in the informal sector.[35] As labour is more abundantly available, the marginal productivity of capital $r_{K,t}^I$ increases, firms employ less capital in the informal sector4.5b. Informal output expands. Real marginal cost of production in the informal sector rises, leading to an increase in informal sector inflation.

The impact of higher informal sector inflation dominates the lower formal sector inflation, and aggregate inflation rises. This leads to an increase in the nominal interest rates by the monetary authority when $e = 100$. Real interest rates rise on impact. Thus, fiscal consolidation leads to higher income from holding debt, lower real wages in the formal sector, while higher (than steady-state) real wages in the informal sector induce reallocation of labour effort by R agents. Note that a greater supply of labour when public and private goods are substitutable results in a muted increase in wages relative to the benchmark case of no utility from G_t.

To increase the F sector output (Y_t^F), capital deployed in F sector (K_t^F) rises

[35]Note that the increase is muted as compared to the benchmark case with no utility from public good.

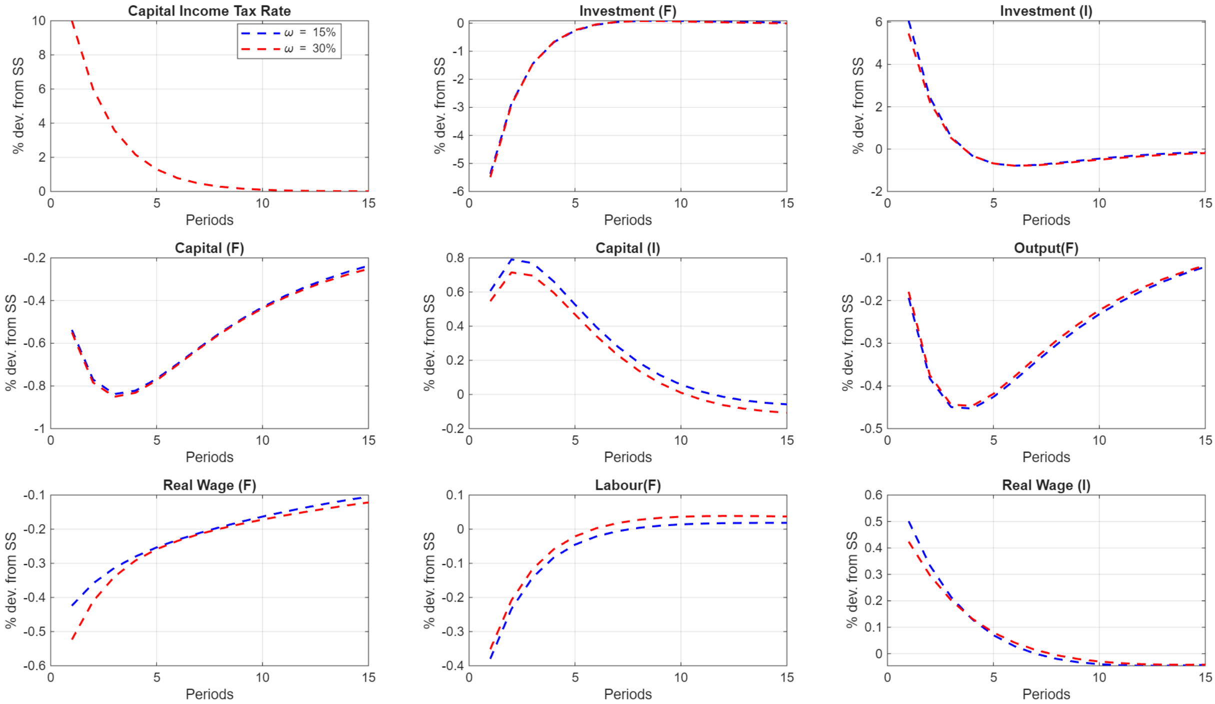
while capital deployed in I sector (K_t^I) falls leading to a decline in $r_{K,t}^F$ and an increase in $r_{K,t}^I$. Higher real incomes lead to higher consumption C_t^F, greater investment I_t^F, but lower labour supply L_t^F in the formal sector. Investment in the informal sector I_t^I declines to equate real returns across instruments. Higher private consumption and investment in the F sector are insufficient to compensate for a reduction in demand by the government. Formal sector output declines. Lower demand for labour suppresses tax collections from labour income, while higher private consumption of the formal good leads to higher tax revenues. The decline in the cost of capital is offset by a higher capital deployment in the formal sector. Total tax revenues rise when the private and public goods are substitutes, while total expenditure falls by a similar magnitude. Debt issuance declines. Aggregate GDP (see panel 4.5a) rises when the public and private goods are moderately or perfectly substitutable. However, the debt-to-output ratio falls. We find that the R agents can privately compensate for a reduction in the provision of public goods. However, effective consumption of financially constrained households declines as in panel 4.5d. With lower labour employment, capital deployment and consumption of the formal goods when goods are complementary ($e = 0.5$), tax revenues fall more on impact. As inflation has fallen more, the real value of interest payments rises, leading to higher total expenditures and debt.

Our findings partly corroborate those of Dave et al. (2021), especially in terms of expansionary fiscal consolidations being an outcome (an increase in aggregate GDP) only when private and public goods are perfect substitutes in utility. We observe this to be the case even when there is moderately high substitutability between public and private goods. However, key divergences emerge for debt-to-output ratios. They find that debt-to-output ratios increase after a fiscal consolidation, while we observe a decline. They have utility from government and private bonds, and model the economy as a small open economy with flexible prices. A decrease in public goods leads to households supplying more labour, which leads to higher disposable incomes and demand for government bonds, private bonds and investment. A greater demand for debt lowers yields, potentially enabling the government to issue more debt at lower cost. As the increase in output is smaller than the increase in debt, the debt-GDP ratio rises. In contrast, the debt-GDP ratio falls in our framework. The impulse response functions are expected to be stronger if utility from public good for agents $k \in \{R, H\}$ is modelled as $C_{k,t} = (C^F_{k,t} + \gamma_C G_t)$ in the case of substitutes and $C_{k,t} = (C^F_{k,t} G^\nu_t)$ for complementary case in the CES utility for formal and informal goods. This would capture the inter-sectoral dynamics of fiscal consolidation more strongly. We do not perform this exercise here because of the lack of comparability between the two cases.

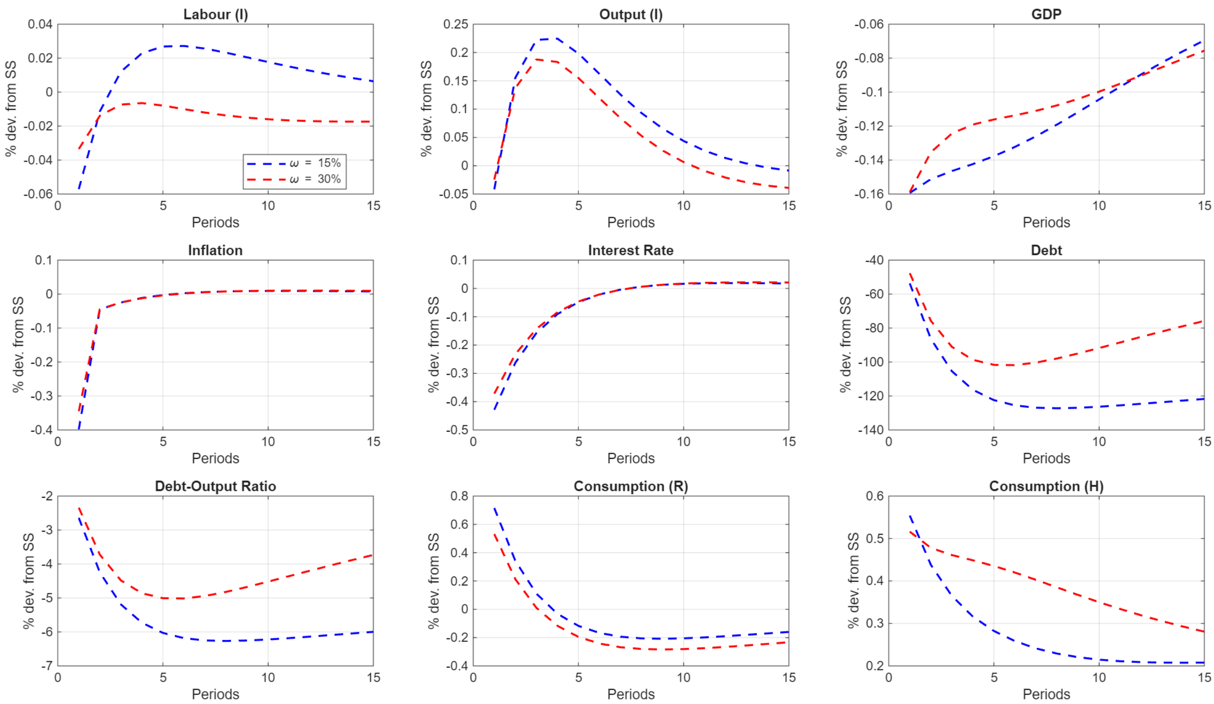
4.4.3 Tax-based Consolidations

We consider the case of a single-period increase in tax rate on returns to formal capital. As it lowers the return to capital, investment in the formal sector falls, while investment in the informal sector rises. As there is a reduction in demand for the F sector output due to a lower I^F_t, real wages decline to reduce employment in the F sector. As the fiscal consolidation shock is deflationary (See Figure 4.6b), real wages in the I sector rise, leading to lower employment of informal labour. Informal Output and aggregate GDP decline. Y^I_t recovers due to higher investment.[36] The monetary authority responds by lowering rates leading to lower expenditures on account of interest payments, lower government

[36] The presence of informal sector leads to higher investment. In a one-sector model, Blanchard & Perotti 2002 find that investment declines sharply when tax or government spending increases.



(a) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent



(b) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent

Figure 4.6: Impulse responses for a single period fiscal consolidation shock (τ_t^K) when there is no utility from public good-varying share of financially constrained agents ω

consumption (as it is proportional to GDP), but higher tax revenues. Thus, debt issuance and the debt-output ratios decline. The consumption of R agents increases due to the intertemporal substitution effect and lower lump-sum taxes, while H consumption rises because of higher real wages and lower lump-sum taxes. However, the increase is smaller for H agents

A higher share of H agents who can exclusively work in the I sector (red-dashed line with $\omega = 30\%$) leads to a greater reduction in w_t^F and smaller decline in L_t^I. The value of economic output falls by less due to a smaller impact on relative prices. Thus, debt and debt-output ratio also decline by less. Comparing Figure 4.4a and Figure 4.6b, we observe that tax-based consolidations are more costly in terms of reduction in output, but are more effective in lowering debt and debt-output ratios. This is in contrast to the evidence from Latin American and Caribbean countries in Carrière-Swallow et al. (2021).

The effectiveness of capital-tax-based fiscal consolidation in reducing public debt relies on the assumption that formal-sector agents do not engage in tax evasion. Relaxing this assumption would require incorporating two additional features into the model: (i) government enforcement mechanism as in Restrepo-Echavarria (2014), Alba & McKnight (2022), Aruoba (2021), Ferrara et al. (2025), Dellas et al. (2024) and (ii) households' endogenous evasion choices, as in Papp & Takáts (2024). As higher tax rates can increase the incentives for evasion, tax hikes may reduce revenues and undermine fiscal consolidation. Stronger enforcement, though costly for the government, lowers the likelihood of evasion in the present and future, having implications for current and future tax collections. Consequently, optimal tax rates and enforcement policies should be determined jointly, given their dynamic interaction. While the literature models evasion using a reduced-form 'shame' parameter that determines the share of the Ricardian households that evade (as in Papp & Takáts 2024, Kalra & Gupta

2025), it does not account for the dynamic effects on evasion choice. We wish to explore this in future work.

4.5 Extensions

We consider three extensions to the baseline model to enhance realism: (i) labour mobility across households for the Ricardian household, (ii) issuance of long-maturity debt by the government and (iii) government investment in public capital.

4.5.1 Partial Labour Mobility

Following M. Horvath (2000), Petrella & Santoro (2011), Petrella et al. (2019), Cantelmo & Melina (2023), Bouakez et al. (2025), we express disutility from supplying labour as a CES aggregate between sectors denoted as

$$L_{R,t} = \left(\alpha_N^{-\frac{1}{\varphi}} {L^I}_{R,t}^{\frac{1+\varphi}{\varphi}} + (1-\alpha_N)^{-\frac{1}{\varphi}} {L^F}_{R,t}^{\frac{1+\varphi}{\varphi}} \right)^{\frac{\varphi}{1+\varphi}}, \tag{4.41}$$

where $\varphi > 0$ represents the elasticity of substitution in labour supply and $\alpha_N \in (0,1)$ denotes the steady state employment share by the Ricardian agents. $\varphi \to 0$ represents immobile labour, while $\varphi < \infty$ represents partial or limited mobility of labour while $\varphi \to \infty$ represents perfect mobility of labour across sectors.[37] The impulse response analysis for a reduction in government spending with partial labour mobility of the Ricardian agents across sectors and no utility from public consumption is presented in Section C.3.1 of the Technical Appendix C. We find that a lower share of workers exclusively working in the

[37] The analysis assumes $\varphi = 0.5$ and $\varphi = 1.5$ for complementarity and substitutability between working in F and I sectors, respectively. To ensure identical parametrisation while ensuring a positive value of steady-state lump-sum taxes, we use the steady-state value of the BY ratio to 0.0493, $\alpha_N = 0.8, \chi^H = 1.5, \chi_R = 5$ and impose $\vartheta = 4 * 0.1268$. Increasing responsiveness of fiscal policy is necessary because monetary policy is mildly active ($\phi_\pi = 1.0514$), especially for $\Omega = 0.15$.

informal sector improves debt-reduction. Substitutability between inter-sectoral labour supply of the Ricardian agent induces Ricardian households to reallocate labour toward the informal sector in response to a reduction in government expenditure, raising their effective labour input and marginal product of capital. This stimulates informal investment, supporting output and income despite the contraction in government demand. The resulting improvement in fiscal revenues leads to a greater decline of the debt-to-output ratio, whereas under complementarity, weaker reallocation of labour leads to a smaller decline and faster reversion to the steady state. While a higher presence of exclusively formal workers lowers the effectiveness of fiscal consolidation measures in both the baseline and partial labour mobility case, reallocation toward untaxed production in the substitutability case reverses the gains from the reduction in G, due to the lowering of tax revenues due to reallocation of labour (tax base erosion).

4.5.2 Longer-maturity Bond Issuance

As debt issuance by governments is usually long-term, we extend the analysis by including long-term bonds. We introduce a *perpetual* bond with a declining coupon payment as in Woodford (2001).[38]

Let NB_t denote the units of government issuance of one dollar of long-term bond in period t. Each \$1 bill pays a coupon payment of \$1 in period $t+1$, κ in period $t+2$, κ^2 in period $t+3$, and so on, where $\kappa \in [0,1]$. Note that this includes the case of a single-period bond when $\kappa = 0$ and true consol/perpetuity when $\kappa = 1$.

Thus, total coupon payment liability for the government in period t (based on

[38]These have become an increasingly important instrument in the Central Banker's toolkit after the great financial crisis. Large-scale asset purchases by the Monetary Authority raise its prices and lower yield, thereby influencing the return on private debt instruments referenced to the long-term Treasury bills.

past issuances of long-term bonds) is:

$$B_{t-1}^{M} = NB_{t-1} + \kappa NB_{t-2} + \kappa^2 NB_{t-3} + ...$$

and in period $t+1$:

$$B_{t}^{M} = NB_{t} + \kappa NB_{t-1} + \kappa^2 NB_{t-2} + ...$$

.

Then the new issuance in period t satisfies,

$$NB_t = B_t^M - \kappa B_{t-1}^M$$

. Let Q_t denote the real price of a long-term bond of \$1. Then, as coupon payments are decaying at a fixed rate κ every period from period $t+1$ onwards, the price of the bond issued in period $t-j$ trades at the price $\kappa^j Q_t$ for $j \geq 0$ and the value of the long-term bond portfolio is given as:

$$Q_t B_t = Q_t.NB_t + Q_{t-1}NB_{t-1} + Q_{t-2}NB_{t-2} + Q_{t-3}NB_{t-3} + ... \quad (4.42)$$

$$= Q_t NB_t + \kappa Q_t NB_{t-1} + \kappa^2 Q_t NB_{t-2} + \kappa^3 Q_t NB_{t-3}... \quad (4.43)$$

This leads to the following modification of the Ricardian household's budget constraint:

$$(1+\tau_{C,t})\frac{P_t^F}{P_t}C_{R,t}^F + \frac{P_t^I}{P_t}C_{R,t}^I + \frac{P_t^F}{P_t}I_{R,t}^F + \frac{P_t^I}{P_t}I_{R,t}^I + \frac{B_{R,t}}{P_t} + Q_t\left(\frac{B_{R,t}^M}{P_t} - \kappa\frac{B_{R,t-1}^M}{P_{t-1}\Pi_t}\right)$$
$$\leq (1-\tau_{K,t}^F)r_{K,t}^F K_{R,t-1}^F + (1-\tau_{w,t}^F)\eta w_t^F L_{R,t}^F + (1-\eta)w_t^I L_{R,t}^I$$
$$+\frac{B_{R,t-1}R_{t-1}}{P_{t-1}\Pi_t} + \frac{B_{R,t-1}^M}{P_{t-1}\Pi_t} + r_{K,t}^I K_{R,t-1}^I + \Lambda_t^F + \Lambda_t^I - \Gamma_t$$
$$(4.44)$$

This leads to an additional first-order condition for long-term bonds as:

$$\lambda_t^R Q_t = \beta \mathbb{E}_t \left\{ \lambda_{t+1}^R \frac{(1+\kappa Q_{t+1})}{\Pi_{t+1}} \right\} \tag{4.45}$$

Assuming that one-period bonds are in zero net supply, then the GBC is modified as[39]:

$$\underbrace{Q_t \left(\frac{B_t^M}{P_t} - \kappa \frac{B_{t-1}^M}{P_{t-1}\Pi_t} \right)}_{\text{New issuance of bonds}} = G_t + \frac{B_{t-1}^M}{P_{t-1}\Pi_t} - \tau_w w_t^f L_t^F - \tau_c \frac{P_t^F}{P_t} C_t^F - \tau_k r_t^F (1-\omega) K_{t-1}^F - T_t$$

Introducing long-maturity bonds in our setup, with both bonds held by Ricardian agents, does not alter the effectiveness of fiscal consolidation. Incorporating EME features such as sovereign risk premia or asset market segmentation could generate additional valuation effects and materially alter the relative effectiveness of fiscal consolidation across maturity structures. We leave these extensions for future work.

4.5.3 Government investment in public capital

We introduce public investment as in Baxter & King (1993), Eric M. Leeper et al. (2010), and Alok Kumar (2023), by modelling public capital as a public good usable in both sectors costlessly, and constant returns in privately provided inputs, i.e., we assume production function to be modified as

$$Y_t^j = {K_{t-1}^G}^{\alpha_G^j} {K_{t-1}^j}^{\alpha^j} {L_t^j}^{1-\alpha^j},$$

where $K_t^G = (1-\delta_G)K_{t-1}^G + I_t^G$, where δ_G is the depreciation rate of public capital[40] and

$$I_{G,t} = \bar{I}_G^{\,1-\rho_{I_G}} I_{G,t-1}^{\rho_{I_G}} e^{-\varepsilon_{I_{G,t}}}. \tag{4.46}$$

[39]Market clearing ensures that the demand for long-term bonds equals the supply of long-term bonds issued by the government, i.e., $B_t^M = (1-\omega)B_{R,t}^M$.

[40]While Alok Kumar (2023) assumes identical depreciation and capital accumulation process for public capital and a separate investment spending rule for the government, Eric M. Leeper et al. (2010) introduces a time-to-build process to capture gestation lags in infrastructure development.

as in Sims & Wolff (2018).

The impulse responses are presented in the Technical Appendix C.3.2.[41]

Assuming that reducing government investment ($I_{G,t}$) lowers the demand for the formal sector, leading to a decline in the relative price of the formal good.[42] It reduces the stock of public capital available in the next period, lowering the marginal products of both sectors. As the effectiveness of public capital is lower in the informal sector, as estimated by Santanu Chatterjee et al. (2021), the impact on informal sector output is muted. A decline in the demand and the relative price of the F good lowers both real marginal product and real wages, resulting in lower F sector inflation. As real wages in the I sector rise and the value of real marginal product rises, I sector inflation rises. Aggregate inflation and output declines, leading to a lowering of interest rates by the monetary authority. This raises private investment in both sectors. Debt declines, as in the case of government consumption. A higher share of agents restricted to the informal sector lowers the effectiveness of fiscal consolidation. The reduction in the debt-GDP ratio in terms of deviation from the steady state (in percentage points) is much lower than a fiscal consolidation via reduction in public consumption in Figure 4.5c.

4.6 Conclusion and Way Forward

Fiscal consolidation is particularly hard to achieve in EMDEs due to the presence of large informal sectors and underdeveloped financial markets. We find that both

[41]We borrow the estimates of persistence parameter of the government investment process from Alok Kumar (2023) and fix $\rho_{I_G} = 0.804$, while fixing the standard error of the shock to equal the standard error of public consumption shock. This allows comparison in the effectiveness of fiscal consolidation for two types of public expenditures.

[42]Allowing government investment to comprise both formal and informal inputs would attenuate the relative price effects.

tax-based and spending-based consolidations are contractionary. The presence of a larger informal sector lowers the effectiveness of fiscal consolidation measures. Although increasing proportional taxes is more effective in reducing public debt, it induces a reallocation of capital and investment toward the less productive informal sector. Higher taxes on the formal sector raise production costs, discouraging formal activity and shifting output to the informal economy as observed for Greece in Dellas et al. 2024. Conversely, reducing government spending on formal goods tends to boost private consumption and investment in both sectors. These effects are particularly pronounced when government consumption complements private consumption. In contrast to Carrière-Swallow et al. (2021), our findings indicate that tax-based consolidations are more effective in lowering the debt-to-output ratio, albeit at the cost of a sharper contraction in economic activity. This result partly reflects the assumption of full tax compliance underlying the capital-tax-based consolidation exercise. Allowing for endogenous tax evasion and enforcement decisions could alter revenue dynamics and, therefore, the effectiveness of tax-based adjustment, and constitutes an important avenue for future research.

A reduction in government leads to a smaller reduction in debt-GDP ratio than a fiscal consolidation shock that lowers government consumption. As observed in the literature (Stähler & Thomas 2012; Anand & P. Khera 2016; Alok Kumar 2023), such consolidations have higher output costs.

We observe that consolidation measures exacerbate inequality, highlighting the distributional consequences of fiscal policy in economies with substantial informality. This effect is observed for both tax and spending-based consolidations when there is substitutability between public and private goods. Similar to Dave et al. (2021), we find evidence of *expansionary fiscal contractions*, even under moderately high levels of substitutability between public and private goods. However, these output effects remain small even when public and private consumption are assumed to be perfectly substitutable. Since sovereign debt typically consists of longer-duration instruments, we incorporate multi-period bond issuance into the model and find that lengthening of the bond maturity alone is insufficient to generate differences in the mechanism. The analysis can be extended to include features such as sovereign risk premia that may be relevant for EMEs with high external debt. Additional insights may also be obtained by modelling evasion as a function of enforcement. Future research could broaden the scope of analysis by incorporating the declining share of expenditure on informal goods—an empirical pattern documented by Bachas et al. (2024) through *Informality Engel Curves*. Such an extension would be particularly relevant for assessing the long-run effects of fiscal consolidation.

Appendix A

Appendix: Chapter 2

A.1 Technical Appendix

A.1.1 The Model

The model economy is populated by two types of agents ricardian (represented by subscript R) and rule of thumb or poor agents (represented by subscript P).

Rich Agent Optimisation

The optimisation problem is solved in two stages. In the first stage, rich agents maximize consumption index to determine optimal choices of the sectoral goods (intratemporal optimisation) and different varieties, while in the second stage, it determines the optimal level of total consumption, labour and asset holdings (inter-temporal optimisation). Solving backwards, the second stage problem of the Ricardian agent is represented by the following Lagrangian:

$$\mathcal{L}^{\mathcal{R}} = E_0 \sum_{t=0}^{\infty} \beta^t \Bigg\{ \left[\frac{C_{R,t}^{1-\sigma_R}}{1-\sigma_R} - \frac{N_{R,t}^{1+\varphi}}{1+\varphi} \right] - \Upsilon_t \left[P_t C_{R,t} + E_t\{Q_{t+1} B_{t+1}\} - B_t - W_t N_{R,t} - T_{R,t} - Div_t \right] \Bigg\}. \tag{A.1}$$

The first order conditions for $C_{R,t}$, $N_{R,t}$, and B_{t+1} are given by:

$$\frac{\partial \mathcal{L}^{\mathcal{R}}}{\partial C_{R,t}} = C_{R,t}^{-\sigma_R} - \Upsilon_t P_t = 0, \tag{A.2}$$

$$\frac{\partial \mathcal{L}^{\mathcal{R}}}{\partial N_{R,t}} = -N_{R,t}^{\psi} + \Upsilon W_t = 0, \tag{A.3}$$

$$\frac{\partial \mathcal{L}^{\mathcal{R}}}{\partial B_{t+1}} = -\beta^t \Upsilon_t E_t\{Q_{t,t+1}\} + \beta^{t+1} E_t\{\Upsilon_{t+1}\} = 0. \tag{A.4}$$

where Υt is the Lagrange multiplier. Dividing equation A.3 by A.2 gives the labour supply equation (2.16), while using $\frac{1}{E_t\{Q_{t+1}\}} = R_t$, in A.4 yields equation (2.15).

The first stage optimization problem for the Ricardian agents is: maximize equation (2.4) for a given level of expenditure, X_t subject to the period budget constraint.

$$\max_{\{C_{R,A,t}, C_{R,M,t}\}} \frac{(C_{R,A,t})^{\delta_R} (C_{R,M,t})^{1-\delta_R}}{\delta_R^{\delta_R} (1-\delta_R)^{1-\delta_R}} \quad \text{subject to} \tag{A.5}$$

$$P_{A,t} C_{R,A,t} + P_{M,t} C_{R,M,t} = X_t. \tag{A.6}$$

This yields equations (2.9) and (2.10)

$$C_{R,A,t} = \delta_R \left(\frac{P_{A,t}}{P_t} \right)^{-1} C_{R,t} l,$$

$$C_{R,M,t} = (1-\delta_R)\left(\frac{P_{M,t}}{P_t}\right)^{-1} C_{R,t},$$

where the aggregate price level is given by $P_t = P_{A,t}^{\delta_R} P_{M,t}^{1-\delta_R}$.

Poor Agent Optimization

The poor agents receive a part of their agricultural consumption for free. Therefore, their expenditure only depends on their open-market purchases ($P_{A,t}C^O_{P,A,t} + P_{M,t}C_{P,M,t}$). As a fraction of consumption is subsidized, ($C^O_{P,A,t} = (1-\lambda_t)C_{P,A,t}$), the budget constraint for the poor becomes:

$$P_t^{'} C_{P,t} = W_t N_{P,t}.$$

As the poor agents cannot smooth consumption over time, their second-stage decision reduces to a static problem:

$$\max_{\{C_{P,t},N_{P,t}\}} \frac{C_{P,t}^{1-\sigma_P}}{1-\sigma_P} - \frac{N_{P,t}^{1+\varphi}}{1+\varphi}$$

subject to: $P_t^{'} C_{P,t} = W_t N_{P,t}$ leading to the following Lagrangian

$$\mathcal{L}^{\mathcal{P}} = \frac{C_{P,t}^{1-\sigma_P}}{1-\sigma_P} - \frac{N_{P,t}^{1+\varphi}}{1+\varphi} - \mu_t \left[P_t^{'} C_{P,t} - W_t N_{P,t}\right]$$

where μ_t is the Lagrange multiplier.

The first order conditions yield:

$$\frac{\partial \mathcal{L}^{\mathcal{P}}}{\partial C_{P,t}} = C_{P,t}^{-\sigma_P} - \mu_t P_t' = 0, \tag{A.7}$$

$$\frac{\partial \mathcal{L}^{\mathcal{P}}}{\partial N_{P,t}} = -N_{P,t}^{\psi} + \mu_t W_t = 0. \tag{A.8}$$

Dividing equation A.8 by equation A.7 yields the labour supply equation (2.17).

The sectoral demand for goods is determined by solving:

$$\max_{\{C_{P,A,t},C_{P,M,t}\}} \frac{(C_{P,A,t})^{\delta_P}(C_{P,M,t})^{1-\delta_P}}{\delta_P^{\delta_P}(1-\delta_P)^{1-\delta_P}} \quad \text{subject to} \tag{A.9}$$

$$(1-\lambda_t)P_{A,t}C_{P,A,t} + P_{M,t}C_{P,M,t} = X_t. \tag{A.10}$$

This yields equations (2.11) and (2.12)

$$C_{P,A,t} = \delta_P \left(\frac{P'_{A,t}}{P'_t}\right)^{-1} C_{P,t},$$

$$C_{P,M,t} = (1-\delta_P)\left(\frac{P_{M,t}}{P'_t}\right)^{-1} C_{P,t},$$

where the price index for the poor is given by: $P'_t = \{(1-\lambda_t)P_{A,t}\}^{\delta_P} P_{M,t}^{1-\delta_P}$.

The demand for every variety of the M sector good by agent $k \in \{R, P\}$ is given by maximizing

$$C_{k,M,t} = \left(\int_0^1 C_{k,M,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right)^{\frac{\varepsilon}{\varepsilon-1}}, \varepsilon > 1.$$

subject to $\int_0^1 P_{M,t}(j)C_{k,M,t}(j)dj = X_t$ leading to the following Lagrangian

$$\mathcal{L}^{Mk} = \left(\int_0^1 C_{k,M,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right)^{\frac{\varepsilon}{\varepsilon-1}} - \nu_t \left[\int_0^1 P_{M,t}(j)C_{k,M,t}(j)dj - X_t.\right]$$

where ν_t is the Lagrange multiplier.

The first-order condition is given by:

$$C_{k,M,t}^{\frac{1}{\varepsilon}} C_{k,M,t}(j)^{-\frac{1}{\varepsilon}} = \nu_t P_{M,t}(j),$$

resulting in the demand for j^{th} variety of the M good as

$$C_{k,M,t}(j) = \left(\frac{P_{M,t}(j)}{P_{M,t}}\right)^{-\varepsilon} C_{k,M,t}.$$

Substituting $C_{k,M,t}$ in the expenditure constraint yields,

$$\int_0^1 P_{M,t}(j).\left(\frac{P_{M,t}(j)}{P_{M,t}}\right)^{-\varepsilon} C_{k,M,t}dj = P_{M,t}C_{k,M,t}. \tag{A.11}$$

Dividing by $C_{k,M,t}$ and rearranging, the price index in the manufacturing sector is given by:

$$P_{M,t} = \left[\int_0^1 P_{M,t}(j)^{1-\varepsilon}dj\right]^{\frac{1}{1-\varepsilon}} \tag{A.12}$$

Firm Optimization

There are two sectors in our model. Firms in the agricultural sector produce homogeneous goods and have flexible prices.

Agriculture Sector

The representative firm in the agriculture choose employment by maximizing profits each period:

$$\max_{N_{A,t}} \Pi_t = P_{A,t}Y_{A,t} - W_tN_{A,t}$$

subject to the production technology

$$Y_{A,t} = A_{A,t}N_{A,t}. \tag{A.13}$$

where $A_{A,t}$ follows an AR(1) process.

Substituting the production function into the profit function, the problem can be written as

$$\max_{N_{A,t}} \Pi_t = P_{A,t}A_{A,t}N_{A,t} - W_tN_{A,t}. \tag{A.14}$$

The first-order condition is

$$P_{A,t}A_{A,t} = W_t. \tag{A.15}$$

Describing sectoral real wage in terms of economy-wide real wages by dividing with aggregate price index in the economy as

$$\frac{W_t}{P_t} = \frac{P_{A,t}}{P_t}A_{A,t}.$$

Defining terms of trade as $T_t = \frac{P_{A,t}}{P_{M,t}}$, we get:

$$\frac{W_t}{P_t} = A_{A,t}T_t^{1-\delta_R}.$$

Manufacturing Sector

The manufacturing sector consists of a continuum of firms $j \in [0, 1]$. This is standard as in Chapter 3 in Gali 2015.

The optimization problem for firm j is given by

$$\max_{P_{M,t}(j)} E_t \sum_{k=0}^{\infty} \theta^k \Lambda_{t,t+k} \left[P_{M,t}(j) Y_{M,t+k|t}(j) - MC_{M,t+k} Y_{M,t+k|t}(j) \right] \tag{A.16}$$

where $MC_{M,t+k}$ denotes the (nominal) marginal cost in period $t + k$, subject to the demand constraint

$$Y_{M,t+k|t}(j) = \left(\frac{P_{M,t}(j)}{P_{M,t+k}} \right)^{-\epsilon} Y_{M,t+k} \tag{A.17}$$

is the demand facing a firm in period $t + k$ that last reset its price in period t.

The first order condition is given by:

$$E_t \sum_{k=0}^{\infty} \theta^k \Lambda_{t,t+k} \Bigg[Y_{M,t+k|t}(j) + P_{M,t}(j) \frac{\partial Y_{M,t+k|t}(j)}{\partial P_{M,t}(j)} \\ - MC_{M,t+k} \frac{\partial Y_{M,t+k|t}(j)}{\partial P_{M,t}(j)} \Bigg] = 0 \tag{A.18}$$

Simplifying $\frac{\partial Y_{M,t+k|t}(j)}{\partial P_{M,t}(j)}$, we get

$$\frac{\partial Y_{M,t+k|t}(j)}{\partial P_{M,t}(j)} = -\epsilon \left(\frac{P_{M,t}(j)}{P_{M,t+k}} \right)^{-\epsilon} \frac{1}{P_{M,t}(j)} Y_{M,t+k} \tag{A.19}$$

$$= -\epsilon \frac{Y_{M,t+k|t}(j)}{P_{M,t}(j)}. \tag{A.20}$$

Simplifying, we get

$$E_t \sum_{k=0}^{\infty} \theta^k \Lambda_{t,t+k} \left[Y_{M,t+k|t}(j) - \epsilon Y_{M,t+k|t}(j) + \epsilon MC_{M,t+k} \frac{Y_{M,t+k|t}(j)}{P^*_{M,t}(j)} \right] = 0. \tag{A.21}$$

$$P^*_{M,t}(j)\, E_t \sum_{k=0}^{\infty} \theta^k \Lambda_{t,t+k} (1-\epsilon)\, Y_{M,t+k|t}(j) = -E_t \sum_{k=0}^{\infty} (\beta\theta)^k \epsilon\, MC_{M,t+k} Y_{M,t+k|t}(j). \tag{A.22}$$

As all forms resetting the price in period t face an identical problem, dropping (j):

$$P^*_{M,t} = \frac{\epsilon}{\epsilon - 1} \frac{E_t \sum_{k=0}^{\infty} \theta^k \Lambda_{t,t+k} Y_{M,t+k}\, MC_{M,t+k}}{E_t \sum_{k=0}^{\infty} \theta^k \Lambda_{t,t+k} Y_{M,t+k}}. \tag{A.23}$$

As in standard Calvo price setting, a fraction $1 - \theta$ of firms reset prices optimally in period t, while a fraction θ keep their previous prices. Rewriting the price index in equation (A.12) in terms of optimal reset price, we get

$$P_{M,t}^{1-\varepsilon} = \int_0^1 P_{M,t}(j)^{1-\varepsilon}\,dj = (1-\theta)\left(P_{M,t}^{*}\right)^{1-\varepsilon} + \theta \int_0^1 P_{M,t-1}(j)^{1-\varepsilon}\,dj. \quad \text{(A.24)}$$

$$P_{M,t} = \left[(1-\theta)\left(P_{M,t}^{*}\right)^{1-\varepsilon} + \theta\left(P_{M,t-1}\right)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}. \quad \text{(A.25)}$$

Market Clearing

Total value of consumption (at market prices)in equation (2.32)**:**

Aggregate consumption is derived by aggregating sectoral consumption for each agent type and then taking a population-weighted average of agent-specific consumption levels.

Total consumption expenditure can be written as

$$P_tC_t = \mu_R\left[P_{A,t}C_{R,A,t} + P_{M,t}C_{R,M,t}\right] + (1-\mu_R)\left[P_{A,t}C_{P,A,t} + P_{M,t}C_{P,M,t}\right]. \quad \text{(A.26)}$$

Substituting the optimal sectoral consumption choices,

$$P_tC_t = \mu_R\left[P_{A,t}\delta_R\frac{P_t}{P_{A,t}}C_{R,t} + P_{M,t}(1-\delta_R)\frac{P_t}{P_{M,t}}C_{R,t}\right] + (1-\mu_R)\left[P_{A,t}\left(\delta_P\frac{P_t'}{P_{A,t}}C_{P,t} + C_{P,A,t}^{s}\right) + P_{M,t}(1-\delta_P)\frac{P_t'}{P_{M,t}}C_{P,t}\right]. \quad \text{(A.27)}$$

Simplifying,

$$P_tC_t = \mu_R P_tC_{R,t} + (1-\mu_R)\left[P_t'C_{P,t} + P_{A,t}C_{P,A,t}^{s}\right]. \quad \text{(A.28)}$$

Note that the relative price index satisfies

$$\frac{P_t'}{P_t} = (1-\lambda_t)^{\delta_P} \frac{P_{A,t}^{\delta_P} P_{M,t}^{1-\delta_P}}{P_{A,t}^{\delta_R} P_{M,t}^{1-\delta_R}} = (1-\lambda_t)^{\delta_P} T_t^{\delta_P-\delta_R}, \tag{A.29}$$

where $T_t \equiv P_{A,t}/P_{M,t}$.

Using this expression, total consumption expenditure can be written as

$$P_t C_t = \mu_R P_t C_{R,t} + (1-\mu_R)(1-\lambda_t)^{\delta_P} T_t^{\delta_P-\delta_R} P_t C_{P,t} + \phi_t Y_{A,t}^p P_{A,t}. \tag{A.30}$$

Dividing through by P_t, aggregate consumption is given by

$$C_t = \mu_R C_{R,t} + (1-\mu_R)(1-\lambda_t)^{\delta_P} T_t^{\delta_P-\delta_R} C_{P,t} + \phi_t Y_{A,t}^p \frac{P_{A,t}}{P_t}. \tag{A.31}$$

Using $P_{A,t}/P_t = T_t^{1-\delta_R}$, we obtain

$$C_t = \mu_R C_{R,t} + (1-\mu_R)(1-\lambda_t)^{\delta_P} T_t^{\delta_P-\delta_R} C_{P,t} + T_t^{1-\delta_R} \phi_t Y_{A,t}^p \tag{A.32}$$

To get an expression in terms of the redistribution share, express the total amount of agricultural output redistributed in terms of the subsidised output consumed by all poor agents.

Then,

$$\phi_t Y_{A,t}^P = (1-\mu_R)\lambda_t C_{A,t}^P \tag{A.33}$$

$$= (1-\mu_R)\lambda_t \delta_P (1-\lambda_t)^{\delta_P-1} T_t^{\delta_P-1} C_{P,t}. \tag{A.34}$$

Combining the previous two equations (A.32) and (A.34), we get

$$C_t = \mu_R C_{R,t} + (1-\mu_R) C_{P,t} \left(1-\lambda_t\right)^{-(1-\delta_p)} T_t^{\delta_p-\delta_R} \left(1-\lambda_t(1-\delta_p)\right)$$

Total value of output in equation (2.35)

This is computed by combining the aggregate consumption with the value of agricultural output not redistributed as in:

$$Y_t = C_t + \left(\frac{P^{A,t}}{P_t}\right)(1-\phi_t)Y^P_{A,t}$$

Replacing $\frac{P^{A,t}}{P_t} = T_t^{1-\delta_R}$, we get

$$Y_t = C_t + T_t^{1-\delta_R}Y^P_{A,t}(1-\phi_t).$$

The aggregate output in terms of sectoral output is given by:

$$Y_t = \left(\frac{P^{A,t}}{P_t}\right)Y_{A,t} + \left(\frac{P^{M,t}}{P_t}\right)Y_{M,t}.$$

and replacing $\frac{P^{A,t}}{P_t} = T_t^{1-\delta_R}$ and $\frac{P^{M,t}}{P_t} = T_t^{-\delta_R}$ we get the desired expression.

A.1.2 Steady State

We drop subscripts from variables to denote their steady state counterparts. Let X denote the steady-state value of the variable X_t, with the time subscript t omitted to indicate its constancy over time. X_t. We assume no trend growth in productivity, $A_s = 1$ for $s = A, M$. Since $A_M = A_A = 1$, nominal marginal costs are given by: $MC_M = MC_A = W$. Given that the agricultural sector is characterized by perfect competition and flexible prices, price equals nominal marginal cost, so $P_A = W$, while in the manufacturing sector the price is a markup over nominal marginal cost $P_M = \frac{\varepsilon}{\varepsilon-1}W$. Therefore, the steady state term of trade is $T = \frac{P_A}{P_M} = \frac{\varepsilon-1}{\varepsilon}$. With the employment subsidy in the manufacturing sector in place,

$$T = 1.$$

Define the steady state consumption share of the rich, s_R, as

$$s_R = \frac{\mu_R C_R}{C} \tag{A.35}$$

Then using equation (2.32),

$$\begin{aligned} C &= \mu_R C_R + (1-\mu_R)(1-\lambda)^{-(1-\delta_P)} C_P \left(1 - \lambda(1-\delta_P)\right) \\ 1 &= \frac{\mu_R C_R}{C} + \frac{(1-\mu_R)(1-\lambda)^{-(1-\delta_P)} C_P \left(1 - \lambda(1-\delta_P)\right)}{C}. \end{aligned}$$

we get the steady state consumption share of the poor as

$$1 - s_R = \frac{(1-\mu_R) C_P (1-\lambda)^{-(1-\delta_P)} (1 - \lambda(1-\delta_P))}{C}. \tag{A.36}$$

We define the steady state employment share of the rich, N_R

$$N_R = \mu_R N \tag{A.37}$$

and the employment share of the poor as N_P

$$N_P = (1-\mu_R) N. \tag{A.38}$$

From the FOCs for the rich and poor (equations (2.16) and (2.17)) the steady state condition is

$$\frac{N_R^{\varphi}}{C_R^{-\sigma_R}} = \frac{N_P^{\varphi}}{C_P^{-\sigma_P}} . \frac{P'}{P}$$

where $\frac{P'}{P} = (1-\lambda)^{\delta_P} T^{\delta_P - \delta_R} = (1-\lambda)^{\delta_P}$ (since $T = 1$). Since $N_R = \mu_R N$ and $N_P = (1-\mu_R)N$, we have

$$\begin{aligned}
\mu_R^{\varphi} C_R^{\sigma_R} &= (1-\mu_R)^{\varphi} C_P^{\sigma_P} (1-\lambda)^{\delta_P} \\
\mu_R^{\varphi} \left(\frac{s_R}{\mu_R} C\right)^{\sigma_R} &= (1-\mu_R)^{\varphi} \left[\frac{(1-s_R)}{(1-\mu_R)(1-\lambda)^{-(1-\delta_P)}(1-\lambda(1-\delta_P))} C\right]^{\sigma_P} (1-\lambda)^{\delta_P} \\
C^{\sigma_R - \sigma_P} &= \frac{(1-\mu_R)^{\varphi - \sigma_P}}{\mu_R^{\varphi - \sigma_R}} \frac{(1-s_R)^{\sigma_P}}{s_R^{\sigma_R}} \frac{(1-\lambda)^{\delta_P + \sigma_P(1-\delta_P)}}{(1-\lambda(1-\delta_P))^{\sigma_P}} \\
&= \Gamma
\end{aligned}$$

The steady state aggregate consumption is therefore,

$$C = \Gamma^{\frac{1}{\sigma_R - \sigma_P}} \tag{A.39}$$

where Γ is a constant. Once we know the expression for C, equations (A.35) and (A.36) yield C_R and C_P, respectively. From the market-clearing condition (equation (2.34), the production function for manufacturing, and the optimal demand (equation (2.23) for manufacturing goods, we have

$$N_M = Y_M = C_M = (1-\bar{\delta})C = (1-\bar{\delta})\Gamma^{\frac{1}{\sigma_R - \sigma_P}}.$$

where $\bar{\delta} = s_R \delta_R + \frac{(1-s_R)\delta_P}{1-\lambda(1-\delta_P)}$.

Using optimal consumption demand for the agricultural good from equation (2.22), we have $C_A = \bar{\delta} C$

Denoting μ_A as the steady state employment share in agricultural sector, then, using $N_M = (1-\mu_A)N$, we can write aggregate employment, N, as

$$N = \frac{N_M}{1-\mu_A} = \frac{1-\bar{\delta}}{1-\mu_A} C. \tag{A.40}$$

And using $N_A = \mu_A N$ and the market clearing condition for the agriculture sector (equation (2.29)),

$$N = \frac{N_A}{\mu_A} = \frac{Y_A}{\mu_A} = \frac{1}{\mu_A}\left[\bar{\delta}C + Y_A^P(1-\phi)\right]. \tag{A.41}$$

Equating (A.40) and (A.41), we obtain

$$Y_A^P = \frac{C}{1-\phi}\left[\frac{\mu_A - \bar{\delta}}{1-\mu_A}.\right]$$

This is the steady state level of agricultural output procured. For $Y_A^P > 0$, it needs to be that $\mu_A > \bar{\delta}$, which implies that the steady state labor share in agriculture is greater than its consumption share since a fraction of agricultural output is not consumed. Note that in the absence of procurement ($Y_A^P = 0$), and these two steady state shares are equal as $C\left(\frac{\mu_A - \bar{\delta}}{1-\mu_A}\right) = 0 \implies \mu_A = \bar{\delta}$. The steady state relation in the agricultural sector then becomes

$$N_A = Y_A = C_A + (1-\phi)Y_A^P = C\frac{\mu_A}{1-\mu_A}(1-\bar{\delta})$$

From the aggregate market clearing condition (equation (2.35)), $Y = C + (1-\phi)Y_A^P = C\left(\frac{1-\bar{\delta}}{1-\mu_A}\right)$. The steady state share of consumption in output $\left(c = \frac{C}{Y}\right)$ equals

$$c = \frac{1-\mu_A}{1-\bar{\delta}}. \tag{A.42}$$

Note that as a fraction of the agriculture good is not consumed $(\mu_A > \bar{\delta})$, $c < 1$.

We now relate c with the steady state share of consumption in output in the agricultural sector $\left(c_A = \frac{C_A}{Y_A}\right)$. We already have $Y_A = C\left(\frac{\mu_A}{1-\mu_A}\right)(1-\bar{\delta})$, and $C_A = \bar{\delta}C$. Therefore,

$$c_A = \frac{\bar{\delta}(1-\mu_A)}{\mu_A(1-\bar{\delta})} = \frac{\bar{\delta}}{\mu_A}c. \tag{A.43}$$

Note that $c_A < c$ given that $\mu_A > \bar{\delta}$.

We next derive the steady state value of λ. Note that $\lambda = \frac{\phi Y_A^P}{(1-\mu_R)C_{PA}}$. From (2.11), $C_{PA} = \delta_P C_P (1-\lambda)^{-(1-\delta_P)}$ (as $T = 1$) and using the relation between C_P and C from.(A.36). Therefore,

$$\lambda = \frac{\phi Y_A^P (1-\lambda)^{(1-\delta_P)}}{(1-\mu_R)\delta_P C_P} = \frac{\phi Y_A^P (1-\lambda(1-\delta_P))}{\delta_P(1-s_R)C}.$$

Using $Y_A^P = \frac{1}{(1-\phi)}\frac{(\mu_A-\bar{\delta})}{(1-\mu_A)}C$, this implies

$$\lambda = \frac{(\mu_A-\bar{\delta})\phi(1-\lambda(1-\delta_P))}{\delta_P(1-\mu_A)(1-\phi)(1-s_R)} \tag{A.44}$$

Solving for λ, we obtain

$$\lambda = \frac{\phi(\mu_A-\bar{\delta})}{(1-\delta_P)\phi(\mu_A-\bar{\delta}) + \delta_P(1-\mu_A)(1-s_R)(1-\phi)}. \tag{A.45}$$

Solving for ϕ,this implies

$$\phi = \frac{\lambda\delta_P(1-\mu_A)(1-s_R)}{\lambda\delta_P(1-\mu_A)(1-s_R) + (\mu_A-\bar{\delta})(1-\lambda(1-\delta_P))}. \tag{A.46}$$

Given the other parameter restrictions in the model $(\mu_A - \bar{\delta} > 0, \mu_A < 1, s_R < 1, \delta_P > 0, \lambda \geq 0,)$, this implies that $\phi \geq 0$. Since $\phi < 1$, this is equivalent to

$$\lambda < \frac{1}{1-\delta_P}$$

A.1.3 The Log-Linearized Model

We log-linearize the model's key equations around the computed steady-state and express variables in terms of percentage deviations. Define $\hat{X}_t = \ln X_t - \ln X$ as the log of deviation of X, where X is the steady state value of X. For variables that are in fractions or have a percentage interpretation, we define $\hat{X}_t = X_t - X$.

Derivation of Equation (2.42): To derive an expression for the log-linearized consumption for the poor, using the definition of $\lambda_t = \frac{\phi_t Y_{A,t}^P}{C_{P,A,t}(1-\mu_R)}$, and using equation (2.11), we have

$$\lambda_t = \frac{\phi_t Y_{A,t}^P}{(1-\mu_R)\delta_P C_P (1-\lambda_t)^{-(1-\delta_P)} T_t^{-(1-\delta_P)}}.$$

Log linearization of this equation gives

$$\hat{\lambda}_t = \left[\frac{\lambda(1-\lambda)}{1-\delta_P\lambda}\right]\left[\frac{\widehat{\phi}_t}{\phi} + \widehat{Y}_{A,t}^P - \widehat{C}_{P,t} + (1-\delta_P)\widehat{T}_t\right]$$

The log-linearized first order condition (equation (2.17)) for the poor is given by

$$\widehat{W}_t - \widehat{P}_t = \varphi\widehat{N}_{P,t} + (\sigma_P + \lambda_p)\,\widehat{C}_{P,t} - \lambda_p\left[\frac{\widehat{\phi}_t}{\phi} + \widehat{Y}_{A,t}^P\right] + \{\delta_P - \delta_R - \lambda_P(1-\delta_P)\}\,\widehat{T}_t$$

Using $\widehat{N}_{R,t} = \widehat{N}_{P,t} = \widehat{N}_t$. for all t and combining this with equation (2.40) we get equation (2.42).

Derivation of Equation (A.47): To derive an expression for $\widehat{C}_{R,t}$,substituting equation (2.42) for $\widehat{C}_{P,t}$ into equation (2.39), the log-linearized consumption of the rich is given by,

$$\widehat{C}_{R,t} = \left[s_R + \frac{(1-s_R)\sigma_R(1-\lambda_p\tau)}{\sigma_P+\lambda_p}\right]^{-1} \tag{A.47}$$
$$.\left[\widehat{C}_t - \left\{\Psi(1-\delta_P) + (1-s_R)(\delta_P-\delta_R)\Big(\frac{\sigma_P+\lambda_P-(1-\lambda_P\tau)}{\sigma_P+\lambda_P}\Big)\right\}\widehat{T}_t - \Psi\left\{\frac{\widehat{\phi}_t}{\phi} + \widehat{Y}_{A,t}^P\right\}\right]$$

where $\Psi = \frac{\lambda_p(1-s_R)(1+\tau\sigma_P)}{\sigma_P+\lambda_p}$ and $\tau = \frac{\lambda(1-\delta_P)}{1-\lambda(1-\delta_P)}$

Let $x = 1 - \lambda(1-\delta_P)$. Combining equations (2.44) and (2.38), we obtain the Euler equation in terms of aggregate output

$$\begin{aligned}\widehat{Y}_t = E_t\{\widehat{Y}_{t+1}\} - c\Phi^{-1}\left[\widehat{R}_t - E_t\{\Pi_{t+1}\}\right] - c\left[\left(\frac{\mu_A-\bar{\delta}}{1-\mu_A}\right) + \Psi\right] E_t\left\{\Delta\widehat{Y}^P_{A,t+1}\right\}\\ - c\left[\frac{\Psi}{\phi} - \left(\frac{1}{1-\phi}\right)\left(\frac{\mu_A-\bar{\delta}}{1-\mu_A}\right)\right] E_t\left\{\Delta\widehat{\phi}_{t+1}\right\} \qquad \text{(A.48)}\\ - c\left[(1-\delta_R)\left(\frac{\mu_A-\bar{\delta}}{1-\mu_A}\right) + \Psi\left\{(1-\delta_P)+(\delta_P-\delta_R)z\right\}\right] E_t\left\{\Delta\widehat{T}_{t+1}\right\}\end{aligned}$$

Log-linearization of the market clearing condition in the agricultural sector (equation (2.29)) gives

$$\begin{aligned}\widehat{Y}_{A,t} = \frac{c}{\mu_A}\left[s_R\delta_R\widehat{C}_{R,t} + (1-s_R)\frac{\lambda_p}{x\lambda_s}\widehat{C}_{P,t} + \left\{\frac{(1-s_R)\lambda_p(1-\delta_P)}{x} + \left(\frac{\mu_A-\bar{\delta}}{1-\mu_A}\right)\right\}\widehat{Y}^P_{A,t}\right]\\ \text{(A.49)}\\ + \frac{c}{\mu_A}\left[\frac{(1-s_R)\lambda_p(1-\delta_P)}{x\phi} - \left(\frac{1}{1-\phi}\right)\left(\frac{\mu_A-\bar{\delta}}{1-\mu_A}\right)\right]\widehat{\phi}_t\\ - \frac{c}{\mu_A}\left[s_R\delta_R(1-\delta_R) + \frac{(1-s_R)\lambda_p(1-\delta_P)}{x\lambda_s}\right]\widehat{T}_t\end{aligned}$$

where $\lambda_s = \frac{\lambda}{1-\lambda}$. Log-linearization of the optimal demand for manufacturing output (equation (2.23)) gives

$$\begin{aligned}\widehat{Y}_{M,t} = \frac{1}{1-\bar{\delta}}\left[s_R(1-\delta_R)\widehat{C}_{R,t} + \frac{(1-s_R)(1-\delta_P)(1-\lambda)(1+\lambda_p)}{x}\right]\widehat{C}_{P,t}\\ \text{(A.50)}\\ + \frac{1}{1-\bar{\delta}}\left[s_R(1-\delta_R)\delta_R + \frac{(1-s_R)(1-\delta_P)(1-\lambda)(\delta_P-\lambda_p(1-\delta_p))}{x}\right]\widehat{T}_t\\ - \frac{1}{1-\bar{\delta}}\left[\frac{\lambda_p(1-s_R)(1-\lambda)(1-\delta_P)}{x}\right]\left(\frac{\widehat{\phi}_t}{\phi} + \widehat{Y}^P_{A,t}\right)\end{aligned}$$

Log-linearization of the labor market clearing condition (2.33) gives

$$\widehat{N}_t = \mu_A \widehat{N}_{A,t} + (1-\mu_A)\widehat{N}_{M,t} = \mu_A \widehat{Y}_{A,t} + (1-\mu_A)\widehat{Y}_{M,t} - \widehat{A}_t \tag{A.51}$$

where $\widehat{A}_t = \mu_A \widehat{A}_{A,t} + (1-\mu_A)\widehat{A}_{M,t}$, and $\mu_A = \frac{N_A}{N}$ is the steady state employment share in agriculture. The last line uses log linearization of the sectoral production functions.

From equations (2.40) and (A.47) and noting that $\widehat{N}_{R,t} = \widehat{N}_t$, we can write equation (2.16) as

$$\widehat{W}_t - \widehat{P}_t = \varphi \widehat{N}_t + \Phi \widehat{C}_t - \Psi\Phi \left[\frac{\widehat{\phi}_t}{\phi} + \widehat{Y}^P_{A,t} + \{(1-\delta_P) + (\delta_P - \delta_R)z\} \widehat{T}_t \right] \tag{A.52}$$

Substituting equations (A.49) and (A.50) into (A.51), and the resulting equation into (A.52), we get:

$$\widehat{W}_t - \widehat{P}_t = \Lambda \widehat{C}_t + \{\varphi(1-c) - \Psi\Phi\} \widehat{Y}^P_{A,t} - \left\{ \varphi(1-c) \left(\frac{1}{1-\phi} \right) + \frac{\Psi\Phi}{\phi} \right\} \widehat{\phi}_t \tag{A.53}$$

$$- \left[\varphi c (1-s_R) \{\delta_P \tau + \delta_P - \delta_R\} + \Psi\Phi \{1 - \delta_P + (\delta_P - \delta_R)z\} \right] \widehat{T}_t - \varphi \widehat{A}_t$$

where $\Lambda = \{\varphi c + \Phi\}$.

Finally, the log linearized real marginal cost in the manufacturing sector is given by:

$$\widehat{mc}_{M,t} = \widehat{W}_t - \widehat{P}_t + \delta_R \widehat{T}_t - \widehat{A}_{M,t} \tag{A.54}$$

A.1.4 Flexible price equilibrium

Derivation of DIS in Equation (2.46): Given that under flexible prices, real marginal cost is a constant, so that $\widehat{mc}_{M,t}^{N} = 0$, equation (A.54) becomes $0 = \widehat{W}_t^N - \widehat{P}_t^N + \delta_R \widehat{T}_t^N - \widehat{A}_{M,t}$. Combining this with the flexible price counterpart of equation (A.53), we get:

$$\begin{aligned}
\widehat{C}_t^N &= \Lambda^{-1}\left\{\varphi(1-c)\left(\frac{1}{1-\phi}\right) + \frac{\Psi\Phi}{\phi}\right\}\widehat{\phi}_t \\
&\quad - \Lambda^{-1}\left\{\varphi(1-c) - \Psi\Phi\right\}\widehat{Y}_{A,t}^P + \Lambda^{-1}\left(\varphi\widehat{A}_t + \widehat{A}_{M,t}\right) \\
&\quad + \Lambda^{-1}\left[\varphi c(1-s_R)\left\{\delta_P\tau + \delta_P - \delta_R\right\} + \Psi\Phi\left\{1 - \delta_P + (\delta_P - \delta_R)z\right\} - \delta_R\right]\widehat{T}_t^N
\end{aligned} \tag{A.55}$$

Note that procurement is the same under both sticky and flexible prices. Thus, the flexible price counterpart of equation (2.38) is

$$\begin{aligned}
\widehat{Y}_t^N &= c\widehat{C}_t^N + (1-c)\left[(1-\delta_R)\widehat{T}_t^N + \widehat{Y}_{A,t}^P - \left(\frac{1}{1-\phi}\right)\widehat{\phi}_t\right] \\
&= \left(\frac{1-\mu_A}{1-\bar{\delta}}\right)\widehat{C}_t^N + \left(\frac{\mu_A - \bar{\delta}}{1-\bar{\delta}}\right)\left[(1-\delta_R)\widehat{T}_t^N + \widehat{Y}_{A,t}^P - \left(\frac{1}{1-\phi}\right)\widehat{\phi}_t\right]
\end{aligned} \tag{A.56}$$

Substituting equation (A.55) into equation (A.56), forwarding one period and then subtracting from each other, we obtain

$$\widehat{Y}_t^N = E_t\Big\{\widehat{Y}_{t+1}^N\Big\} - [c\Lambda^{-1}\{\Psi\Phi\} + (1-c)(1-\Lambda^{-1}\varphi c)]E_t\Big\{\Delta\widehat{Y}_{A,t+1}^P\Big\} \quad \text{(A.57)}$$
$$- \Big\{c\Lambda^{-1}\Big[\frac{\Psi\Phi}{\phi}\Big] - \Big(\frac{1}{1-\phi}\Big)(1-c)(1-\Lambda^{-1}\varphi c)\Big\}E_t\{\Delta\widehat{\phi}_{t+1}\}$$
$$- \Bigg[(1-\delta_R)\{1-c\} + c\Lambda^{-1}\{(1-s_R)\varphi c\Big(\Big(\delta_P - \delta_R\Big) + \delta_P\tau\Big)$$
$$+ \Psi\Phi\Big\{1-\delta_P + (\delta_P-\delta_R)z\Big\} - \delta_R\}\Bigg]E_t\Big\{\Delta\widehat{T}_{t+1}^N\Big\}$$
$$- c\Lambda^{-1}E_t\Big\{\varphi\Delta\widehat{A}_{t+1} + \Delta\widehat{A}_{M,t+1}\Big\}$$

Finally, substituting (2.44) into (2.38) and then subtracting equation (A.57) we obtain the dynamic IS (DIS) curve given by equation (2.46).

Derivation of NKPC in Equation (2.49): From equation (2.38), the consumption gap is written as

$$\widetilde{C}_t = \frac{1}{c}\Big[\widetilde{Y}_t - (1-c)(1-\delta_R)\widetilde{T}_t\Big] \quad \text{(A.58)}$$

From equation (A.54) and given that $\widehat{mc}_{M,t}^N = 0$,

$$\widetilde{mc}_{M,t} = \widetilde{W}_t - \widetilde{P}_t + \delta_R\widetilde{T}_t. \quad \text{(A.59)}$$

And from equation (A.53),

$$\begin{aligned}\widetilde{W}_t - \widetilde{P}_t = \Lambda\widetilde{C}_t - \Big[&\varphi c(1-s_R)\left\{\delta_P\tau + (\delta_P-\delta_R)\right\} \\ &+ \Psi\Phi\left\{1-\delta_P + (\delta_P-\delta_R)z\right\}\Big]\widetilde{T}_t\end{aligned} \quad \text{(A.60)}$$

Substituting equation (A.60) in equation (A.59) expresses the real marginal cost gap for the manufacturing sector as a function of the aggregate consumption gap and the terms of trade gap.

$$\begin{aligned}\widetilde{mc}_{M,t} = \Lambda\widetilde{C}_t + \Big[&\delta_R - \varphi c(1-s_R)\{\delta_P\tau + (\delta_P-\delta_R)\} \\ &- \Psi\Phi\{1-\delta_P + (\delta_P-\delta_R)z\}\Big]\widetilde{T}_t\end{aligned} \quad \text{(A.61)}$$

We also have the relationship that connects CPI inflation with sectoral inflation and TOT as

$$\pi_t = \pi_{M,t} + \delta_R \Delta \widetilde{T}_t \tag{A.62}$$

Substituting equations (A.58) and (A.62) into equation (2.28) yields equation (2.49).

A.2 Data Appendix

In this section, we describe how we have estimated the structural parameters used in the calibration exercise.

- *Share of rich in population*: $\mu_R = 0.3279$
  - We define agents to be poor if they receive food grain under the NFSA 2013. Accordingly, we classify the "rich" as comprising 25% of the rural population and 50% of the urban population. Taking population of the rural and urban areas to be 833.1 million and 377.1 million, respectively, from the Census of India 2011, we get $\mu_R = 0.3279$
- Share of agriculture in consumption for agents is determined by taking the ratio of expenditure on cereals and cereal substitutes in total expenditure where the latter is defined to be expenditure on cereals, cereals substitutes, pan tobacco and intoxicants, clothing, footwear, toilet articles, other household consumables, and minor durable type goods. We use data from Table 6B-R: (Page 104) and Table 6B-U (Page 105) from National Sample Survey 2011b which report the average monetary value of consumption of food and non-food groups for a period of 30 days for each fractile class of MPCE$_{MRP}$ in rural and urban areas, respectively.
  - *Share of agriculture purchases by poor*: $\delta_P = 0.4807$.
    * We split the 7^{th} decile (70-80%) into two halves for the rural data set (to be able to get division into bottom 75% and top 25% by MPCE). The agriculture expenditure shares for different fractile classes of rural areas are combined by taking a weighted average using

appropriate weights (0.1333 for deciles and 0.0667 for the first two fractile classes (0-5% and 5-10%) and the (70-75%) fractile class). The agriculture expenditure shares for different fractile classes of urban areas are combined by taking a weighted average using appropriate weights (0.2 for deciles and 0.1 for first 2 fractile classes (0-5% and 5-10%)). These two shares are combined by taking a weighted average using rural and urban shares in total poor population as weights.

- *Share of agriculture purchases by rich:* $\delta_R = 0.3527$.
    * The agriculture expenditure shares for different fractiles of rural areas are combined by taking a weighted average using appropriate weights (0.4 for the 70-80th percentile and 0.2 for the 70-75th, 90-95th and 95-100th percentiles)). The agriculture expenditure shares for different fractiles of urban areas are combined by taking a weighted average using appropriate weights (0.2 for deciles and 0.1 for the 90-95th and 95-100th percentiles). These two shares are combined by taking a weighted average using shares in the total rich population as weights.

• *Share of rich consumption relative to total consumption*: $s_R = 0.5367$

- We use data from Table 1C of National Sample Survey 2011b on Page 83, that reports the average MPCE ($MPCE_{MMRP}$) and estimated number of households and persons by gender for each fractile class. Share of Total Consumption Expenditure for each fractile is computed by multiplying the estimated number of people in each fractile class with Average MPCE of that fractile class. The share of rich agents for the respective areas is determined by dividing total consumption estimates for fractiles greater than 75% for the rural areas and above 50% for urban areas by their respective total consumption estimates. The two shares are combined using the population shares

- *Share of subsidized consumption*: $\lambda = 0.2457$
  - We use data from Statement 2 of National Sample Survey 2011c (Page 18). It reports the percentage share of consumption (by quantity) sourced from the Public Distribution System (PDS) for households across different MPCE fractile classes, separately for wheat, rice, sugar, and kerosene, and distinguishes between urban and rural areas. We combine the PDS shares of wheat and rice by taking a weighted average using relative shares in consumption for each fractile. (For example, the weight of rice is determined by taking the expenditure on rice divided by the expenditure on wheat and rice). The data is taken from Table 5C-R (Page 100) and Table 5C-U (Page 101) from the NSS Report 555 which reports the monetary value of consumption of cereals and pulses for a period of 30 days for a person in each fractile class of MPCE$_{MMRP}$. (MMRP is used here as PDS shares are available using type 2 data-MMRP approach). The share of subsidy in consumption is determined by taking a weighted average of shares for bottom 9 fractile classes (0-75%) for the rural areas and by taking a weighted average of shares for bottom 6 fractile classes (0-50%) for the urban areas. These two values are combined by using relative shares of agents among the poor.

- Steady state value of ϕ
  - Using the selected parameter values in equation (A.46), the steady state value of ϕ is computed to be 47.93%

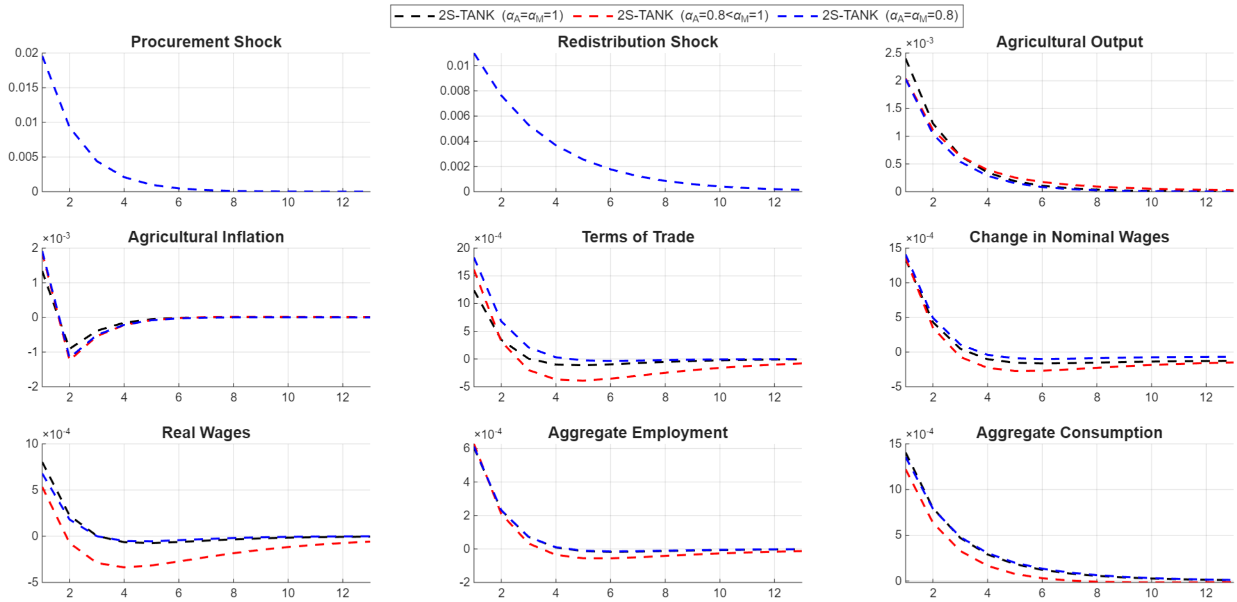
A.3 Impulse Response Functions for a Redistributive Policy Shock with Decreasing Returns to Scale in Production

Under a linear production technology with no entry/fixed costs, scale effects do not constrain expansion. In this subsection, we abstract away from the assumption of a linear production function, i.e. assume

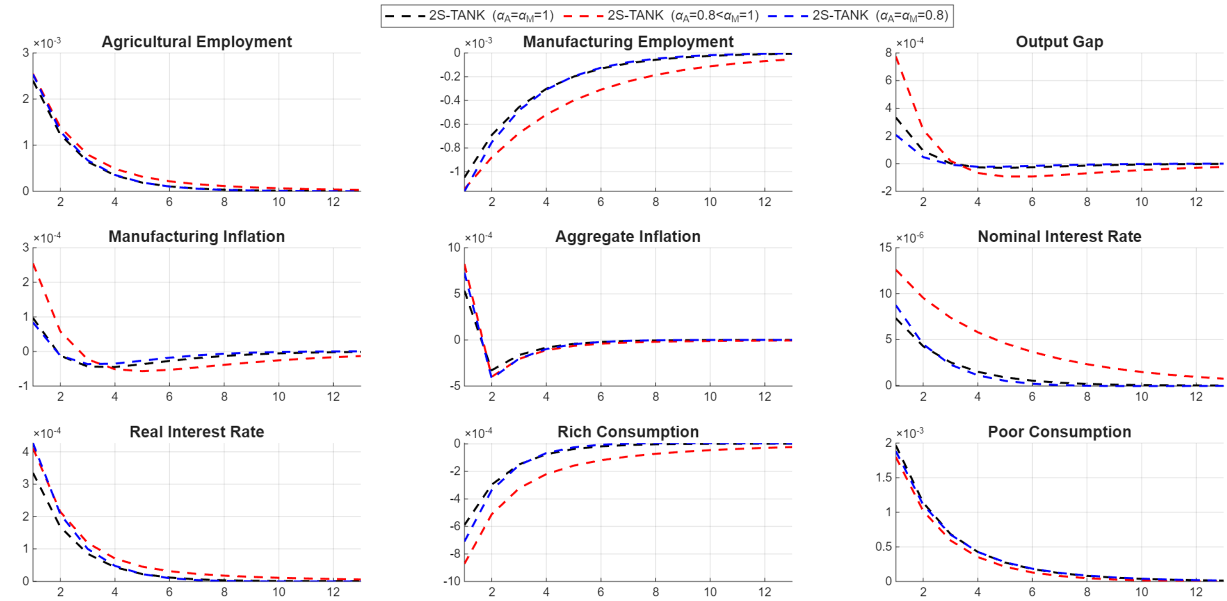
$$Y_{j,t} = A_{j,t}N_{j,t}^{\alpha}, \text{ where } 0 < \alpha < 1 \text{ for } j \in \{A, M\}.$$

This makes the sectoral marginal product dependent on output, and breaks the proportionality between real wages and the TOT. In the Figure A.1, we compare the IRFs for redistributive policy shock in the benchmark model (black-dashed line) with linear production technology in both sectors to alternative models wherein (i) only the agriculture sector exhibits diminishing marginal product of labour (red-dashed line) and (ii) both sectors exhibit diminishing marginal products (blue-dashed line). The results for decreasing returns to scale remain qualitatively similar to the benchmark model via the lower increase in supply of the agriculture good, resulting in higher TOT. Aggregate output and manufacturing sector inflation depend on the production elasticity parameter α, which governs the degree of returns to scale in production. The expansionary effect of a redistributive policy shock is muted when only the labour in the agriculture sector exhibits diminishing marginal product.

The effects would be more pronounced in a medium-scale NK model with capital accumulation, where the marginal product of capital declines with firm size. This weakens investment incentives as firms expand, leading to a change in the propagation of shocks. However, creating a medium-scale NK-DSGE model with two sectors and agents and redistributive policy would not be analytically tractable.

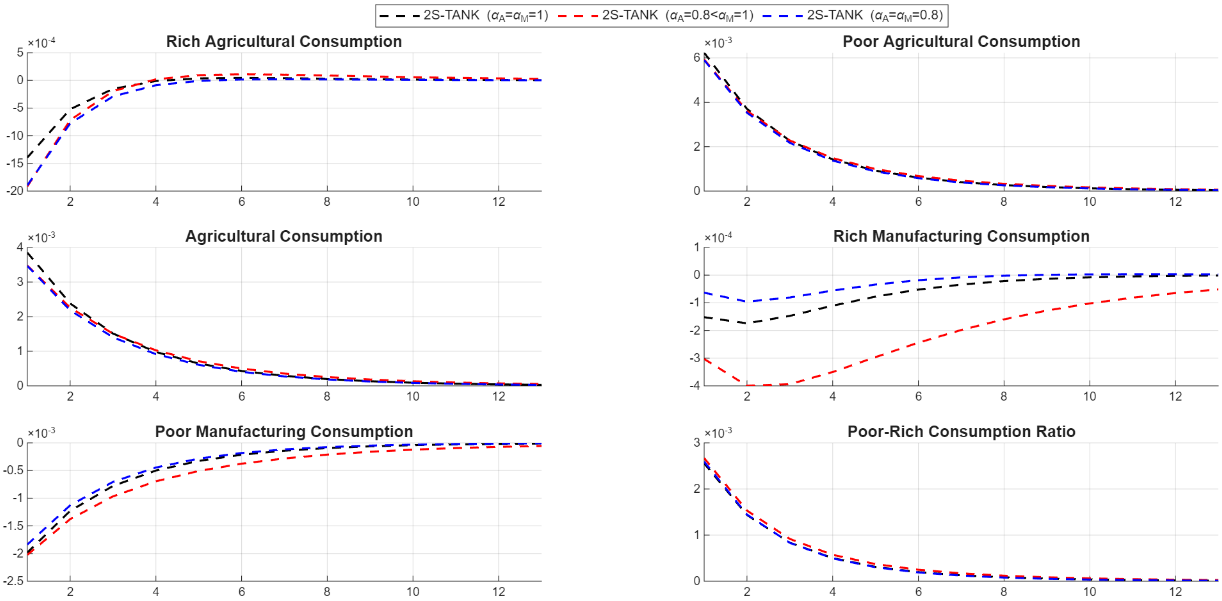


(a) Impact of single period redistributive policy shock on macroeconomic aggregates



(b) Impact of single period redistributive policy shock on macroeconomic aggregates

Figure A.1: Impact of single-period positive procurement and redistributive policy shock



(c) Distributional impact of single period positive procurement and redistributive policy shock

Figure A.1: Impact of single period positive procurement and redistributive policy shock

Appendix B

Appendix: Chapter 3

B.1 Impulse Response Functions for a redistributive policy shock under Ramsey Optimal Monetary Policy

We contrast the case of a utilitarian planner with three cases: (i) with a planner who only values the Ricardian agents' welfare (ii) with a Rawlsian Planner- who values the welfare only of the poor agents and (iii) benevolent social planner who values them in accordance to their representation in the economy.

In contrast to standard Taylor-type rules, which respond mechanically to inflation or output, the Ramsey policy optimally balances trade-offs across time and agents. For instance, it may delay inflation stabilisation in favour of output smoothing, depending on the model's frictions and household preferences.

We observe that the planner responds to a redistributive policy shock with an increase in the nominal interest rate when he maximises the discounted utility of the rich agent. This leads to a greater increase in real interest rates and a contraction in consumption and higher labour supply by the rich agent. Higher labour supply leads to a muted response in manufacturing sector inflation and a smaller decline in the output gap.

When the planner maximises the welfare of the poor agents who are financially constrained, the policy response prioritizes short-term consumption stabilisation. Since the poor households are highly sensitive to current labour income and lack access to credit, the planner lowers nominal interest rates to stimulate demand and labour hours, thereby boosting wage income. The planner tolerates a rise in inflation because the welfare cost of inflation is relatively low for the poor households compared to the utility loss from reduced consumption. At the same time, output may fall further below its efficient level—that is, the output gap becomes more negative—because the planner prioritises stabilising the consumption of hand-to-mouth households over fully offsetting the shock's effect on output. In doing so, the planner accepts weaker overall economic performance to protect the most vulnerable agents. This reflects a shift in policy trade-offs: maintaining price stability and output stability are no longer the primary goals, but are instead balanced against the urgent need to preserve consumption for liquidity-constrained households.

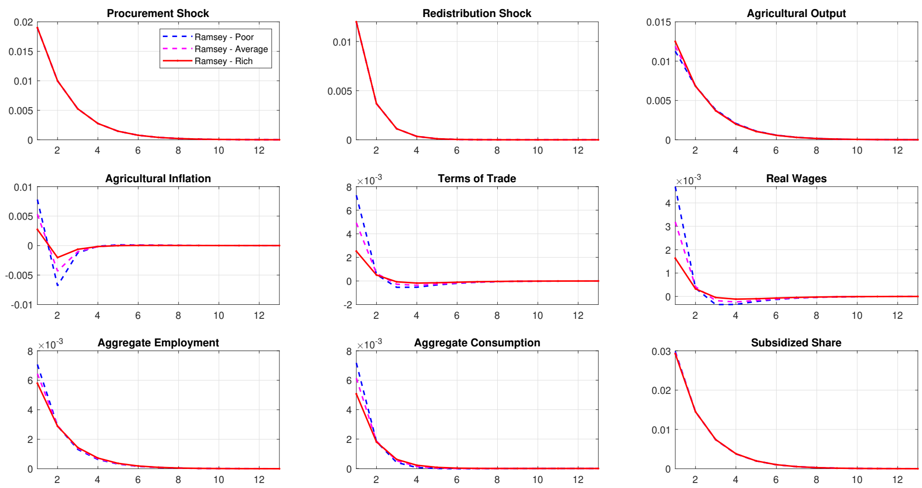


Figure B.1: Impulse response analysis for a redistributive policy shock with different weights in the planner objective function

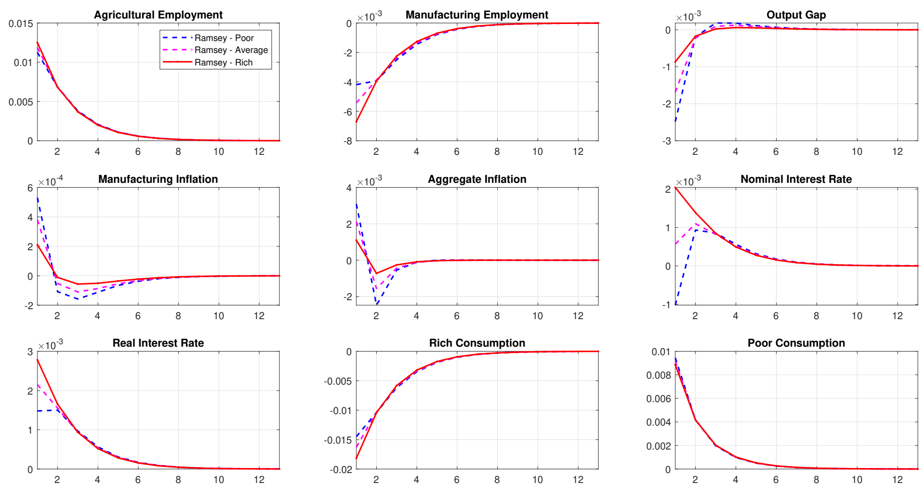


Figure B.2: Impulse response analysis for a single period redistributive policy shock with different weights in the planner objective function

B.2 Raising Upper Bound for inflation coefficient in estimation of Taylor Rule using OSR

Table B.2 reports the variances of key variables. Ramsey policy tolerates somewhat higher aggregate inflation volatility because its objective is to minimise overall welfare loss, not to stabilise inflation at all costs. In a heterogeneous

	ϕ_r	ϕ_π	ϕ_y	$CE_{CR}*100$	$CE_{CP}*100$	$CE_{UR}*100$	$CE_{UP}*100$
OSR	0	3	0	0.003501	0.002408	0.003699	0.002682
OSR (High ϕ_π)	0	10	0	0.000221	0.000664	0.000261	0.000647

Table B.1: OSR Policy Parameters and Consumption Equivalents

	π	π^M	i	$\tilde{Y}$	C_R	C_P	N
Ramsey	0.2408	0.0382	0.2243	0.1546	2.2769	0.8886	0.7596
OSR	0.1692	0.1219	0.5168	0.1284	2.3270	0.8781	0.7408
OSR (High ϕ_π)	0.0452	0.0334	0.4598	0.0338	2.5080	0.8499	0.6747

Table B.2: Macroeconomic Volatilities

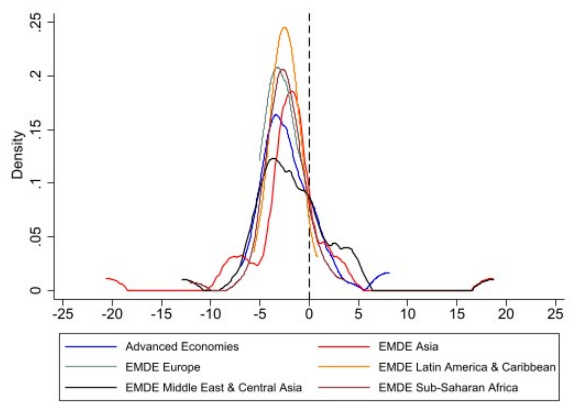
agent model, tight inflation stabilisation requires aggressive interest rate movements that destabilise income and consumption for hand-to-mouth households. Commitment allows the planner to accept short-run inflation fluctuations while promising future corrections, thereby smoothing real activity. This explains why consumption variance is slightly higher under Ramsey than OSR with $\phi_\pi = 10$, but Ramsey remains welfare-superior because it balances the trade-offs across agents.

Appendix C

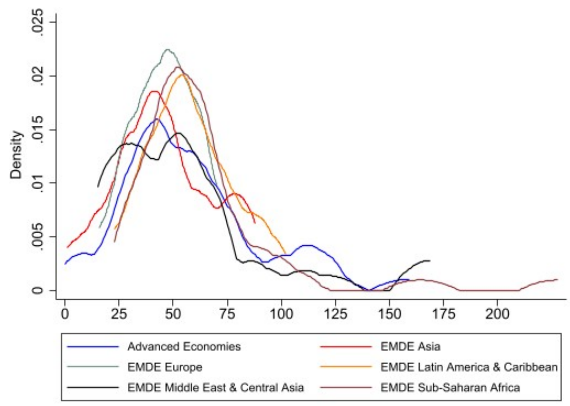
Appendix: Chapter 4

C.1 Average deficits and debt by region

Between 1980 and 2023, most countries ran average fiscal deficits, with regional patterns shown in the k-density plots. EMDE Latin America & Caribbean (orange) and EMDE Europe (green) had small, consistent deficits, while Advanced Economies (blue) showed wider variation, including both large deficits and surpluses. EMDE Asia (red) recorded some extreme deficits, while EMDE Sub-Saharan Africa (brown) displayed greater heterogeneity due to a wider deficit spread. Right-skewed Debt-to-GDP ratios in the right panel indicate outliers, especially in AEs. EMDE Europe clustered tightly around 40–50%, EMDE Sub-Saharan Africa showed more extreme and varied debt levels, EMDE Latin America & Caribbean and EMDE Asia peaked around 40–60% with broader dispersion, while EMDE Middle East & Central Asia (black) was moderately dispersed, peaking just below 50%. Overall, AEs had few very high debt outliers, whereas EMDEs generally had lower debt but more uneven patterns across regions, reflecting substantial regional heterogeneity.



(a) Deficit to GDP ratio (%)



(b) Debt to GDP ratio (%)

Figure C.1: Density plots by region

C.2 Formal Employment in the Informal Sector

A "formally hired worker" in the context of the Annual Survey of Unincorporated Sector Enterprises (ASUSE) is defined as a worker who is eligible for both paid leave and social security benefits, such as provident fund and other statutory entitlements. Table C.1 summarises the share of formally hired workers by firm size. Among all workers in firms with 1–5 employees, only 0.03372% (or 0.0003372 in decimal) are formally hired. Alternatively, if 1,000 workers are employed in small firms (with 1–5 workers), only about 0.34 of them (i.e., less than 1 worker) are formally hired on average. A relatively higher standard deviation indicates that while most firms do not hire workers formally, some firms are hiring one or more workers, increasing the variation.

Number of workers	Share of formally hired workers (%)	Standard Deviation
1-5	0.0003	0.1836
6-10	0.6580	6.8244
11-15	2.9165	14.18162
16-20	6.8020	22.0708
21-50	13.2967	29.62847
50-100	30.3692	39.5916
>100	51.8029	38.8740

Table C.1: Share of formally-hired workers by firm size

C.3 Extensions

C.3.1 Partial Labour Mobility

Figures (C.3a-C.3d) and (C.2a-C.2d) present the impulse responses to a fiscal consolidation shock via a reduction in government consumption for varying shares of agents restricted to the informal sector. The first set assumes complementarity between formal and informal labour in the utility of Ricardian agents, while the second assumes substitutability. There is no utility from public consumption in both scenarios.

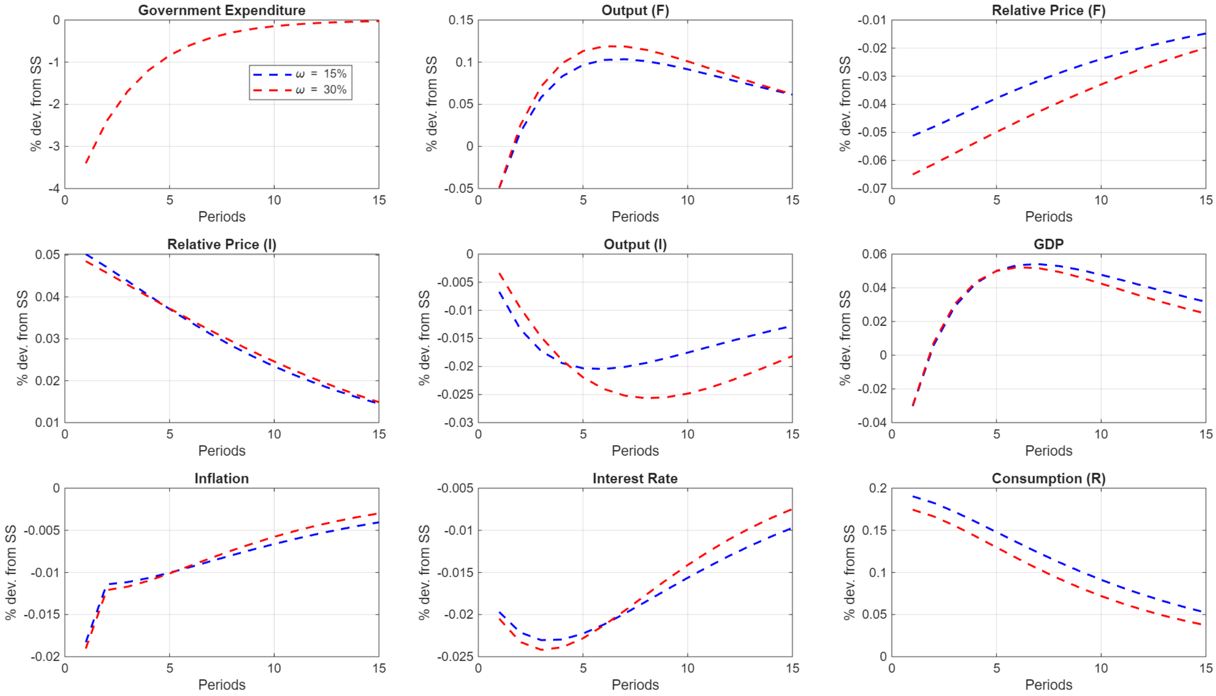
The reallocation mechanism becomes particularly visible when the two types of labour are substitutable (Figures C.2a-C.2d). In this case, Ricardian households can more easily adjust their labour supply across the formal and informal sectors in response to the fiscal consolidation shock.

When government consumption declines, aggregate demand falls, reducing activity in the formal sector. Ricardian households optimally reallocate labour toward the informal sector, where marginal returns remain relatively more attractive.

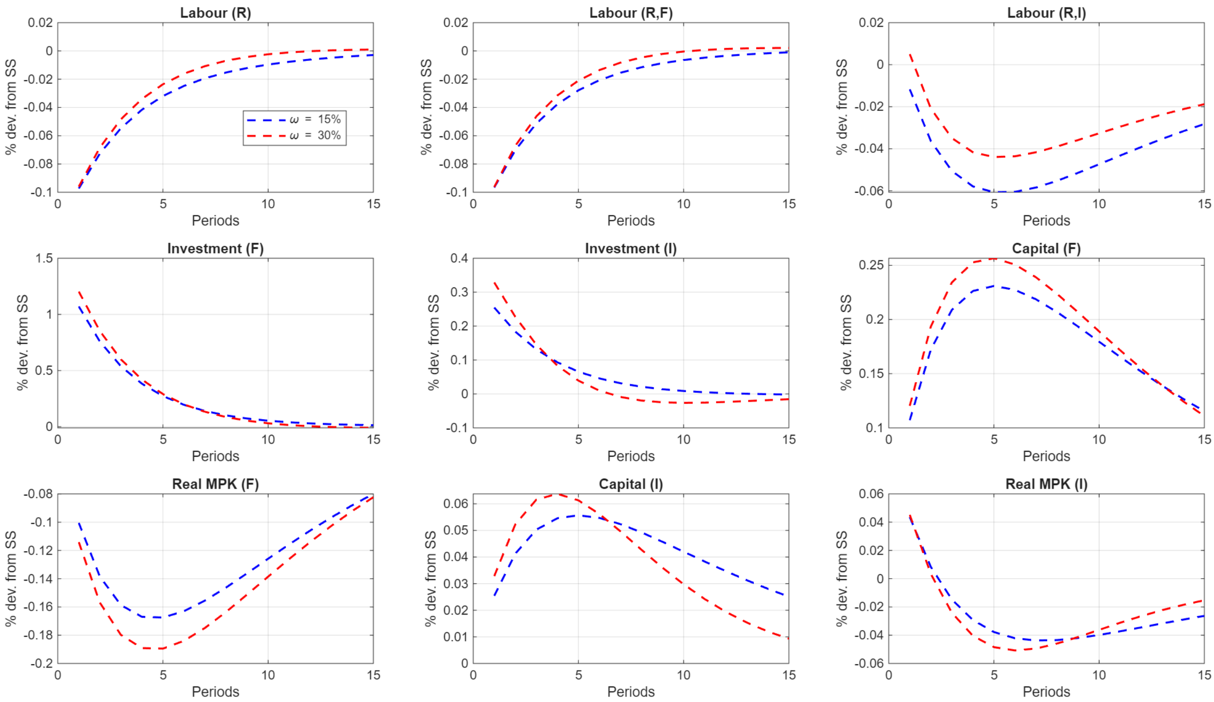
Because labour types are substitutable, an increase in Ricardian informal labour supply raises effective informal-sector labour input. Given the sectoral production function, this increases the real marginal product of capital in the informal sector. As a result, the expected return to informal capital rises, stimulating informal investment.

This mechanism is weaker when labour types are complementary. Ricardian labour reallocation has smaller effects on marginal productivity and therefore on investment when the productivity of informal Ricardian labour depends more strongly on the presence of formal Ricardian labour.

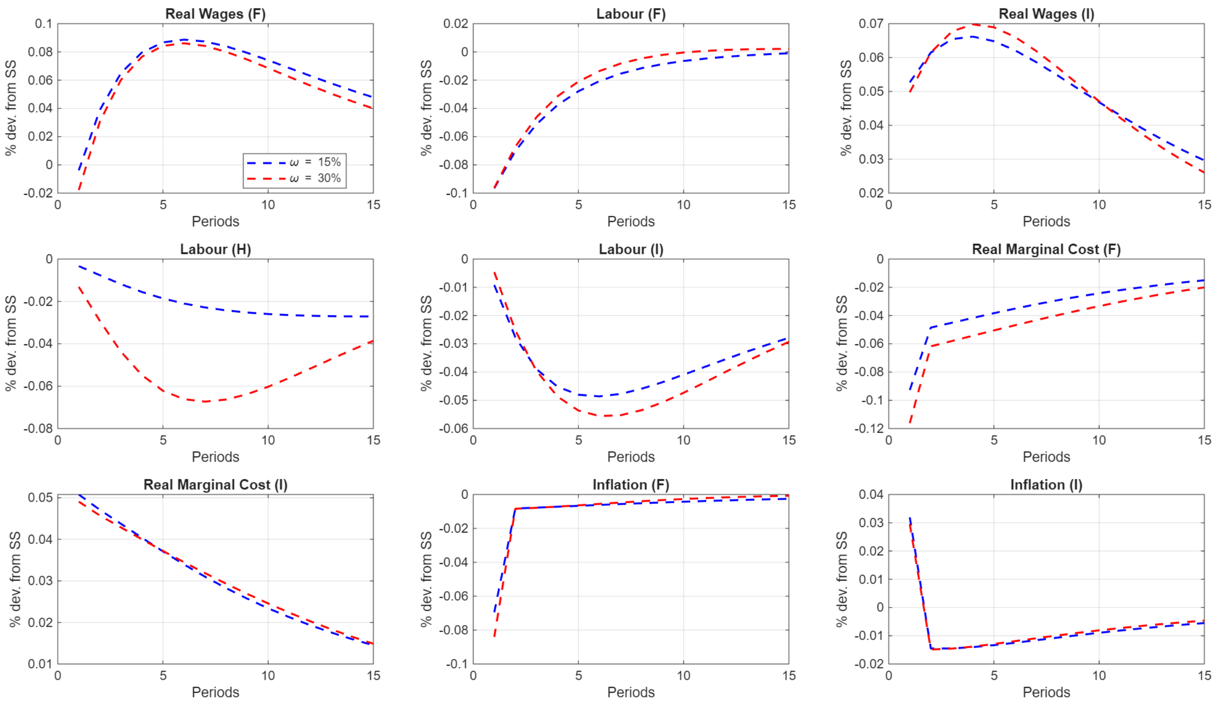
With partial labour mobility, the reallocation of hours occurs gradually. Nevertheless, when labour types are substitutable, the reallocation toward the informal sector is sufficiently strong to accelerate the adjustment of aggregate variables. Higher informal investment supports output and income, improves the fiscal position, and speeds up the convergence of public debt to its steady-state level. Under complementarity, the weaker reallocation dampens this stabilising channel, leading to less persistent debt dynamics.



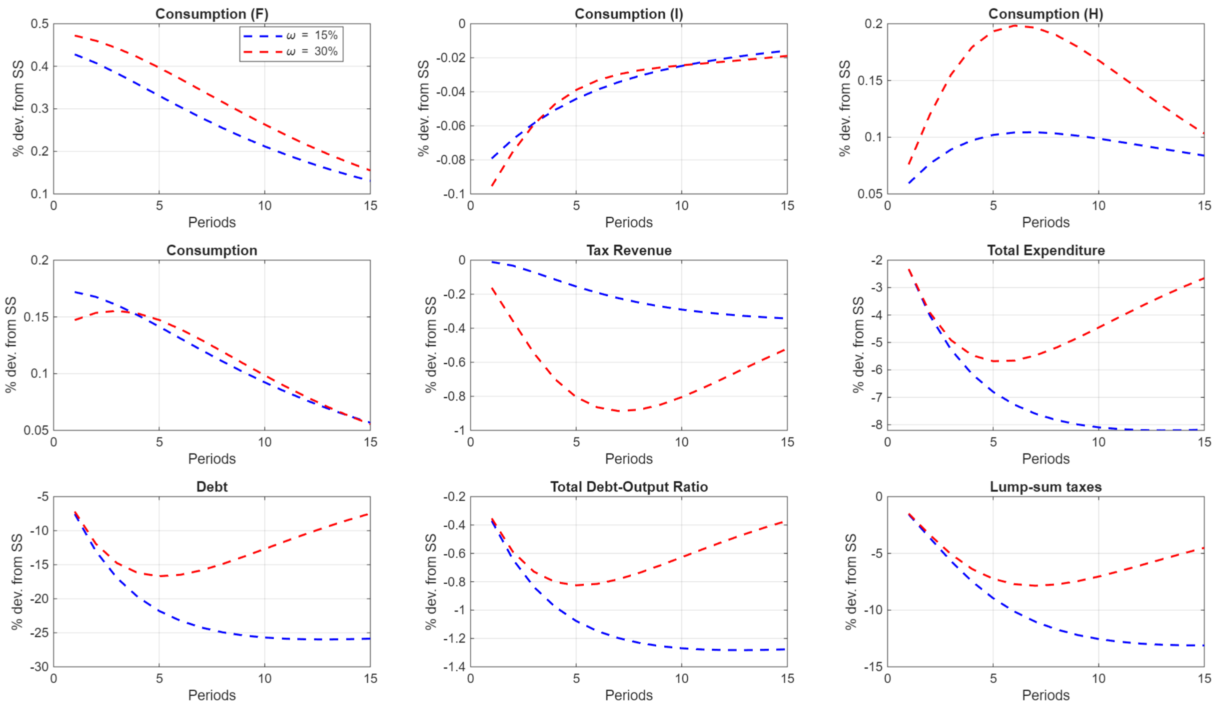
(a) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent



(b) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent

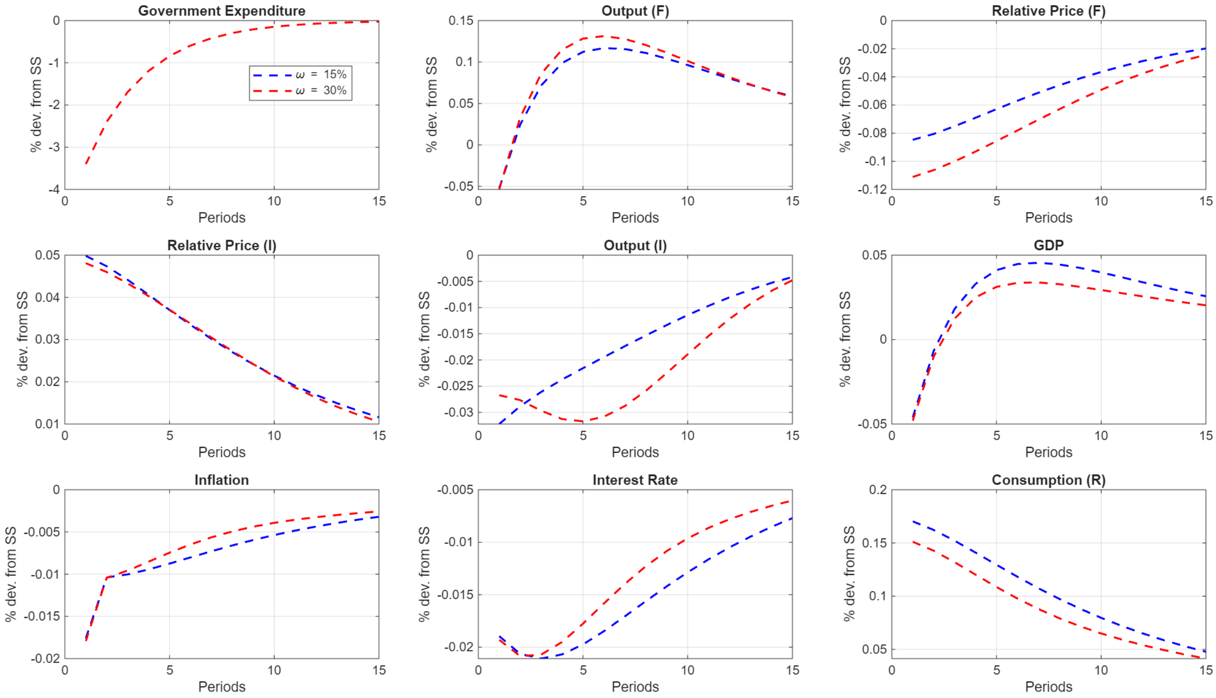


(c) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent

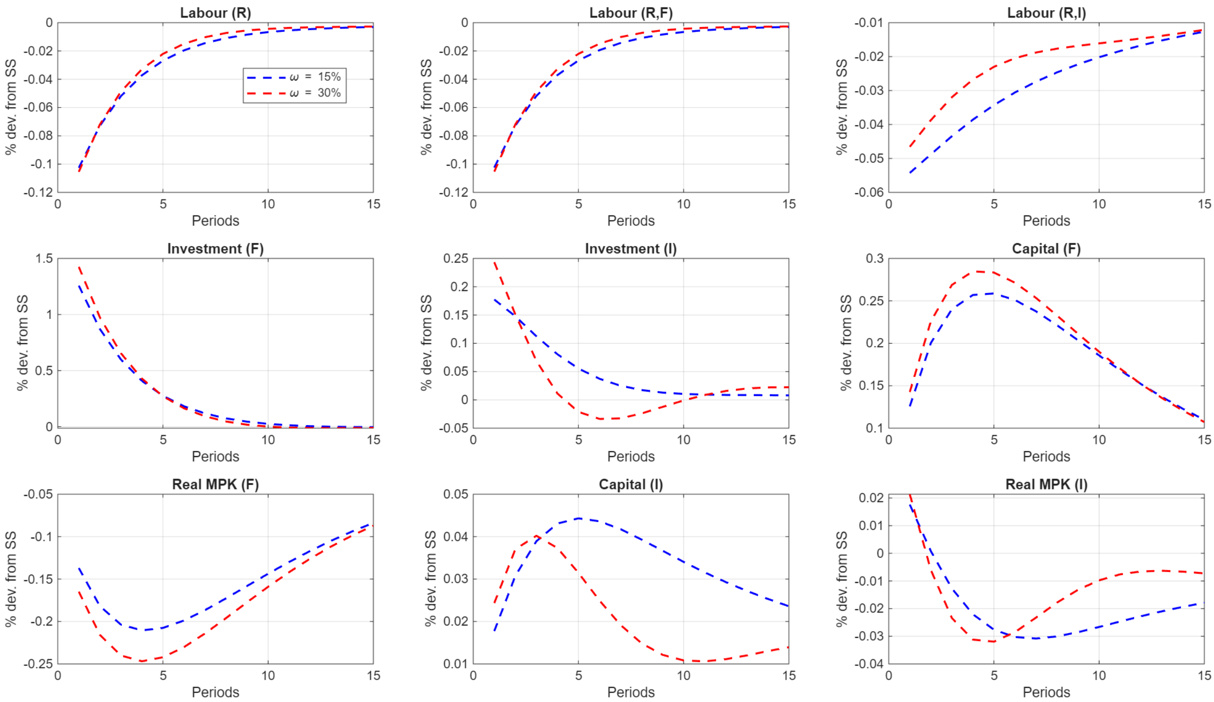


(d) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent

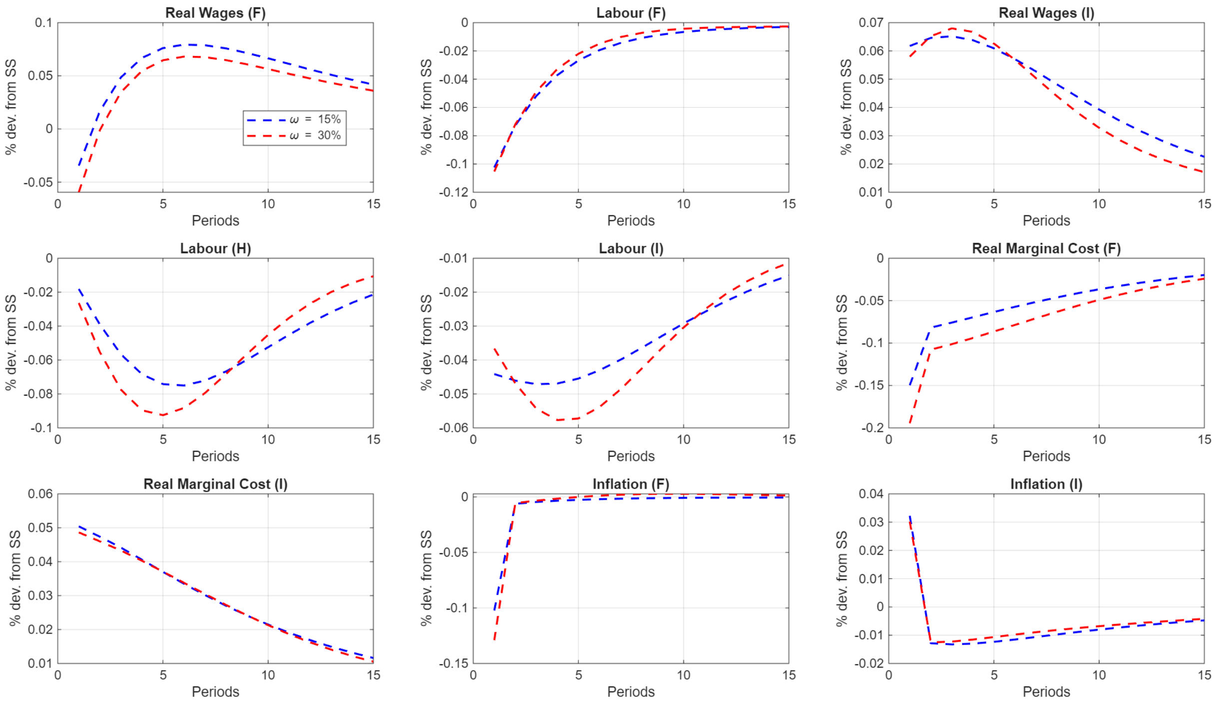
Figure C.2: Impulse responses for a single-period fiscal consolidation shock when there is no utility from the public good when both types of labour are substitutable for the Ricardian agents.



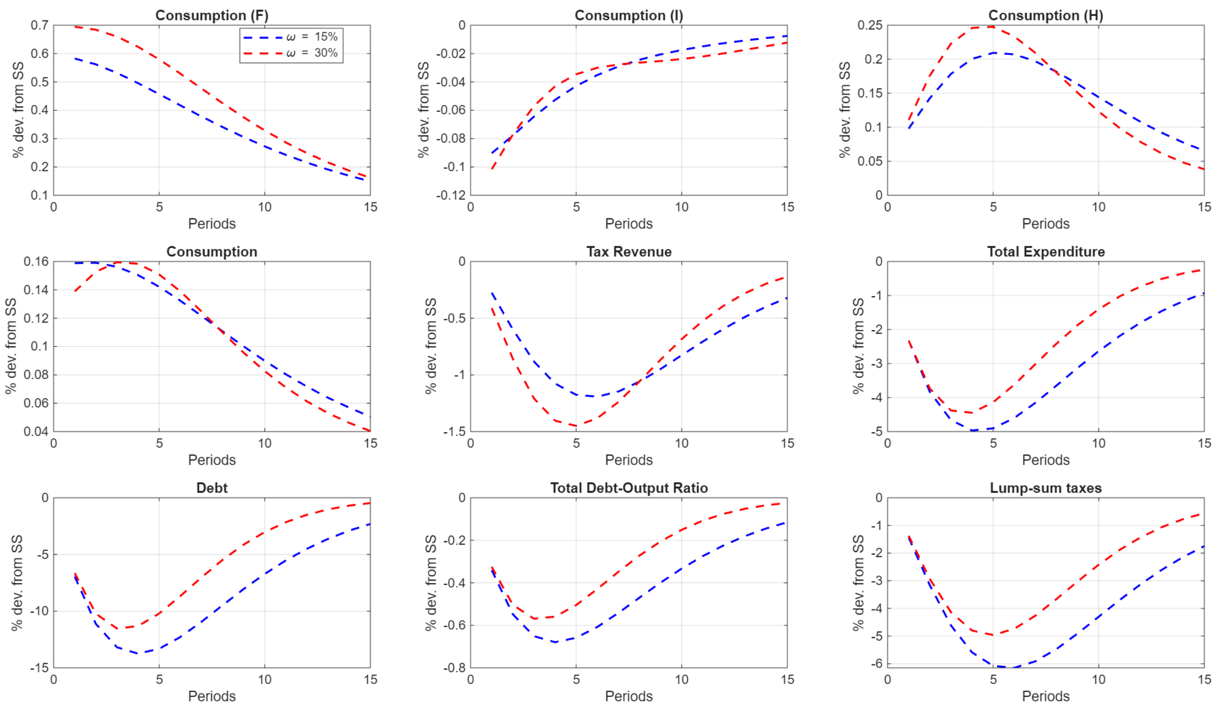
(a) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent



(b) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent



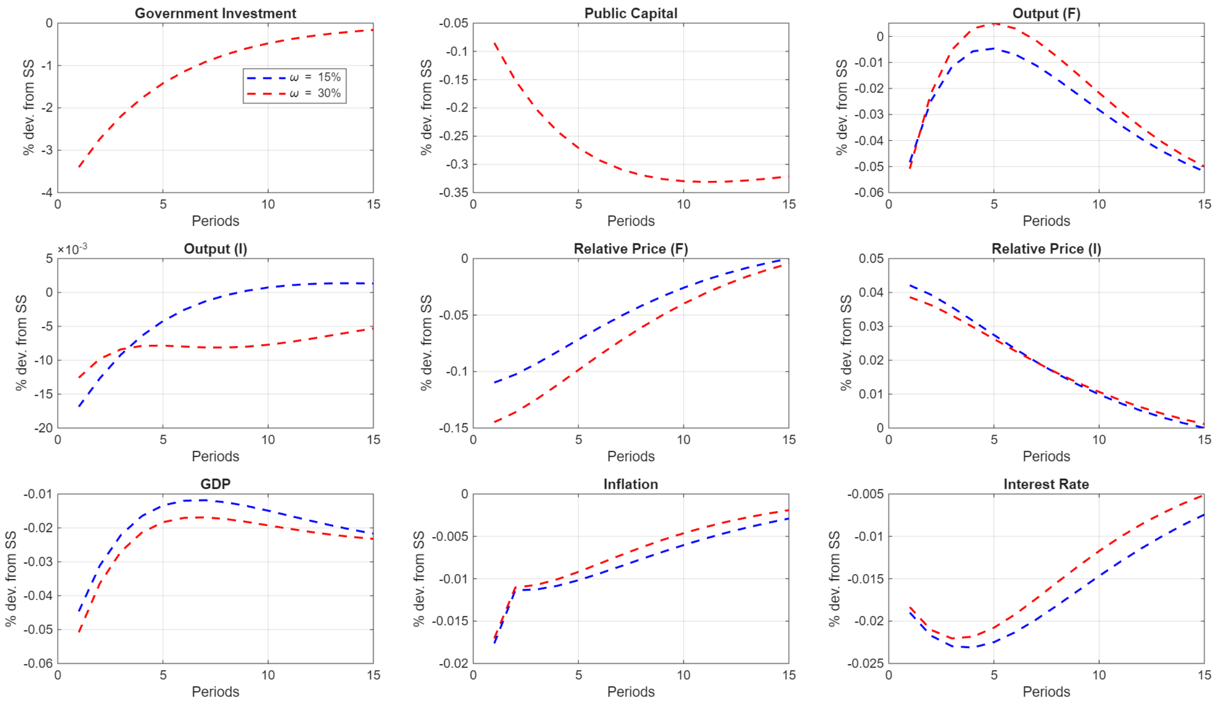
(c) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent



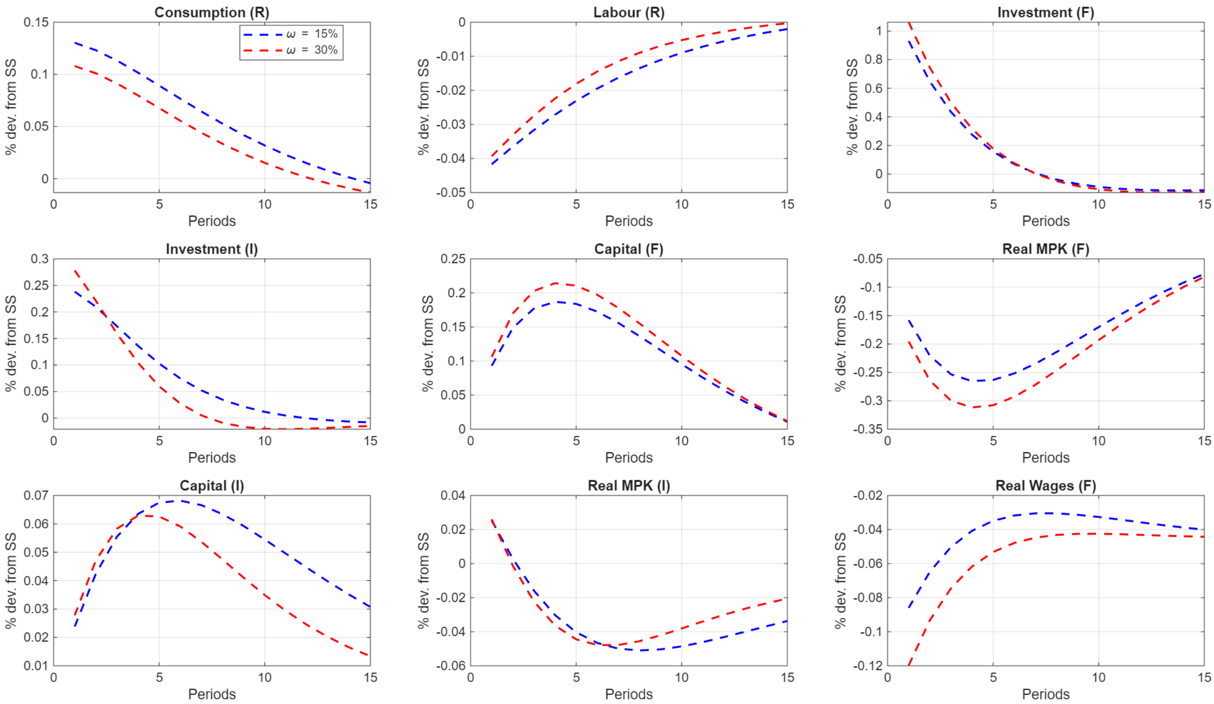
(d) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent

Figure C.3: Impulse responses for a single period fiscal consolidation shock when there is no utility from public good when both types of labour are complementary for the Ricardian agents.

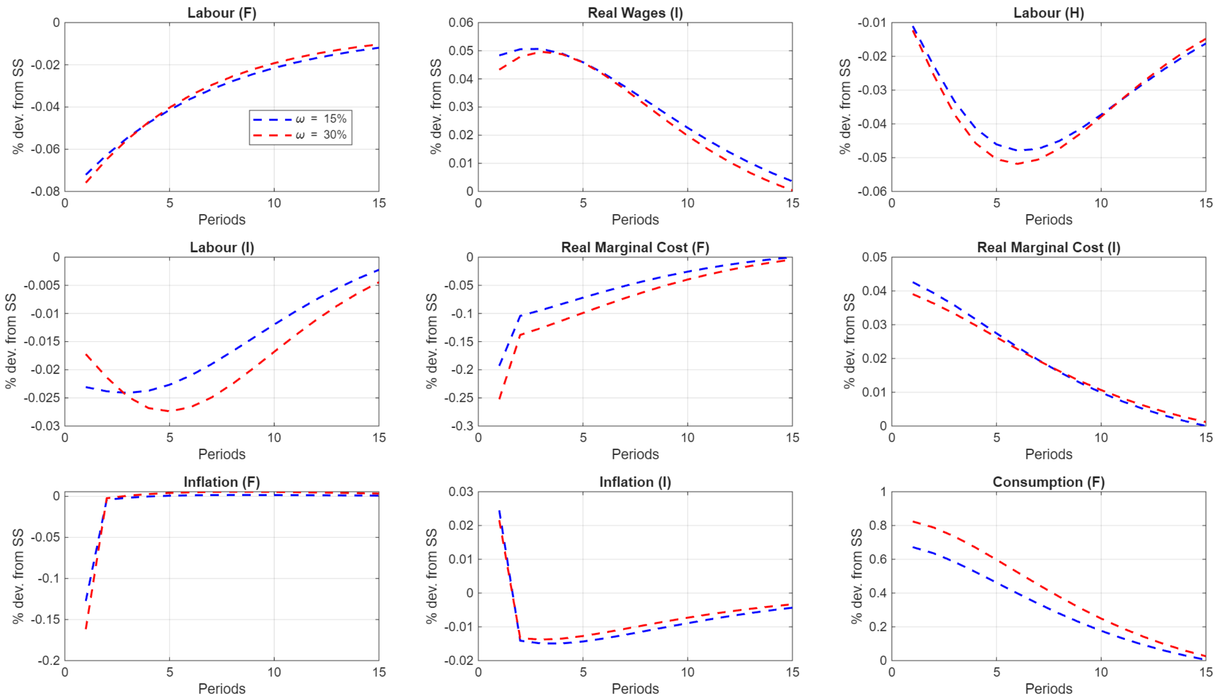
C.3.2 Government Investment in Public Capital



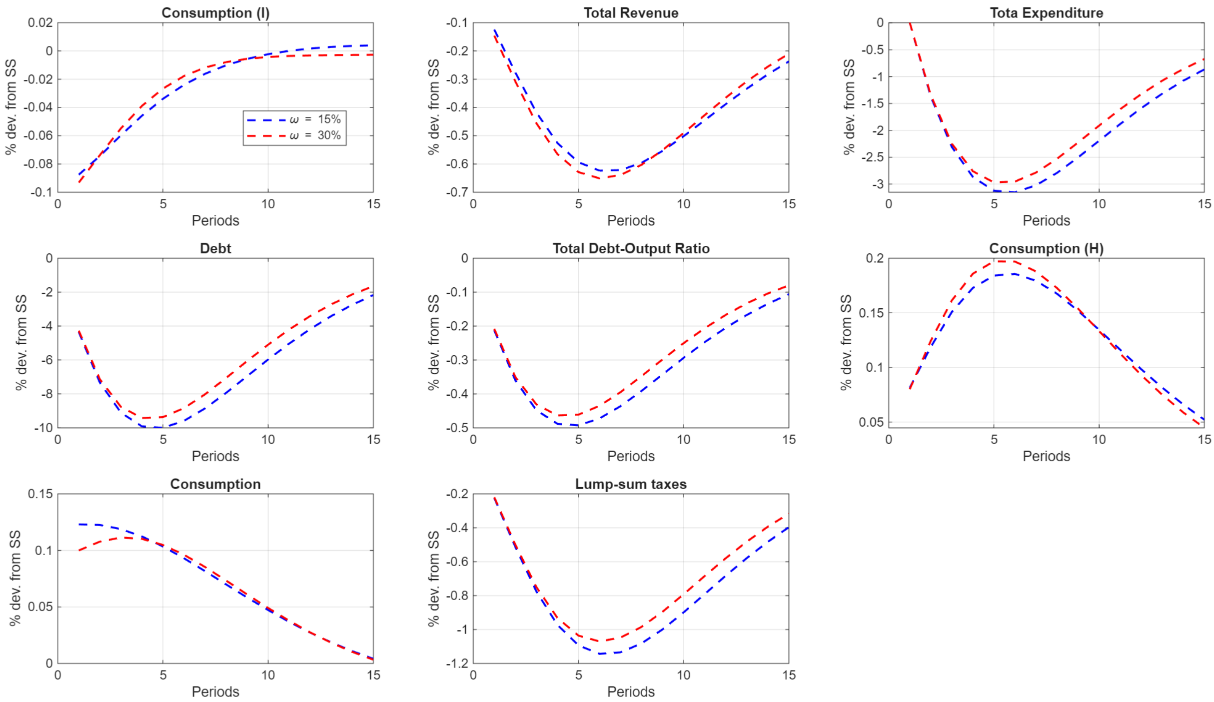
(a) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent



(b) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent



(c) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent



(d) *Note:* F: Formal Sector, I: Informal Sector, R: Ricardian Agent, H: HTM Agent

Figure C.4: Impulse responses for a single-period reduction in government investment in public capital when there is no utility from the public good.

Bibliography

Adjemian, Stéphane, Houtan Bastani, Michel Juillard, Ferhat Mihoubi, George Perendia, Marco Ratto & Sébastien Villemot (2011). "Dynare: Reference manual, version 4". In: Dynare Working Papers 1.

Alba, Carlos & Stephen McKnight (2022). "Laffer curves in emerging market economies: The role of informality". In: Journal of Macroeconomics 72, p. 103411.

Alberola, Enrique & Carlos Urrutia (2020). "Does informality facilitate inflation stability?" In: Journal of Development Economics 146, p. 102505.

Alesina, Alberto & Silvia Ardagna (2010). "Large changes in fiscal policy: taxes versus spending". In: Tax policy and the economy 24.1, pp. 35–68.

Alesina, Alberto, Carlo Favero & Francesco Giavazzi (2019a). "Effects of austerity: Expenditure-and tax-based approaches". In: Journal of Economic Perspectives 33.2, pp. 141–162.

Alesina, Alberto, Francesco Giavazzi & Carlo Favero (2019b). Austerity: When it Works and when it Doesn't. Princeton University Press.

Amaglobeli, David, Todd Benson & Ms Tewodaj Mogues (2024). Agricultural producer subsidies: Navigating challenges and policy considerations. International Monetary Fund.

Anand, Rahul & Purva Khera (2016). Macroeconomic impact of product and labor market reforms on informality and unemployment in India. Working Paper 16/47. International Monetary Fund.

Anand, Rahul & Eswar S. Prasad (2010). Optimal Price Indices for Targeting Inflation under Incomplete Markets. Working Paper 10/2000. Washington, DC: International Monetary Fund.

Anand, Rahul, Eswar S. Prasad & Boyang Zhang (2015). "What Measure of Inflation Should a Developing Country Central Bank Target?" In: Journal of Monetary Economics 74, pp. 102–116.

Aoki, Kosuke (2001). "Optimal Monetary Policy Responses to Relative-Price Changes". In: Journal of Monetary Economics 48, pp. 55–80.

Aruoba, S Borağan (2021). "Institutions, tax evasion, and optimal policy". In: Journal of Monetary Economics 118, pp. 212–229.

Ascari, Guido, Efrem Castelnuovo & Lorenza Rossi (2011). "Calvo vs. Rotemberg in a trend inflation world: An empirical investigation". In: Journal of Economic Dynamics and Control 35.11, pp. 1852–1867.

Atkeson, Andrew & Masao Ogaki (1996). "Wealth Varying intertemporal Elasticities of Substitution: Evidence from Panel and Aggregate Data". In: Journal of Monetary Economics 38, pp. 507–534.

Auclert, Adrien (2019). "Monetary Policy and the Redistribution Channel". In: Journal of Monetary Economics 119, pp. 2333–2367.

Bachas, Pierre, Lucie Gadenne & Anders Jensen (2024). "Informality, consumption taxes, and redistribution". In: Review of Economic Studies 91.5, pp. 2604–2634.

Balisacan, Arsenio M., Mercedita A. Sombilla & Rowell C. Dikitanan (2010). "Rice Crisis in the Philippines: Why did it occur and What Are its Policy Implications?" In: The Rice Crisis: Markets, Policies, and Food Security, pp. 123–142.

Banerjee, Shesadri & Parantap Basu (2019). "Technology shocks and business cycles in India". In: Macroeconomic Dynamics 23.5, pp. 1721–1756.

Banerjee, Shesadri, Parantap Basu & Chetan Ghate (July 2020). "A Monetary Business Cycle Model For India". In: Economic Enquiry 58 (3), pp. 1362–1386.

Baxter, Marianne & Robert G King (1993). "Fiscal policy in general equilibrium". In: The American economic review, pp. 315–334.

Baylis, Kathy, Ben Crost & Aditya Shrinivas (2019). "Labor Market E¤ects of Social Transfers: Evidence from India's Public Distribution System".

Beghin, John C., Jean-Christophe Bureau & Sung Joon Park (2003). "Food Security and Agricultural Protection in South Korea". In: American Journal of Agriculture Economics 85, pp. 618–632.

Blanchard, Olivier & Roberto Perotti (2002). "An empirical characterization of the dynamic effects of changes in government spending and taxes on output". In: the Quarterly Journal of economics 117.4, pp. 1329–1368.

Bouakez, Hafedh, Omar Rachedi & Emiliano Santoro (2025). "The sectoral origins of heterogeneous spending multipliers". In: Journal of Public Economics 248, p. 105404.

Bouakez, Hafedh & Nooman Rebei (2007). "Why does private consumption rise after a government spending shock?" In: Canadian Journal of Economics/Revue canadienne d'économique 40.3, pp. 954–979.

Broer, Tobias, Neils-Jakob Harbo Hansen, Per Krussel & Erik Öberg (2020). "The New Keynesian Transmission Mechanism: A Heterogeneous-Agent Perspective". In: Review of Economic Studies 87(1), pp. 77–101.

Brooks, Wyatt J, Joseph P Kaboski & Yao Amber Li (2021). "Agglomeration, misallocation, and (the lack of) competition". In: American Economic Journal: Macroeconomics 13.4, pp. 483–519.

Calvo, Guillermo A. (1983). "Staggered Prices in a Utility-Maximizing Framework". In: Journal of Monetary Economics 12 (3), pp. 383–398.

Cantelmo, Alessandro & Giovanni Melina (2023). "Sectoral labor mobility and optimal monetary policy". In: Macroeconomic Dynamics 27.1, pp. 1–26.

Carrière-Swallow, Yan, Antonio C David & Daniel Leigh (2021). "Macroeconomic effects of fiscal consolidation in emerging economies: New Narrative evidence from Latin America and the Caribbean". In: Journal of Money, Credit and Banking 53.6, pp. 1313–1335.

Census of India (2011). Census of India 2011-Rural Urban Distribution of Population.pdf. URL: https://censusindia.gov.in/nada/index.php/catalog/42617.

Chakraborty, Pubali, Anand Chopra & Lalit Contractor (2025). The equilibrium impact of agricultural support prices and input subsidies. STEG.

Chatterjee, Santanu, Thomas Lebesmuehlbacher & Abhinav Narayanan (2021). "How productive is public investment? Evidence from formal and informal production in India". In: Journal of Development Economics 151, p. 102625.

Chatterjee, Shoumitro, Rohit Lamba & Esha D Zaveri (2024). "The role of farm subsidies in changing India's water footprint". In: Nature communications 15.1, p. 8654.

Chen, Han, Vasco Curdia & Andrea Ferrero (2012). "The Macroeconomic Effects of Large Scale Asset Purchase Programs". In: The Economic Journal 122, F289–F315.

Christiano, Lawrence, Martin Eichenbaum & Sergio Rebelo (2011). "When is the government spending multiplier large?" In: Journal of Political Economy 119.1, pp. 78–121.

Cloyne, James S, Oscar Jorda & Alan M Taylor (2020). Decomposing the fiscal multiplier. Tech. rep. National Bureau of Economic Research.

Coenen, Günter, Christopher J Erceg, Charles Freedman, Davide Furceri, Michael Kumhof, René Lalonde, Douglas Laxton, Jesper Lindé, Annabelle Mourougane, Dirk Muir, et al. (2012). "Effects of fiscal stimulus in structural models". In: American Economic Journal: Macroeconomics 4.1, pp. 22–68.

Coenen, Günter, Roland Straub & Mathias Trabandt (2013). "Gauging the effects of fiscal stimulus packages in the euro area". In: Journal of Economic Dynamics and Control 37.2, pp. 367–386.

Colombo, Emilio, Davide Furceri, Pietro Pizzuto & Patrizio Tirelli (2022). Fiscal multipliers and informality. International Monetary Fund.

— (2024). "Public expenditure multipliers and informality". In: European Economic Review 164, p. 104703.

Colombo, Emilio, Lorenzo Menna & Patrizio Tirelli (2019). "Informality and the labor market effects of financial crises". In: World Development 119, pp. 1–22.

Das, Satadru, Chetan Ghate, Subhadeep Halder, Debojyoti Mazumder, Sreerupa Sengupta & Satyarth Singh (2025). Monetary Policy and Informal Labor Markets. Working Paper 47/2025. Centre for Applied Macroeconomic Analysis (CAMA).

Dave, Chetan, Chetan Ghate, Pawan Gopalakrishnan & Suchismita Tarafdar (2021). "Fiscal austerity in emerging market economies". In: Studies in Nonlinear Dynamics & Econometrics 25.5, pp. 365–391.

Dawood, Taufiq Carnegie & John Nana Francois (2018). "Substitution between private and government consumption in African economies". In: Economic Modelling 73, pp. 129–139.

De Loecker, Jan, Pinelopi K Goldberg, Amit K Khandelwal & Nina Pavcnik (2016). "Prices, markups, and trade reform". In: Econometrica 84.2, pp. 445–510.

De Ridder, Maarten, Basile Grassi & Giovanni Morzenti (2024). "The hitchhiker's guide to markup estimation: assessing estimates from financial data". In: Work. Pap., London Sch. Econ./Bocconi Univ./Analysis Group, UK/Milan, Italy/Paris, France.

Debortoli, Davide & Jordi Gali (2017). "Monetary Policy with Heterogeneous Agents: Insights from TANK models".

Dellas, Harris, Dimitris Malliaropulos, Dimitris Papageorgiou & Evangelia Vourvachaki (2024). "Fiscal policy with an informal sector". In: Journal of Economic Dynamics and Control 160, p. 104820.

DeLong, J Bradford, Lawrence H Summers, Martin Feldstein & Valerie A Ramey (2012). "Fiscal policy in a depressed economy [with comments and discussion]". In: Brookings Papers on Economic Activity, pp. 233–297.

Demirgüç-Kunt, Asli, Leora Klapper, Dorothe Singer & Saniya Ansar (2022). The Global Findex Database 2021: Financial inclusion, digital payments, and resilience in the age of COV World Bank Publications.

Drèze, J & A Somanchi (2021). "The Covid-19 crisis and food security". In: Ideas for India, http://www. ideasforindia. in/topics/poverty-inequality/the-covid-19-crisis-and-food-secur

Drèze, Jean & Reetika Khera (2013). "Rural poverty and the public distribution system". In: Economic and Political Weekly, pp. 55–60.

Dutta, Bhaskar & Bharat Ramaswami (2001). "Targeting and efficiency in the public distribution system: Case of Andhra Pradesh and Maharashtra". In: Economic and Political Weekly, pp. 1524–1532.

Elgin, Ceyhun, M Ayhan Kose, Franziska Ohnsorge & Shu Yu (2021). Understanding informality. Working Paper 76/2021. Centre for Applied Macroeconomic Analysis (CAMA).

Erceg, Christopher J & Jesper Lindé (2013). "Fiscal consolidation in a currency union: Spending cuts vs. tax hikes". In: Journal of Economic Dynamics and Control 37.2, pp. 422–445.

Esteban-Pretel, Julen & Sagiri Kitao (2021). "Labor market policies in a dual economy". In: Labour Economics 68, p. 101956.

Faia, Ester & Tommaso Monacelli (2007). "Optimal interest rate rules, asset prices, and credit frictions". In: Journal of Economic Dynamics and control 31.10, pp. 3228–3254.

Fatás, Antonio & Lawrence H Summers (2018). "The permanent effects of fiscal consolidations". In: Journal of International Economics 112, pp. 238–250.

Fernández, Andrés & Felipe Meza (2015). “Informal employment and business cycles in emerging economies: The case of Mexico”. In: Review of Economic Dynamics 18.2, pp. 381–405.

Fernández-Villaverde, Jesús & Juan Francisco Rubio-Ramírez (2004). “Comparing Dynamic Equilibrium Models to Data: a Bayesian Approach”. In: Journal of Econometrics 123.1, pp. 153–187.

Ferrara, Maria, Cristiana Fiorelli, Elisabetta Marzano & Monica Varlese (2025). “Fiscal consolidation plans with underground economy”. In: Economic Inquiry 63.1, pp. 144–159.

Frankel, Jeffrey (2010). “Monetary policy in emerging markets”. In: Handbook of Monetary Economics. Vol. 3. Elsevier, pp. 1439–1520.

Gabriel, J Vasco, Levine Paul, Pearlman Joseph & Bo Yang (2012). “An Estimated DSGE Model of the Indian Economy”. In: The Oxford Handbook of the Indian Economy. Ed. by Chetan Ghate. Oxford University Press, New York, pp. 835–890.

Gabriel, Vasco, Paul Levine, Joseph Pearlman & Bo Yang (2016). “An estimated DSGE model of the Indian economy”. In: Monetary Policy in India:A Modern Macroeconomic Perspective. Ed. by Chetan Ghate & Kenneth M. Kletzer. India: Springer.

Gali, Jordi (2015). “The Basic New Keynesian Model”. In: Monetary Policy, Inflation, and the Business Cycle (2nd Edition). Princeton University Press. Chap. 3, pp. 52–97.

Gali, Jordi & Tommaso Monacelli (2005). “Monetary Policy and Exchange Rate Volatility in a Small Open Economy”. In: Review of Economic Studies 72, pp. 707–734.

— (2008). “Optimal monetary and fiscal policy in a currency union”. In: Journal of International Economics 76.1, pp. 116–132.

Gali, Jordi, Javier Vallés & J. David López-Salido (2007). “Understanding the Effects of Government Spending on Consumption”. In: Journal of the European Economic Association 5, pp. 227–270.

Ghate, Chetan, Sargam Gupta & Debdulal Mallick (2018). “Terms of Trade Shocks and Monetary Policy in India”. In: Computational Economics 51, pp. 75–121.

Ghate, Chetan & Kenneth M Kletzer (2016). Monetary policy in India: A modern macroeconomic perspective. Springer.

Giavazzi, Francesco & Marco Pagano (1990). "Can severe fiscal contractions be expansionary? Tales of two small European countries". In: NBER Macroeconomics Annual 5, pp. 75–111.

Ginn, William & Marc Pourroy (2019). "Optimal Monetary Policy in the Presence of Food Price Subsidies". In: Economic Modelling 81, pp. 551–575.

— (2022). "The contribution of food subsidy policy to monetary policy in India". In: Economic Modelling 113, p. 105904.

Gulati, Ashok & Shweta Saini (2015). Leakages from public distribution system (PDS) and the way forward. Tech. rep. Working Paper.

Gunter, Samara R, Daniel Riera-Crichton, Carlos A Vegh & Guillermo Vuletin (2021). Policy implications of non-Linear effects of tax changes on output. Tech. rep. 1050 Massachusetts Avenue Cambridge, MA 02134: National Bureau of Economic Research.

Gupta, Sargam (2024). "Inefficient shocks and optimal monetary policy". In: Economic Modelling 135, p. 106720.

Horvath, Jaroslav & Guanyi Yang (2022). "Unemployment dynamics and informality in small open economies". In: European Economic Review 141, p. 103949.

Horvath, Michael (2000). "Sectoral shocks and aggregate fluctuations". In: Journal of Monetary Economics 45.1, pp. 69–106.

Hory, Marie-Pierre (2016). "Fiscal multipliers in emerging market economies: can we learn something from advanced economies?" In: International Economics 146, pp. 59–84.

Hossain, Mahabub & Uttam Deb (2010). "Volatility in Rice Prices and Policy Responses in Bangladesh". In: The Rice Crisis: Markets, Policies, and Food Security. The Food, Agriculture Organization of the United Nations, and Earthscan, pp. 91–108.

Huidrom, Raju, M Ayhan Kose & Franziska L Ohnsorge (2018). "Challenges of fiscal policy in emerging and developing economies". In: Emerging Markets Finance and Trade 54.9, pp. 1927–1945.

Ilzetzki, Ethan, Enrique G Mendoza & Carlos A Végh (2013). "How big (small?) are fiscal multipliers?" In: Journal of Monetary Economics 60.2, pp. 239–254.

Jalles, João Tovar, Carola Pessino & Ana Cristina Calderón (2025). "Fiscal Consolidations in Latin America and the Caribbean: Do Inequality, Informality and Corruption Matter?" In: Journal of Macroeconomics 84.

Johri, Alok, Shahed Khan & César Sosa-Padilla (2022). “Interest rate uncertainty and sovereign default risk”. In: Journal of International Economics 139, p. 103681.

Junior, Celso J Costa, Alejandro C Garcia-Cintado & Carlos Usabiaga (2021). “Fiscal adjustments and the shadow economy in an emerging market”. In: Macroeconomic Dynamics 25.7, pp. 1666–1700.

Kalra, Snigdha & Sargam Gupta (2025). Improving tax revenues in the emerging markets: A Laffer curve analysis. Tech. rep. Indira Gandhi Institute of Development Research, Mumbai, India.

Kaplan, Greg, Benjamin Moll & Giovanni Violante (2018). “Monetary Policy According to HANK”. In: American Economic Review 108, pp. 697–743.

Keen, Benjamin & Yongsheng Wang (2007). “What is a realistic value for price adjustment costs in New Keynesian models?” In: Applied Economics Letters 14.11, pp. 789–793.

Keller, Wouter J (1976). “A nested CES-type utility function and its demand and price-index functions”. In: European Economic Review 7.2, pp. 175–186.

Khan, Aubhik, Robert G. King & Alexander Wolman (2003). “Optimal Monetary Policy”. In: Review of Economic Studies 70, pp. 825–860.

Khera, Reetika (2011). “India’s public distribution system: utilisation and impact”. In: Journal of Development Studies 47.7, pp. 1038–1060.

— (2024). “Impact of the Food Security Act on Public Distribution System”. In: Perspectives.

Kraay, Aart (2012). “How large is the government spending multiplier? Evidence from World Bank lending”. In: The Quarterly Journal of Economics 127.2, pp. 829–887.

Kumar, Alok (2023). “Financial market imperfections, informality and government spending multipliers”. In: Journal of Development Economics 163, p. 103103.

Kumar, Ankit, Rahul Rao & Chetan Subramanian (2025). “Conventional vs. unconventional monetary policy under credit regulation”. In: Macroeconomic Dynamics 29, e52.

La Porta, Rafael & Andrei Shleifer (2014). “Informality and development”. In: Journal of economic perspectives 28.3, pp. 109–126.

Lahcen, Mohammed Ait & Pedro Gomis-Porqueras (n.d.). “A model of endogenous financial inclusion: implications for inequality and monetary policy”. Working Paper 310, Department of Economics - University of Zurich.

Leeper, Eric M, Todd B Walker & Shu-Chun Susan Yang (2009). Government investment and fiscal stimulus in the short and long runs. Tech. rep. 1050 Massachusetts Avenue Cambridge, MA 02138: National Bureau of Economic Research.

Leeper, Eric M., Nora Traum & Todd B. Walker (2017). "Clearing Up the Fiscal Multiplier Morass". In: American Economic Review 107, pp. 2409–2454.

Leeper, Eric M., Todd B. Walker & Shu-Chun S. Yang (2010). "Government Investment and Fiscal Stimulus". In: Journal of Monetary Economics 57, pp. 1000–1012.

Leyva, Gustavo & Carlos Urrutia (2020). "Informality, labor regulation, and the business cycle". In: Journal of International Economics 126, p. 103340.

Loecker, Jan De & Frederic Warzynski (2012). "Markups and firm-level export status". In: American Economic Review 102.6, pp. 2437–2471.

Lucas, Robert (1987). "Models of Business Cycles". In: Yrjö Johansson Lectures Series. London: Blackwell.

Martínez, Lina & Maria Isabel Zafra (2025). "The hidden penalties of informal work: Life-job satisfaction and negative affect". In: Wellbeing, Space and Society 8, p. 100253.

McKay, Alisdair, Emi Nakamura & Jon Steinsson (2016). "The Power of Forward Guidance". In: American Economic Review 106, pp. 3133–3158.

McPhail, Joseph, Peter Orazem, Rick Stammer & Rajesh Singh (2018). "Do State Marginal Tax Rates Lower State Labor Productivity?" In: mimeo.

Medina, Leandro & Friedrich Schneider (2019). Shedding light on the shadow economy: A global database and the interaction with the official one. Working Paper 7981/2019. CESifo working paper.

Mehrotra, Aaron N & James Yetman (2014). "Financial inclusion and optimal monetary policy". In: Monetary and Economic Department.

Mishra, Prachi, Peter Montiel & Rajeswari Sengupta (2016). "Monetary transmission in developing countries: Evidence from India". In: Monetary policy in India: A Modern Macroeconomic Perspective. Springer, pp. 59–110.

Muralidharan, Karthik, P Niehaus & S Sukhtankar (2011). "Piloting and evaluating e-PDS and cash transfer options for Improved Food Security in Bihar". In: Presentation at the Bihar Growth Conference.

Nandi, Aurodeep (2020). "Indian fiscal policy: a DSGE primer". In: The Journal of Developing Areas 54.2.

National Sample Survey (2011a).
Report 554 -Employment and Unemployment Situation in India. URL: https://cse.azimpremjiuniversity.edu.in/wpcontent/uploads/2019/06/NSS_68_Emp_Unemp_2011-2012.pdf.

— (2011b). Report 555-Level and Pattern of Consumer Expenditure 20ll-12. URL: https://www.mospi.gov.in/sites/default/files/publication_reports/nss_rep_555.pdf.

— (2011c).
Report 565 -Public Distribution System and Other Sources of Household Consumption 2011-12. URL: https://mospi.gov.in/sites/default/files/publication_reports/report_565_26june2015.pdf.

Pal, Rupayan & Udayan Rathore (2016). "Estimating workers' bargaining power and firms' markup in India: Implications of reforms and labour regulations". In: Journal of Policy Modeling 38.6, pp. 1118–1135.

Papp, Tamás K & Előd Takáts (2024). "Tax rate cuts and tax compliance–the Laffer curve revisited". In: Public Finance Quarterly= Pénzügyi Szemle 70.4, pp. 9–28.

PEO Report N0 189, Planning Commission (2005).
Performance evaluation of targeted public distribution system (TPDS). Tech. rep. Programme Evaluation Organisation. URL: https://dmeo.gov.in/sites/default/files/2019-10/Performance%20Evaluation%20of%20Targeted%20Public%20Distribution%20System%20%28TPDS%29.pdf.

Petrella, Ivan, Raffaele Rossi & Emiliano Santoro (2019). "Monetary Policy with Sectoral Trade-Offs". In: The Scandinavian Journal of Economics 121.1, pp. 55–88.

Petrella, Ivan & Emiliano Santoro (2011). "Input–output interactions and optimal monetary policy". In: Journal of Economic Dynamics and Control 35.11, pp. 1817–1830.

Pham, Toan Khanh Tran & Quyen Hoang Thuy To Nguyen Le (2024). "Does public debt moderate government spending–informal economy nexus? Evidence from the Asian countries". In: International Journal of Sociology and Social Policy 44.7/8, pp. 629–642.

Poole, William (1970). "Optimal choice of monetary policy instruments in a simple stochastic macro model". In: The Quarterly Journal of Economics 84.2, pp. 197–216.

Pourroy, Marc, Benjamin Carton & Dramane Coulibaly (2016). "Food prices and inflation targeting in emerging economies". In: International Economics 146, pp. 108–140.

Ramaswami, Bharat (2005). "The Public Distribution System". In: Prepared for the Oxford Companion to Economics in India. New Delhi: Indian Statistical Institute.

RBI's Handbook of Statistics on the Indian Economy, 2018-2019 (n.d.). Table 27: Public Distribution System – Procurement, Off-take and Stocks. URL: https://rbidocs.rbi.org.in/rdocs/Publications/PDFs/TABLE27A68593E6722446029CA014620E0EA3D3.PDF.

Reinhart, Carmen M & M Belen Sbrancia (2015). "The liquidation of government debt". In: Economic Policy 30.82, pp. 291–333.

Restrepo-Echavarria, Paulina (2014). "Macroeconomic volatility: The role of the informal economy". In: European Economic Review 70, pp. 454–469.

Saifullah, Agus (2010). "Indonesia's Rice Policy and Price Stabilization Program: Managing Domestic Prices During the 2008 Crisis". In: The Rice Crisis: Markets, Policies, and Food Security. The Food, Agriculture Organization of the United Nations, and Earthscan, pp. 109–122.

Schmitt-Grohe, Stephanie & Martin Uribe (2007). "Optimal, Simple and Implementable Monetary and Fiscal Rules". In: Journal of Monetary Economics 54, pp. 1702–1725.

Schmitt-Grohé, Stephanie & Martín Uribe (2006). Optimal simple and implementable monetary and fiscal rules: Expanded version.

Schorfheide, Frank (2000). "Loss function-based Evaluation of DSGE models". In: Journal of Applied Econometrics 15.6, pp. 645–670.

Shrinivas, Aditya, Kathy Baylis & Benjamin Crost (2025). "Food Transfers and Child Nutrition: Evidence from India's Public Distribution System". In: American Economic Journal: Applied Economics 17.3, pp. 161–207.

Sims, Eric & Jonathan Wolff (2018). "The Output and Welfare Effects of Government Spending Shocks over the Business Cycle". In: International Economic Review 59, pp. 1403–1435.

Singh, Rajesh, Amartya Lahiri & Carlos A Vegh (2017). Optimal Monetary Policy under Asset Market Segmentation. Tech. rep. Iowa State University, Department of Economics.

Singh, Rajesh & Chetan Subramanian (2009). "Optimal choice of monetary policy instruments under velocity and fiscal shocks". In: Economic Modelling 26.5, pp. 865–877.

Sinha, Dipa (2015). "Cash for food—A misplaced idea". In: Economic and Political Weekly, pp. 17–20.

Sivadasan, Jagadeesh (2009). "Barriers to competition and productivity: Evidence from India". In: The BE Journal of Economic Analysis & Policy 9.1.

Stähler, Nikolai & Carlos Thomas (2012). "FiMod—A DSGE model for fiscal policy simulations". In: Economic modelling 29.2, pp. 239–261.

Taylor, John (1993). "Discretion versus Policy Rules in Practice". In: Carnegie-Rochester Conference Series on Public Policy 35, pp. 195–214.

Thibault, Lemaire (2020). Fiscal Consolidations and Informality in Latin America and the Caribbean. Working Paper 764/2020. Banque de France.

Troug, Haytem (2020). "Monetary policy with non-separable government spending". In: Journal of Applied Economics 23.1, pp. 426–449.

Woodford, Michael (2001). Fiscal requirements for price stability.

— (2010). "Optimal Monetary Stabilization Policy". In: Handbook of Monetary Economics. North Holland. Chap. 14, pp. 723–828.

Zhou, Deshui, Qingqing Zhang & Jingshan Li (2024). "Impact of informal employment on individuals' psychological well-being: microevidence from China". In: International Journal of Mental Health Systems 18.1, p. 29.