

DISTRIBUTIONAL CONSEQUENCES OF MONETARY POLICY IN  
EMERGING MARKET ECONOMIES AND THE ROLE OF FOOD PRICES

by

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(Under the Direction of William D. Lastrapes)

ABSTRACT

My dissertation is devoted to studying the distributional consequences of monetary policy on household food consumption in emerging market economies, and the channel through which these distributional effects occur. The main contribution of my dissertation is finding evidence of the presence a “*food price channel*” of monetary policy in emerging market economies (EME’s). Three essays examine the impact of the “*food price channel*” of monetary policy on the distribution of food consumption in EME’s.

Chapters 2 and 3 of the dissertation, titled “The Food Price Channel: Effects of Monetary Policy on the Poor in India” and “Monetary Policy and Distribution of Food Consumption in China: The Role of Food Prices” estimate the dynamic effects of monetary policy shocks on *relative* food prices and the distribution of food consumption in two of the fastest growing emerging market economies-India and China respectively, by relying on household survey data and time series methods. Results for India and China show that the *relative* price of food responds *positively*, and the distribution of food consumption responds *negatively* to expansionary monetary policy shocks, providing evidence in favor of the impact of a “*food price channel*” of monetary policy on the distribution of food consumption in both economies. However, in India while expansionary monetary shocks via the “*food price channel*” appear to increase inequality, in China expansionary monetary shocks via the same

channel are found to reduce inequality.

Chapter 4 titled “The Food Price Channel in India Revisited” reinvestigates the impact of the “*food price channel*” of monetary policy on the distribution of food consumption in India, using a two sector dynamic stochastic general equilibrium (DSGE) model with flexible food and sticky non-food prices, and heterogeneous agents who differ in their proximity to *subsistence* food threshold. Results from the DSGE analysis point to expansionary monetary shocks having heterogeneous *negative* effects on food consumption which reduce food consumption at the lower end of the distribution much less than that at the upper end, thus reporting a decline in inequality from the “*food price channel*”.

INDEX WORDS:     Development, Food Price, Food Subsistence, Inequality, Monetary Policy, Poverty, Vector Autoregression

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## DEDICATION

For those who taught me how to learn

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## CHAPTER 1

### INTRODUCTION

Food security and hunger are a primary concern of developing countries, where they can have significant implications for long-term economic growth.<sup>1</sup> Food intake below the biological minimum leads to undernutrition, malnutrition, and mortality, which represent a direct loss to the human capital and productivity, thereby reducing the pace and durability of economic growth (Dreze and Sen, 1989; Horton, 1999; Behrman et al., 2004; Deaton and Dreze, 2009; Dreze and Sen, 2013). Despite concerns of food security, it has been largely ignored in the practice and conduct of monetary policy. How does monetary policy affect the distribution of food consumption? This question remains relatively unaddressed in the monetary policy literature. The objective of my dissertation is to fill the gaps by investigating the distributional consequences of monetary policy on household food consumption in two of the fastest growing emerging market economies of the world today - India and China. Both developing countries, even though have recorded robust GDP growth rates in the last 20 years, are strikingly different with regards to their demography, structure, household characteristics, and economic policies.

In chapter 2, using household survey data from 1996:Q2 to 2013:Q4, I estimate the dynamic effects of monetary policy shocks on the distribution of food consumption in rural and

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<sup>1</sup>Food and Agriculture Organization (FAO) defines “hunger” as chronic undernourishment and food intake less than 2100 Kcal, over a period of one year. About 795 million people or 11% of the world’s population suffer from chronic undernourishment. Almost all the hungry people, 780 million, live in developing countries. The 1996 World Food Summit defines “food security” as follows: “Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life”.

urban India from a dynamic common factor model (Bernanke, Boivin, and Elias, 2005 and Stock and Watson, 2011), and identify monetary policy shocks using the sign restriction approach of Uhlig (2005). I report two principal findings from my empirical investigation. First, expansionary monetary policy shocks have statistically significant *negative* effects on the distribution of food consumption in India. These shocks seem to play a non-trivial role in accounting for fluctuations in the distribution of food consumption. For example, forecast error variance decompositions suggest that the contribution of monetary policy shocks to fluctuations in food consumption of households is of the same order of magnitude (*nearly 15-20%*), as the contribution of these shocks to any other macroeconomic variable like GDP or inflation. Second, there appears to be strong heterogeneity in the food consumption responses faced by households across different expenditure classes to the policy shocks. The heterogeneous effects vary systematically across the expenditure distribution in rural and urban India: food consumption at the lower end of the distribution (poor households) falls far more than that at the upper end (rich households).<sup>2</sup> The lower the expenditure class, the higher the sensitivity and the lower the persistence to policy shocks. Expansionary monetary policy shocks in India are found to increase the observed inequality across households in food consumption.

Results of this chapter point towards a plausible channel through which these distributional effects occur - "*the food price channel*". The mechanism is fairly straightforward: in order to stimulate the economy when the central bank employs an expansionary monetary policy, food prices being relatively more flexible, adjust quicker than the overall price level in the economy. Thus expansionary monetary policy shocks generate an increase in the *relative* prices of food. Because poor households in India rely heavily on cash purchases of food and spend a disproportionate share of their income on food, this relative price

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<sup>2</sup>Poor households or low-income households feature those households who belong to the bottom 20% of expenditure/income distribution (bottom quintile or 20<sup>th</sup> percentile) and rich households or high income households feature those who belong to the top 20% (top quintile or 80<sup>th</sup> percentile).

response is tantamount to a large *negative* real income effect. Because food is a *necessity* and essential for welfare, their ability to substitute into other less expensive good, when food prices rise, is limited. Furthermore, poor households work in the informal sector (daily wage workers whose wages are not indexed to inflation) and do not have access to the formal banking system (no access to credit markets and simply consume their current labor income). Informal wages and borrowing constraints cannot hedge against the rise in relative food prices. Due to all these influences, expansionary monetary policy shocks reduce the food consumption of poor households significantly (from their biological minimum) and hurt them unintendedly. There does not appear to be much evidence of any factor that insulate the food consumption of households at the lower end of the expenditure distribution from the effects of policy shocks. Interestingly, rich households are relatively less affected by the rise in relative food prices. This is primarily because first, they spend relatively little on food due to which the negative income effect, if any, may be insignificant; second, they comprise the educated workforce in the formal sector, where wages tend to rise after expansionary monetary shocks; and finally, they are financially included due to which they can benefit from decline in interest rates following expansionary monetary shocks. Because rich households can gain from expansionary monetary shocks, it can offset for any lost real income. Lower food share, formal employment and financial inclusion can be quite effective at insulating the food consumption of households at the upper end of the expenditure distribution from the effects of policy shocks. Therefore expansionary monetary shocks which increase the relative price of food end up penalizing the poor far more than the rich, increasing the observed inequality across households in food consumption. In sum, while expansionary monetary policy is a potent tool to stimulate the economy, it may come with an unwanted side effect in India: decline in the *subsistence* food consumption of poor households and increase in food consumption inequality. To the extent, that Planning Commission of India relies on food based poverty measures such as the hunger criterion, food-share criterion, and calorie cut-off as criterion, the results also imply that expansionary monetary policy exacerbates

poverty in the country. Taken together, results of chapter 2 provide evidence of the impact of a “*food price channel*” of monetary policy on the distribution of food consumption, as well as poverty and inequality in India.

In chapter 3, I explore the “*food price channel*” of monetary policy for China. Using data from the household surveys conducted by China’s National Bureau of Statistics, I estimate the dynamic effects of monetary policy shocks on the *relative* price of food and the distribution of food consumption in rural and urban China from a vector auto regression (VAR) model, and identify monetary policy shocks using the sign restriction approach of Uhlig (2005). VAR results show that expansionary monetary policy shocks in China *positively* impact the *relative* price of food, and *negatively* impact the distribution of food consumption with smaller negative impact at the lower end of the distribution. More specifically, in rural China food consumption at the lower end of the distribution remains unaffected (on average) while that at the upper end of the distribution falls, and in urban China food consumption at the lower end of the distribution falls, but much less than that at the upper end. This is happening in China because first, the food demand of poor households who have very low levels of initial food consumption (*subsistence*) is relatively more price inelastic compared to rich households, suggesting that food is more a *necessity* for the poor (Portillo et al., 2012). Second, the rural poor in China rely heavily on self-produced food; food self sufficiency seem to be quite effective at insulating the food consumption responses of many rural households in the bottom of the income distribution from the effects of policy shocks. Expansionary monetary shocks in China are found to be associated with lower levels of food consumption inequality. Overall, results of chapter 3 also provide evidence of the impact of the “*food price channel*” of monetary policy on the distribution of food consumption and inequality in China.

Interestingly, the results observed for China (chapter 3) are a striking contrast to those observed for India (chapter 2). In India while expansionary monetary shocks via the “*food*

*price channel*” increase food consumption inequality, in China expansionary monetary shocks via the same channel reduce inequality. This observed difference in the results could be attributed to the differences in the characteristics and features of poor households across the two countries. In particular, there are four differential features that are noteworthy: (i) while in India the bottom quintile (poor households) allocate on average roughly 65-70% of their total budget towards food, in China they allocate about 50-55%; (ii) while in India the rural poor rely largely on cash purchases of food (*food purchased from the market*) to meet their daily food requirements which make them more sensitive to fluctuations in relative food prices, in China they rely heavily on self-produced food which plays a key role in dampening the effects of relative food price changes on them; (iii) while in India the poor live hand-to-mouth, i.e., they have no access to credit markets and simply consume their current labor income, in China the poor have significantly higher access to the formal financial institutions that hedge in some way against inflation (Anand and Prasad, 2015; Fungacova et al., 2015; Sparreboom and Duflos, 2012). Due to differences in the degree of financial inclusion, poor households in the two countries differ significantly in terms of their ability to smooth consumption behaviour in the face of idiosyncratic shocks. Finally, India is characterized by the presence of a huge informal sector (90%) compared to China (50%); higher relative food price acts as an implicit tax for the Indian poor engaged in the informal sector where wages are not indexed to inflation, and where workers don’t have much bargaining power vis-a-vis their employers. (Easterly and Fischer, 2001; Rada, 2010; Gulati and Saini 2013; Rajan, 2016). Due to the above factors, the privation imposed on the poor in India, by rise in relative food prices from expansionary monetary shocks is large enough, that their food consumption (despite being at subsistence) seems to be far more elastic with respect to price, than the poor in China. Therefore, expansionary monetary policy shocks, which increase the relative price of food, have stronger adverse effects on the Indian poor.

Aside from these factors, other differences in household characteristics (with regard to

socioeconomic and demographic factors, such as age and education, rural-urban migration, income, wealth, employment status, tax and housing status, patterns of food consumption) between the two economies could also potentially have implications for their response to changes in monetary policy. Many mechanisms through which monetary policy affects households in different ways may be at play, and it is a daunting task to disentangle and identify these effects empirically (Yannick and Ekobena, 2014). In conclusion, results for India and China suggest that in emerging market economies the impact of “*food price channel*” of monetary policy on inequality is a priori ambiguous, and rather specific to the household characteristics, institutions and histories of each economy.

Finally in chapter 4, I reinvestigate the impact of the “*food price channel*” of monetary policy on the distribution of food consumption in India using a dynamic stochastic general equilibrium (DSGE) model. The DSGE analysis is based on a two sector new-Keynesian model with flexible food and sticky non-food prices, and heterogeneous agents who differ in their proximity to subsistence food threshold. Results from the DSGE analysis point to expansionary monetary shocks having heterogeneous *negative* effects on food consumption which reduce food consumption at the lower end of the distribution much less than that at the upper end. Lower the income class, lower the sensitivity to policy shocks. Because proximity to subsistence reduces the income and price elasticities of demand in the food sector, and also reduces the inter-temporal elasticity of substitution (increases the risk aversion), poor households are far more demand inelastic with respect to food price compared to the rich. Consequently their food consumption does not show much variation in response to policy shocks. So, following expansionary monetary shocks, poor households witness a much smaller decline in food consumption compared to rich households.

Consistent with my FAVAR analysis in chapter 2, the DSGE analysis in chapter 4 also provides evidence in favor of the impact of the “*food price channel*” of monetary policy on

the distribution of food consumption in India. However contrary to the FAVAR analysis, the DSGE exercise points towards monetary expansion reducing the observed inequality across households in food consumption via the “*food price channel*” (instead of increasing). Understanding why the theoretical and empirical framework in the second and fourth chapter produce different results could be complex, however in understanding this, careful consideration needs to be given to how well the theoretical model is able to replicate the real economy. While the empirical framework (FAVAR) uses actual real time data which reflects many heterogeneous features of households like differential wages, labor market segmentation and financial inclusion, the theoretical exercise (DSGE) relies only on *proximity to subsistence* and abstracts away from many of the other aforementioned heterogeneous household characteristics. This is primarily done to keep the model simple and tractable. Incorporating some of the other heterogeneous features of households in the DSGE model like financial inclusion and labor market segmentation could be helpful in making the two models more comparable, however this is beyond the scope of the current study and forms an avenue for future research.

## CHAPTER 2

### THE FOOD PRICE CHANNEL: EFFECTS OF MONETARY POLICY ON THE POOR IN INDIA

#### 2.1 INTRODUCTION

Poverty and hunger are a primary concern of developing countries, where they can have significant implications for long-term economic growth.<sup>1</sup> Food intake below the biological minimum leads to undernutrition, malnutrition, and mortality, which represent a direct loss to the human capital and productivity, thereby reducing the pace and durability of economic growth (Dreze and Sen, 1989; Horton, 1999; Behrman et al., 2004; Deaton and Dreze, 2009; Dreze and Sen, 2013). Indirect losses from child undernutrition are caused by poor cognitive function, grade repetitions, and lower school attainment. Dasgupta (1997) shows that a poverty trap can operate with undernourished people finding it hard to get employment because they are unproductive, and remaining unproductive because they are unemployed. Many other studies have examined how physical productivity of labour and, thereby, employment and wages are related to food intake (Dasgupta, 1995; Haddard and Bouis, 1991; Sahn and Alderman, 1988; Behrman and Deolalikar, 1988; Dasgupta and Ray, 1986; Stiglitz, 1976). In total, the economic cost of hunger is estimated to range from 2 to 3 percent of Gross Domestic Product (GDP) in low income countries, to as much as 16 percent of GDP in most affected countries.<sup>2</sup>

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<sup>1</sup>Food and Agriculture Organization (FAO) defines “hunger” as chronic undernourishment and food intake less than 2100 Kcal, over a period of one year. About 795 million people, 11% of the world’s population suffer from chronic undernourishment and almost all the hungry people, 780 million, live in developing countries (FAO).

<sup>2</sup>Productivity losses as a result of undernutrition have been conservatively estimated in low income countries to be at least 2-3 percent of GDP annually (Horton, 1999; Behrman et al., 2004). However in Africa, these losses are very high. The economic costs of undernutrition have been

Despite its importance, poverty and hunger have been largely ignored in the practice and conduct of monetary policy. Most papers in applied monetary economics are concerned with aggregate macroeconomic data, and ignore the possible consequences of monetary policy interventions on poor households. The aim of this chapter is to fill the gaps by investigating the impact of monetary policy shocks on poor households in India - a developing country ranked as one of the fastest growing large economies in the world but paradoxically also ranked as one of the poorest countries in the world, measured by '*gross national income per capita*', that makes it an interesting case for such a study. In particular, I estimate the dynamic effects of monetary policy shocks on the distribution of food consumption and compare effects across this distribution, to understand its implications for poverty and inequality in the country. My primary motivation to select the food consumption distribution is the indispensable role played by food in the physical survival and welfare of the huge proportion of poor households in India. Nearly 25% of the population or close to 300 million people, live below the national poverty line and spend about 65-70% of their income on food. Despite spending such a large proportion of income on food, they still remain substantially food deprived. The per capita per day intake of calories for poor households is 1,500 Kcal in rural India and 1,577 Kcal in urban India, which is significantly below the biological minimum intake of 2,400 Kcal in rural areas and 2,100 Kcal in urban areas. Hunger accounts for 24% of under-five deaths and 30% of neo-natal deaths. Despite years of robust economic growth, poverty and hunger continue to remain India's compelling challenge.<sup>3</sup>

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estimated to be 16.5% of GDP in Ethiopia and 10.3% of GDP in Malawi (The Cost of Hunger in Africa-COHA study, African Union Commission, 2013).

<sup>3</sup>India has been ranked 97 among 118 developing countries (ranked from least to most hungry) in the 2016 Global Hunger Index. The GHI, adopted and developed by the International Food Policy Research Institute (IFPRI) in 2006, is a multidimensional statistical tool used to describe the state of a country's hunger situation. The GHI combines 4 component indicators: 1) the proportion of the undernourished as a percentage of the population; 2) the proportion of children under the age of five suffering from wasting; 3) the proportion of children under the age of five suffering from stunting; 4) the mortality rate of children under the age of five.

In this chapter, using household survey data from 1996:Q2 to 2013:Q4, I estimate the dynamic effects of monetary policy shocks on the distribution of food consumption in rural and urban India from a dynamic common factor model (Bernanke, Boivin, and Elias, 2005 and Stock and Watson, 2011), and identify monetary policy shocks using the sign restriction approach of Uhlig (2005). I report two principal findings from my empirical study. First, expansionary monetary policy shocks have statistically significant *negative* effects on the distribution of food consumption in India. These shocks seem to play a non-trivial role in accounting for fluctuations in the distribution of food consumption. For example, forecast error variance decompositions suggest that the contribution of monetary policy shocks to fluctuations in food consumption of households is of the same order of magnitude (*nearly 15-20%*), as the contribution of these shocks to any other macroeconomic variable like GDP or inflation. Second, there appears to be strong heterogeneity in the food consumption responses faced by households across different expenditure classes to the policy shocks. The heterogeneous effects vary systematically across the expenditure distribution in rural and urban India: food consumption at the lower end of the distribution (poor households) falls far more than that at the upper end (rich households).<sup>4</sup> The lower the expenditure class, the higher the sensitivity and the lower the persistence to policy shocks. Expansionary monetary policy shocks in India are found to increase the observed inequality across households in food consumption.

Results of this chapter point towards a plausible channel through which these distributional effects occur - "*the food price channel*". The mechanism is fairly direct: in order to stimulate the economy when the central bank employs an expansionary monetary policy, food prices being relatively more flexible, adjust quicker than the overall price level in the economy. Thus expansionary monetary policy shocks generate an increase in the *relative*

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<sup>4</sup>Poor households or low-income households feature those households who belong to the bottom 20% of expenditure distribution (bottom quintile or 20<sup>th</sup> percentile) and rich households or high income households feature those who belong to the top 20% (top quintile or 80<sup>th</sup> percentile). Refer to section 2.4 on data for details.

prices of food.<sup>5</sup> Because poor households in India rely heavily on cash purchases of food and spend a disproportionate share of their income on food, this relative price response is tantamount to a large *negative* real income effect. Because food is a *necessity* and essential for welfare, their ability to substitute into other less expensive good, when food prices rise, is limited. Furthermore, poor households work in the informal sector (daily wage workers whose wages are not indexed to inflation) and do not have access to the formal banking system (no access to credit markets and simply consume their current labor income).<sup>6</sup> Informal wages and borrowing constraints cannot hedge against the rise in relative food prices. Due to all these influences, expansionary monetary policy shocks in India reduce the food consumption of poor households significantly (from their biological minimum) and hurt them unintendedly. The policy shocks end up penalizing the poor far more than the rich.

Taken together, results of this chapter imply that, while expansionary monetary policy is a potent tool to stimulate the economy, it may come with an unwanted side effect: decline in the *subsistence* food consumption of poor households and increase in food consumption inequality. To the extent, that Planning Commission of India uses alternative poverty measures based on food such as the hunger criterion, food-share criterion, and calorie cut-off as criterion, the results also imply that expansionary monetary policy exacerbates poverty in India.

In prior literature, various channels explaining the impact of monetary policy on poverty and inequality focused mostly on advanced countries. Because monetary policy is transmitted through different direct and indirect channels, and because households in developing countries significantly differ from those in advanced countries in many respects (with regard

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<sup>5</sup>The relative price increase is not uniform across the different food types. In particular, agricultural food prices like cereals (rice, wheat, jowar, bajra, maize, barley, ragi, gram), lentils (arhar, moong, masur, urad), vegetables which are cheap sources of nutrition, and form the largest component of poor people's diet (more than 50%) increase more than manufactured food prices.

<sup>6</sup>Refer to section 2.2 on supporting evidence.

income, wealth, employment status, financial inclusion, institutions, patterns of consumption expenditure, savings etc.), channels through which monetary policy affects households in advanced countries may not be relevant to developing countries (Yannick and Ekobena, 2014). For example, on average, the share of food in total household expenditure is 40-50% in developing countries as compared to 10-15% in advanced countries (Figure 2.1; Anand and Prasad, 2015); on average more than half of the population in developing countries do not have access to the formal banking and financial system, by contrast in advanced countries, almost all households have such access (Figure 2.2; Anand and Prasad, 2015). Due to differences in the degrees of development across countries, monetary policy channels do not affect households in all countries in the same way.<sup>7</sup> The main contribution and novelty of this study is finding evidence of the impact of a “*food price channel*” of monetary policy on poverty and inequality in a developing country, India. This channel is particularly relevant to developing countries, due to certain features of poor households in these countries, notably being, high share of food expenditure in total consumption expenditure and low financial inclusion. This study may hold important policy implications for Indian policymakers as well as those in similar developing countries.

## 2.2 SUPPORTING EVIDENCE

In this section, I present some stylized facts that provide suggestive evidence of the dominant role played by changes in relative food prices in the welfare of the India poor.

Nearly 25% of the Indian population or close to 300 million people, live below the national poverty line of Rs 33 (50 cents) per person per day in urban areas and Rs 27 (42 cents) per person per day in rural areas. These poor households rely heavily on cash purchases of food, and spend a very large portion of their income, about 65-70%, on food (Figures

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<sup>7</sup>The distributional effects of monetary policy on the rich versus the poor is specific to the institutions, characteristics and histories of each economy (Easterly and Fischer, 2001).

2.3-2.6). Despite spending such a large portion of their income on food, they still remain substantially food deprived. The per capita per day intake of calories for these households is 1,500 Kcal in rural India and 1,577 Kcal in urban India, which is significantly below the biological minimum intake of 2,400 Kcal in rural areas and 2,100 Kcal in urban areas.

Because poor households in India rely heavily on the risky market for food and spend such a large proportion of their income on food, increase in relative food prices have large negative income effects on them.<sup>8</sup> Because they have very low levels of initial food consumption, food is a *necessity* for them, and their ability to substitute into other less expensive goods, when relative food prices increase, is limited. In a pioneering study, Mellor (1978) using a partial equilibrium analysis estimates the income effect of a change in relative prices of foodgrains on consumption and income distribution in India. The author finds that, all other influences being constant, the income effect on low-income people of foodgrain price changes is larger relative to high income people due to their very large food share, and that the bulk of adjustment to reduced food supplies is made by low-income households. Even though foodgrain is a *necessity* for the poor, yet the author finds that the expenditures of the poor on foodgrains are far more elastic with respect to the income effects of price than are those of the rich. The privation imposed on lower income deciles by rising grain prices is very great, that an increase in relative foodgrain prices leads to substantially reduced consumption by the poor of agricultural commodities of high nutritive value. In another empirical study on estimation of demand elasticities, conducted by the National Centre for Agricultural Economics and Policy Research, India (Kumar et al., 2011), the price elasticities with respect to food have been found to be much higher for the poor households compared to the rich. These studies suggest that in India, poor households are likely to be hurt much more from increase in relative food prices than the rich.

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<sup>8</sup>See literature.

The Public Distribution System in India is endeavoured to providing subsidized cereals and sugar to poor households but this does not seem to improve their nutrition status because, first, food grains distributed by the Public Distribution System (PDS) forms a small part of the food consumption of poor households (Figure 2.7), and second, these households still have to rely on the market for consumption of other essential food commodities such as lentils, milk, fruits and animal proteins that provide important micro nutrients to the human body.

Furthermore, the financial inclusion in India is very low, more than half of the population lack access to the formal financial and banking system (Figure 2.2). The poor live hand-to-mouth, i.e., they have no access to credit markets and simply consume their current labor income. Due to financial exclusion, the credit-constrained poor households cannot smoothen consumption behaviour in a way explained by permanent income hypothesis; they cannot insure against idiosyncratic shocks and market fluctuations (Anand and Prasad, 2015).

Finally, India is characterized by the presence of a huge informal sector (90%); higher relative food price acts as an implicit tax on the poor engaged in the informal sector where wages are not indexed to inflation, and where workers don't have much bargaining power vis-a-vis their employers (Easterly and Fischer, 2001; Rada, 2010; Gulati and Saini 2013; Rajan, 2016).<sup>9</sup>

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<sup>9</sup>Despite robust economic growth in India, mean real wages rose at a slow rate of only 1.03% in rural India and 2.6% in urban India. Sen et al. (2013) argue that the reason why economic growth in India has led to so little increase in wages is owing to 'jobless growth'. India's rapid economic growth during the last twenty years has been driven mainly by the 'service sector' which is heavily skill intensive (such as software development, financial services and other specialized work) rather than more traditional labor intensive sectors. While this has helped, the educated class to earn higher wages, the bulk of the labor force has been left behind in agriculture and other informal sectors (which employs more than 90 percent of the labor force) where wages remained very low.

The main summary from the above discussion is that, poor households in India rely heavily on the risky market to meet their daily food requirements, spend a very large proportion of their income on food, work in the informal sector and do not have access to the formal banking system; all these features make them vulnerable to fluctuations in relative food prices and hold potential implications for their response to changes in monetary policy.

## 2.3 LITERATURE REVIEW

My study is closely linked to three strands of literature, which I summarize below.

### 2.3.1 MONETARY POLICY AND FOOD PRICE

In the context of monetary policy, the main issue is whether food and non food prices adjust with the same frequency to monetary policy shocks or not.<sup>10</sup> It is theoretically argued that as agricultural prices are less rigid, they respond faster to changes in money supply than non-agricultural prices. Several theoretical models have been developed that explain this phenomenon. An important one is the overshooting model proposed by Frankel (1986). It divides an economy into two sectors: the agricultural sector with flexible prices and the manufacturing sector with sticky prices, and predicts that agricultural prices overshoot shortly after an expansionary money supply shock occurs. Further, Bordo (1980) shows that agricultural commodities exhibit lower transaction cost than manufactured goods, therefore agriculture prices are characterized by short term contracts and respond more quickly to monetary changes than do prices of other goods. The infrequent price adjustments to monetary changes has been empirically validated by a number of studies for different countries. For the US economy, Chambers and Just (1982), Barnett et al. (1983), Orden (1986), Orden and Fackler (1989), Cho et al. (1993), Dorfman and Lastrapes (1996), Lastrapes (2006), and

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<sup>10</sup>Richard Cantillon, in “An Essay on the Nature of Trade in General” published in 1755 was the first to point out the idea that price level changes are caused by increases in the quantity of money, which in turn depends on the way new money is injected into the economy and actually where it affects prices first.

Balke and Wynne (2007) provide empirical evidence that an increase in money supply raises agricultural prices relative to the general price level in the economy. The authors provide evidence of short- and long-run monetary non-neutrality. Several other studies have also found similar evidence in many emerging market economies. In Hungary, Slovenia, South Africa, India, Pakistan, China, Korea, the Philippines, and Thailand, authors have shown that monetary changes have real short- and long-run effects on agricultural prices (Saghaian et al., 2002; Peng, Marchant and Reed, 2004; Asfaha and Jooste, 2007; Siddiqui et al., 2010; Khundrakpam and Das, 2011; Bakucs and Ferto, 2013).

In sum, the literature on monetary policy and agricultural prices confirm the tendency of agricultural prices to be more flexible relative to the general price level, and therefore respond more quickly to changes in monetary policy than prices of other goods in the economy. Since poor households in developing countries spend a high proportion of their income on food and depend directly or indirectly on agriculture for a high proportion of their employment and income, the linkages between monetary policy variables and food prices hold potential implications for household welfare especially in the short run.

### 2.3.2 FOOD PRICE AND INCOME DISTRIBUTION

The most straightforward question about food price and income distribution in low income countries is, given all other factors are constant, what are the short run effects of a change in the relative price of food on the absolute and relative income levels of various household income classes?<sup>11</sup> Mellor (1978), using a partial equilibrium analysis, estimates the income

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<sup>11</sup>In the longer run, food prices may affect movements in the supply of wage-goods, and thereby influence the employment and income of poor households (Mellor, 1978). Thus, there are important trade-offs and conflicts among various direct short-run influences and indirect long-run effects of changes in relative food prices on the real incomes of the poor. Because the interrelationship among food price, supply of commodities, pattern of production, wage, employment, and income distribution are so complex, only a general equilibrium analysis can unequivocally determine the net effect of changes in relative food prices on income distribution. However, the substantial literature in this area is dominated largely by partial equilibrium analysis (Mellor, 1978).

effect of a change in relative prices of foodgrains on consumption and income distribution in India. The author finds that, all other influences being constant, the income effect on low-income people of foodgrain price changes is larger relative to high income people due to their very large food share, and that the bulk of adjustment to reduced food supplies is made by low-income households. Even though the initial level of foodgrain consumption in the lower income deciles is *subsistence* suggesting that foodgrain is a *necessity*, yet the author finds that the expenditures of the poor on foodgrains are far more elastic with respect to the income effects of price than are those of the rich. The privation imposed on lower income deciles by rising grain prices is very great, that an increase in relative foodgrain prices leads to substantially reduced consumption by the poor of agricultural commodities of high nutritive value.<sup>12</sup> In a related study, Ravallion (1990) goes beyond partial equilibrium analysis, and examines the rural welfare distributional effects of changes in relative foodgrain (rice) prices under induced wage responses for rural Bangladesh. The author concludes that an increase in the relative price of foodgrain is very unlikely to be passed on in the agricultural wage rate even in the long-run, and therefore the distributional effects on rural welfare in Bangladesh tend to be in the same direction as those implied by the partial equilibrium analysis of Mellor (1978): the rural rich are likely to gain and the rural poor lose from an increase in the relative price of food staples.

Apart from differential effects on real income of the rich and the poor, higher relative food prices also generate differential effects on the real income of net buyers and net sellers of food (Dev and Ranade, 1998; Kapila and Krishna, 2009). Dev and Ranade (1998) inves-

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<sup>12</sup>The foregoing partial analysis of the author is based on the calculation of the income effect of a relative price change holding everything else constant. *“The extent to which observed behavior is consistent with it depends on the extent of the substitution effects, and countervailing or reinforcing employment, and income effects. Substitution effects of relative price changes cannot be determined on an a priori basis and empirically cannot be separated from several other mechanisms at play. It is, of course, conceivable, but neither logical nor likely, that the poor would respond to increased foodgrain prices by substituting more expensive higher-quality foods which have not increased in price.”* (Mellor, 1978)

tigate the distributional consequence of a rise in relative food prices in India, through its effects on net buyers vs. net sellers of food. The authors find that by a very conservative estimate, the entire urban population and at least 50 per cent of the total rural population in India is adversely affected by an increase in relative prices of food. Robles and Torero (2010) in their 2007-2008 welfare study of 'food crisis' on four Latin American countries: Guatemala, Honduras, Nicaragua and Peru find that the 'poverty incidence' increases by 1% point in Guatemala, Honduras and Peru, and 4% points in Nicaragua from rise in relative food prices. Ivanic and Martin (2008) using preshock household survey data for 10 low-income countries estimate the welfare impact of increase in relative food prices, and again find that poverty increases in most countries in their sample even after accounting for the existence of net food sellers among the poor. Research studies done on Zimbabwe and Sub-Saharan Africa also provide empirical evidence of a positive correlation between relative food prices, poverty, hunger and child malnutrition (Wodon et al. 2010; Alderman, Hoddinott, and Kinsey, 2006).

Given these previous literatures a conclusion is reached: change in the relative prices of food is, in the short run, one of the most important determinants of change in the relative and absolute real income of poor households in developing countries, for, they rely heavily on cash purchases of food and end up spending a disproportionate share of their total budget on food.

### 2.3.3 MONETARY POLICY AND INCOME DISTRIBUTION

Recent literature has given a great deal of attention to monetary policy and income distribution, however most of these studies have been conducted on well-developed market economies. Coibion et al. (2012) summarize five channels whereby monetary policy can have effects on inequality (i) income composition channel - the tendency of capital income to rise more relative to wage income (ii) financial segmentation channel - the ability of some financial market

agents to benefit more from policy shocks than others (Williamson, 2009; Ledoit, 2009). (iii) portfolio channel - wealthy households who tend to be the largest holders of securities will gain more from asset market booms created by expansionary monetary policy (Erosa and Ventura, 2002; Albanesi, 2007; Saiki and Frost, 2014) (iv) savings redistribution channel - an unexpected decrease in interest rates will hurt savers and benefit borrowers (Doepke and Schneider, 2006; Coibion et al., 2012) and (v) earnings heterogeneity channel - the tendency of lower incomes to be more sensitive to the business cycle (Carpenter and Rodgers, 2004; Heathcote et al., 2010; Coibion et al., 2012). Because monetary policy is transmitted through different direct and indirect channels, and because households in developing countries significantly differ from those in advanced countries in many respects (with regard income, wealth, employment status, financial inclusion, institutions, patterns of consumption expenditure, savings etc.), monetary policy does not affect households in all countries in the same way (Easterly and Fischer, 2001; Yannick and Ekobena, 2014). Yannick and Ekobena (2014) find that whereas expansionary monetary policy via the *savings redistribution channel* decreases poverty in United States, the same channel is unable to capture any effects on poverty in Central Africa primarily because of very low financial development in that region. The main point is that monetary policy channels differ across countries with different degrees of development, and a significant contribution of this chapter is finding evidence of the impact of a “*food price channel*” of monetary policy on poverty and inequality in a low-income country, India.

## 2.4 DATA

The data sample I use for this study is quarterly and ranges from 1996:Q2 to 2013:Q4.<sup>13</sup> I measure aggregate output as real GDP (seasonally adjusted), the price level as the overall Consumer Price Index, the nominal interest rate as the Prime Lending Rate, and the stock

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<sup>13</sup>The time period has been selected based on the availability of quarterly macroeconomic data on India.

of nominal money as M3. Quarterly data on all the above macro variables are taken from the Federal Reserve Bank of St. Louis Data Base (FRED). The average annual growth rates of the macro-variables over the study period are reported in Table 2.1. India witnessed a robust real GDP growth of 6.7% per year over the study period. Nominal money and the overall consumer price index recorded average annual growth rates of 16.5% and 7.1% respectively. Below, I explain the data and sources for some of the other variables in detail.

#### 2.4.1 FOOD PRICE

I use the disaggregated food price data from the Ministry of Statistics and Programme Implementation, Central Statistical Organization: wholesale price indices of food at the highest level of disaggregation. There are over 150 series of individual food prices which includes prices of both agricultural food articles (like different varieties of cereals, lentils, vegetable, fruits, etc.), and manufactured food articles (like milk powder, biscuits, cookies, cakes & muffins, breads & buns etc.). However many of these series have incomplete coverage and missing data. The sample I use contains 98 food prices that have complete quarterly observations from 1996:Q2 to 2013:Q4. The list of the food price series along with the summary statistics is reported in Table 2.3. Figure 2.8 plots the movement in CPI vs. the average nominal food price index (*average of the 98 nominal food prices*) over the period 1996 to 2013. I note that the food price in India fluctuated far more than the general price level in the economy, suggestive of the evidence that food prices are relatively more volatile than the general price level in the economy.

#### 2.4.2 DISTRIBUTION OF FOOD CONSUMPTION

The household consumer expenditure surveys, published by India's National Sample Survey Organization, report the distribution of average nominal monthly per capita food consumption expenditure for different expenditure classes across rural and urban India.<sup>14</sup> Based on

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<sup>14</sup>Household consumer expenditure surveys have been conducted for the following years - 1994, 1997, 1999-2007, 2009 and 2011. For the missing years, during which the survey was not done I

these surveys, the Planning Commission of India characterizes poor and non-poor households. Households who just meet the national poverty line requirements are located in the 20-30% of expenditure distribution.<sup>15</sup> The Planning Commission of India therefore defines “*poor households*” as those who lie in the 0-20% of expenditure distribution, i.e., who lie below the national poverty line. Keeping in mind my focus on poverty and inequality, I select two expenditure classes for this study: households who are located in the 0-20% of expenditure distribution (bottom quintile or 20<sup>th</sup> percentile) and those who are located in the 80-100% of expenditure distribution (top quintile or 80<sup>th</sup> percentile). Consistent with the poverty literature in India, I refer to the former as low-income households or poor households, and the latter as high-income households or rich households. I compute quarterly averages of nominal monthly per capita food consumption expenditure of the poor and rich households taken from the household surveys, and deflate them by the wholesale price index (WPI) of food, to obtain their quarterly averages of real per capita food consumption expenditure (real PFCE). The real per capita food consumption expenditure serves as the measure of food consumption in this study. Figure 2.9 plots the real food consumption expenditures across the distribution in rural and urban India, respectively.<sup>16</sup> Following Coibion et al. (2012) who uses the difference between the 90th percentile and the 10th percentile of the log levels in consumption distribution, I use the difference between the 80th percentile and the 20th percentile of the log levels in food consumption distribution as a measure of food consumption inequality (*also popularly known as the Kuznets ratio*).

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geometrically interpolate the data points assuming constant growth and for the years 2012 and 2013, I extrapolate the numbers using data points of 2009 and 2011. Each household consumer expenditure survey is cross-sectional, representative at the national level and based on a stratified multi-stage sampling design. Participating households are randomly selected and report demographic data and household characteristics, and total consumption expenditure (food and non-food). The data on nominal food consumption expenditure is reported on the basis of a 30 day recall period.

<sup>15</sup>The Planning Commission of India quantifies, in terms of money, an ideal poverty line basket which includes a food component and a non-food component.

<sup>16</sup>I note some odd jumps in the pattern of food consumption particularly between 1997-2000 and 2006-2009. This could be because of statistical discrepancies first, in the coverage of the food items and second, in the method of collection, compilation and reporting of the data between different rounds. I have used, in total, 13 rounds of consumer expenditure surveys from NSSO covering the study period 1996-2013.

Figures 2.3-2.4 present the food expenditure shares of households in rural and urban India respectively. In rural India poor households allocate on average about 70% of their total consumption expenditures to food and rich households allocate about 35%, while in urban India poor households allocate about 65% and rich households 25%. These figures suggest that food expenditures comprise the largest component of poor households' budget accounting for more than half of their total expenditures. Further, Figure 2.6 reports what fraction the poor spend on different food types - cereal, lentils, vegetables, fruits, milk products, animal proteins, spices, sugar, salt, edible oils and beverages. I note that poor households spend maximum (upto 32 %) on cereals, followed by vegetables (17 %), the two cheapest source of nutrition in India. This means that among the different food types, fluctuations in the relative price of cereals and vegetables is likely to affect the poor the most.

### 2.4.3 MONETARY POLICY

The Reserve Bank of India (RBI) is India's central banking institution, which controls the monetary policy of the Indian Rupee. The objectives of monetary policy is to maintain a judicious balance between full employment output and price stability. The monetary policy framework and the associated operating procedure of monetary policy in India has evolved over time. Till mid- 1990's India followed a monetary targeting framework, however structural reforms and financial liberalisation in the late 1990s led to a shift in the monetary policy towards market-determined interest rates and exchange rate. The Reserve Bank adopted a 'multiple indicators approach' in April 1998 as a part of which, information content from a host of quantity variables such as money, credit, output, trade, capital flows and fiscal position as well as from rate variables such as rates of return in different markets, inflation rate and exchange rate was analyzed for drawing monetary policy perspectives. The multiple indicators approach suffered from the weakness of lack of a clearly defined nominal anchor

for monetary policy (Mohanty, 2010). In the backdrop of the same, The Reserve Bank introduced a full-fledged liquidity adjustment facility (LAF) in 2004, which was later reinforced in 2011, with the overnight call money rate (also known as the central bank rate) being explicitly recognised as the operating target of monetary policy and the repo rate, as the only one independently varying policy rate to influence the operating target (Mohanty, 2011).

Because monetary policy framework and the corresponding operating procedure in India underwent periodic modifications and shifts based on experience and development of financial markets, I use the overnight prime lending rate as an indicator of monetary policy change in India.<sup>17</sup> Figures 2.10-2.11 plot the movements in the prime lending rates and the nominal money supply (M3) respectively over the study period.<sup>18</sup>

## 2.5 EMPIRICAL FRAMEWORK

### 2.5.1 EMPIRICAL MODEL AND IDENTIFICATION

The aim of this chapter is to estimate the dynamic responses of relative food prices and the distribution of food consumption to monetary policy shocks in India. To achieve my objective, I make use of a factor-augmented vector auto regression framework (Bernanke, Boivin, and Elias, 2005 and Stock and Watson, 2011). A factor-augmented vector auto regression model (FAVAR) is particularly well-suited for this study because it provides a parsimonious means for incorporating (many different) individual food prices into the analysis without eating up degrees of freedom and also allows for heterogeneity in the

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<sup>17</sup>The Repo Rate is the (fixed) interest rate at which the Reserve Bank provides short-term (overnight) liquidity to banks against the collateral of government and other approved securities under the liquidity adjustment facility (LAF). The prime lending rate is the average rate of interest charged by major banks on loans to its credit worthy borrowers. Significant unidirectional causality has been found from policy interest rate to various measures of liquidity, providing evidence of a high degree of monetary policy transmission in India (Mohanty, 2013).

<sup>18</sup>The RBI instituted a “base rate” system, effective July 1, 2010, with the aim of enhancing transparency in lending rates of banks and enabling better assessment of the transmission of monetary policy (RBI Circular 2009-10/390; dated April 9, 2010). Due to this policy change, I note a dip in the PLR in 2010 (Figure 2.10).

responses across relative prices of the different food types to monetary policy shocks. The dynamic factor model summarizes information from a large sample of disaggregated food prices into one estimated food price index or one latent factor and studies its dynamic effects in response to monetary policy shocks.<sup>19</sup>

Let  $X_t$  be a  $n$ -dimensional vector stochastic process for a set of nominal wholesale price indices of food and a set of “informational” variables, and  $F_t$  be an  $q$ -dimensional vector of latent common factors.  $\Lambda$  is a  $n \times q$  matrix of “factor loadings”. The informational variables are primarily used in estimation to help extract the common latent factors. Given a time series realization for  $X_t$  and the observable subset of  $F_t$ , I estimate the following dynamic factor model of Bernanke, Boivin, and Elias (2005, equations (1) and (2)) and Stock and Watson (2011), and others:

$$X_t = \Phi_x X_{t-1} + \Lambda F_t + v_{xt} \quad (2.1)$$

$$\begin{bmatrix} Y_t \end{bmatrix} = \begin{bmatrix} Z_t \\ F_t \end{bmatrix} = B(L) \begin{bmatrix} Z_t \\ F_t \end{bmatrix} + \begin{bmatrix} \epsilon_t \end{bmatrix} \quad (2.2)$$

where,  $Y_t$  follows the following linear dynamic process

$$Y_t = B_1 Y_{t-1} + \dots + B_p Y_{t-p} + \epsilon_t \quad (2.3)$$

$Y_t$  is a  $m \times 1$  vector of data at date  $t = 1, \dots, T$ ,  $B_i$  are coefficient matrices of size  $m \times m$  and  $\epsilon_t$  is the one-step ahead prediction error with variance-covariance matrix  $\Sigma$ .

The system in Eq. (2.3) is the reduced form, from a dynamic structural model. My interest lies not in the reduced form shocks but, in identifying how the variables in  $Y_t$  respond to structural shocks. The structural counterpart to Eq. (2.3) in moving average form is given

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<sup>19</sup>Dynamic factor models are commonly used in macro-time series analysis to summarize information from a large time series data set into an estimated index, or factor and study its dynamic effects in response to aggregate shocks.

by:

$$Y_t = (I - B_y L)^{-1} D_y u_t \quad (2.4)$$

$$Y_t = (D_0 + D_1 L + D_2 L^2 + \dots) u_t \quad (2.5)$$

where  $u_t$  is a vector of aggregate structural shocks,  $E(u_t u_t')$  is normalized to be the identity matrix.<sup>20</sup> The mapping from the reduced form to the structural form thus entails restrictions on the covariance structure:

$$\Sigma = E(\epsilon_t \epsilon_t') = D_y E(u_t u_t') D_y' = D_y D_y' \quad (2.6)$$

Once I identify the  $m \times m$  matrix  $D_y$  from this mapping, I obtain the dynamic multipliers of interest from equation (2.3) using (2.4) and (2.5). In my study, I do not fully identify  $D_y$  because I am solely interested in the monetary policy shock.<sup>21</sup> So, I impose identifying restrictions to identify only the column of matrix  $D_y$  which corresponds to the monetary policy shock.

I identify a monetary policy shock using the “pure sign-restriction” approach of Faust (1998) and Uhlig (2005).<sup>22</sup> In particular, I identify an expansionary monetary policy shock as one that does not lead to a decrease in real GDP, CPI and nominal money, or an increase in the interest rates over a selected horizon. My primary reason for adopting the “pure sign-restriction” approach is because, first it produces results that are reasonable by conventional wisdom (Uhlig, 2005), and second it eliminates any prize puzzle by construction.

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<sup>20</sup>There are  $m$  fundamental innovations which are mutually independent and normalized to be of variance 1: they can therefore be written as a vector  $u_t$  of size  $m \times 1$  with  $E[u_t u_t'] = I_m$ .

<sup>21</sup>I do not identify the other  $m - 1$  fundamental innovations.

<sup>22</sup>Faust (1998) uses sign restrictions to identify monetary policy shocks, imposing them only at the time of impact, however Canova and De Nicol (2002) identify monetary shocks using sign restrictions on impulse response correlations. More recently, Dedola and Neri (2007) have used sign restrictions to identify technology shocks and Mountford (2005), Peersman (2005), Benati and Mumtaz (2007), Dungey and Fry (2009) and Fry and Pagan (2007) have addressed the issues pertaining to identification of multiple shocks using sign restrictions. .

However, even though the “pure sign-restriction” approach has many advantages over alternative just-identifying schemes, it does not completely lack for criticism. Fry and Pagan (2011) note that the “pure sign-restriction” approach successfully identifies only the structure but not the model. There is a multiple models problem because there are many set of impulse vectors that satisfy the sign restrictions, and will yield the same VAR and give the same fit to the data. One solution to overcome the model identification problem suggested by Fry and Pagan (2011) is to use quantitative information about the magnitude of the impulse responses and reduce the set of models. The “penalty function” method by Uhlig (2005) solves the model identification problem, by minimizing a given criterion function on the space of all impulse vectors, which penalizes any sign restriction violation. While pure sign restriction approach provides a range of impulse vectors consistent with sign restrictions, the penalty function approach uniquely identifies the model and selects the best of all impulse vectors (that goes as far as possible in imposing certain sign restrictions). Given a choice among many candidate monetary impulse vectors the “penalty function” approach picks the one which generates the most decisive response of the variables (Uhlig 2005, p. 414). I use the “penalty function” approach of Uhlig (2005, Appendix B.2, pp. 413-417) as a solution to the model identification problem and as a robustness check for my main empirical method.

## 2.5.2 MODEL SPECIFICATION AND ESTIMATION

Following Bernanke, Boivion, and Elias (2005), I use a two-step estimation method, in which the latent factor is first estimated by principal components prior to estimation of the factor-augmented vector auto regression model (FAVAR).

### MODEL SPECIFICATION

Step I:  $X_t$  in Eq. (2.1) contains the nominal wholesale price indices of 98 different food types. I estimate  $F_t$  as the first principal component of  $X_t$ :  $\hat{F}_t = \left(\frac{1}{n}\right) \hat{\Lambda}' X_t$ , where  $\hat{\Lambda}$  contains the eigenvectors of  $X_t$ , normalized so that  $\left(\frac{1}{n}\right) \hat{\Lambda}' \hat{\Lambda} = I$ . Thus  $\hat{F}_t$  is the estimated common

latent factor that serves as a proxy for the aggregate nominal food price index in my VAR model. I deflate this by the overall CPI to obtain the aggregate *real* food price index.<sup>23</sup>

Step II: With the common latent factor in hand from Step I, the next strategy depends on how I specify the macro subsystem ( $Z_t$ ) in Eq. (2.2). My aim is to estimate the dynamic responses of the distribution of food consumption to monetary policy shocks in rural and urban India respectively. Keeping in mind my objective, I include the following six macro-variables in the macro sub-system ( $Z_t$ ): real GDP, consumer price index (CPI), interest rate, nominal money supply, and the real per capita food consumption expenditures of the top quintile (HH in 80-100% of expenditure distribution) and the bottom quintile (HH in 0-20% of expenditure distribution) respectively.

#### ESTIMATION

The FAVAR ( $Y_t$ ) given by Eq. (2.3) includes the latent factor from step I, and the macro sub-system ( $Z_t$ ) from step II. Once I have specified the FAVAR, next I proceed to estimating the FAVAR using the pure sign restrictions approach. I run FAVAR estimation separately for rural and urban India. I have fitted a VAR with 4 lags in levels of the logs of all the series, except for using the interest rate directly. I add a constant and a time trend to Eq. (2.3). The horizon over which I impose the sign restrictions to identify monetary policy shocks is  $k = 2$  quarters, including the initial period of the shock. These restrictions are imposed only on the real output, consumer price index, interest rate and nominal money supply.<sup>24</sup>

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<sup>23</sup>By including  $\hat{F}_t$  in the VAR, I am augmenting the standard VAR model with an estimated latent factor; this makes the standard VAR a factor-augmented VAR.

<sup>24</sup>One problem confronting the estimation is that the variables in my model are all characterized as non-stationary  $I(1)$  variables (Table 2.2, Appendix Figures 2.24-2.25). Therefore, in the appendix I conduct a robustness check for my results; prior to estimation, I transform all data to log first-differences except for interest rate which is just first differenced to impose stationarity. Due to first differencing, I impose the sign restrictions on the cumulative impulse responses. I find that my results discussed in section 2.6, for the baseline VAR model (estimating the VAR in log levels) are robust to changes in model specification (estimating the VAR in log first differences) (Appendix Figures 2.26-2.29).

I use a Bayesian method to estimate the posterior densities of the parameters of interest, conditional on observing the sample data, for the baseline model as well as alternatives to check for robustness of the model specification. None of the results in section 2.6 are sensitive to increasing the common lag in the VAR to five lags, and to assuming the sign-restriction horizon as three quarters. My results discussed in section 2.6, for the baseline VAR model are robust to changes in model specification.

I estimate the posterior density using the “pure-sign restriction” approach of Uhlig (2005, Appendix B.1, pp 409-412) as generalized by Rubio-Ramirez, Waggoner, and Zha (2010). Note in particular that  $B$  and  $\Sigma$  are directly identified from estimation of the parameters in Eq. (2.3) using OLS. I assume a Gaussian likelihood function and a standard diffuse (Jefferey’s) prior on the reduced form parameters  $B$  and  $\Sigma$ , which implies that the joint posterior density of the parameters is of the Normal-Wishart form (Uhlig 2005, pp. 409-410):<sup>25</sup>

$$\Sigma^{-1} \sim W \left[ \left( T \hat{\Sigma}^{-1} \right), T \right] \quad (2.7)$$

$$(B|\Sigma) \sim N \left[ \hat{B}, \Sigma \times \hat{\Omega} \right] \quad (2.8)$$

where  $T$  is the time series sample,  $\hat{B}$  and  $\hat{\Sigma}$  are the OLS estimates of the dynamic factor model with observable factors, and  $\hat{\Omega} = \frac{1}{T} \sum_{t=1}^T Y_{t-1} Y_{t-1}'$ . The algorithm entails the following steps:

1. Estimate  $\hat{B}$  and  $\hat{\Sigma}$  from Eq. (2.3) by OLS. OLS is efficient given the restrictions of the model.
2. Draw  $\bar{B}$  and  $\bar{\Sigma}$  from the posterior distribution given by Eq. (2.7) and (2.8) and conditional on the OLS estimates from step 1.
3. Using the values from this draw, impose the sign restrictions to identify structural shocks using the following algorithm of Rubio-Ramirez, Waggoner, and Zha (2010, section 6.4, pp. 688)

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<sup>25</sup>see Uhlig(1994) for a detailed discussion on the properties of Normal-Wishart distribution

- (a) Draw a  $m \times m$  matrix  $M$ , element by element, from a standard normal density, and use its “Q-R” factorization to set  $M = QR$ , where  $Q$  is an orthogonal matrix ( $QQ' = I$ ) and  $R$  is normalized to have positive diagonal elements.
  - (b) Set  $D_y = \tilde{D}Q$  which from Eq. (2.5) implies values for  $\bar{D}_k$  for  $k = 1, \dots, K$ , where  $\tilde{D}$  denotes the lower-triangular Cholesky factor of  $\Sigma$ .
  - (c) If the  $\bar{D}_k$  estimates *do not satisfy* the sign restrictions for monetary policy shocks over the chosen horizon  $K$ , return to substep 3(a), draw a new value of  $Q$ , and continue until the draw of  $Q$  yields responses that satisfy the sign-restrictions.
  - (d) If the  $\bar{D}_k$  estimates *satisfy* the sign restrictions, compute and save the corresponding impulse response coefficients relating to the variables in  $Y_t$  and  $X_t$  to these shocks. Then return to step 2 and draw a new set of reduced form parameters.
4. Iterate on steps 2 through 3(d) until 20,000 draws from the posterior distribution of the dynamic responses of all the variables to monetary policy shocks (that satisfy the conditions of step 3(d)) are produced.

I report the median as well as the 16% and the 84% quantiles for the sample of impulse responses.

I use the “penalty function” approach of Uhlig (2005, Appendix B.2, pp. 413-417) as a robustness check for my main empirical method. Consistent with Uhlig (2005), I also find that the results from “penalty function” approach are a sharpening of the results from “pure sign-restrictions” approach, due to additionally desirable properties imposed on the magnitude of the impulse responses. In sum, my results discussed below using the “pure sign-restrictions” approach are robust to changes in the empirical specification.

## 2.6 EMPIRICAL RESULTS

### 2.6.1 DYNAMIC RESPONSES TO MONETARY POLICY SHOCKS

My interest is how the *relative* prices of food and the distribution of food consumption respond to monetary policy shocks. The impulse responses are presented in Figures 2.12-2.21. While Figures 2.12-2.13 present the dynamic responses for rural India, Figures 2.14-2.15 present the dynamic responses for urban India. The impulse responses for the *relative* prices of food at the disaggregated level are given by Figures 2.16-2.21.

I first discuss the results for rural India (Figures 2.12-2.13). An expansionary monetary policy shock causes the interest rate to fall by 30 basis points and the nominal money supply to rise by .40% on impact. The interest rate gradually rises and turns positive after 6 quarters for perhaps one of the following two reasons. First, this may reflect that monetary policy shocks really arise as errors of assessment of the economic situation by the central bank. The central bank may typically try to keep the steering wheel steady: should they accidentally make an error and shock the economy, they will try to reverse course soon afterwards. Second, this may reflect a reversal from a liquidity effect to a Fisherian effect. Given an expansionary monetary policy shock that results in a decline in interest rate by 30 basis points, output responds positively reaching a peak impact of .40% at a one-quarter horizon, and then makes a gentle descent back to its original value at the end of five quarters. The consumer price index increases permanently by .80% in response to the same shock. The impulse responses of the interest rate, nominal money, GDP, and CPI series discussed above lend validity to the identification scheme employed in this chapter (pure sign-restriction), suggesting reliability in the results for the other series, i.e., *relative* prices of food and the distribution of food consumption.

In response to the expansionary monetary shock, the aggregate relative food price index

increases monotonically, reaching a peak impact of .50 at a one-quarter horizon, continues to remain high for the next two quarters, and then gradually approaches its original value at the end of eighth quarters. This means that an expansionary monetary policy shock which results in a decline in interest rate by 30 basis points increases the relative price of food by .50%. Results of this chapter provide empirical evidence that food price is *relatively* more flexible, and following a monetary expansion adjust quicker than the overall price level in the economy. Further, even within the food sector all prices do not respond uniformly to the policy shock, i.e., monetary policy shocks have *distortionary* effects on the different individual food prices. In particular, I observe that prices of agricultural food articles like cereals (rice, wheat, jowar, bajra, maize, barley, ragi, gram), lentils (arhar, moong, masur, urad), vegetables, fruits, and spices (chilies, turmeric, cardamom, coriander, garlic) adjust faster than those of manufactured food items (butter, breads & buns, sugar, biscuits & cookies, oil).<sup>26</sup> These observations are consistent with standard microeconomic evidence in the new-Keynesian literature (Bils and Klenow, 2004; Dhyne et al., 2006; and Nakamura and Steinsson, 2008) that first, food prices change more frequently than the general price level in the economy and second, unprocessed food prices change with markedly higher frequency than manufactured food prices.<sup>27</sup> In India, cereals and lentils (rice, wheat, jowar, bajra, maize, barley, ragi, gram, arhar, moong, masur, urad etc.) are cheap sources of nutrition, and form the largest component of poor people's diet. Results of this chapter show that relative prices of agricultural commodities that form kitchen-staples of the poor in India (eg. cereals, lentils and vegetables that form 50% of the poor people's budget) increase relatively more in response to monetary shocks than other food items. This asymmetric effect of monetary policy on individual food prices can hold potential implications for poor households, especially their incentives for substitution across food types in the face of expansionary monetary shocks.

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<sup>26</sup>The matrix of factor loading is provided in Table 2.3. The impulse responses for disaggregated food prices are given by Figures 2.16-2.21.

<sup>27</sup>Refer to chapter 4, figure 4.3.

The response functions of the distribution of food consumption is the main focus of this research (Figures 2.12-2.13). In rural India, I find that the distribution of food consumption responds negatively to expansionary monetary shocks, with larger negative effects at the lower end of the distribution. Poor households witness a much larger decline in food consumption than the rich. Given an expansionary monetary policy shock, that increases the relative food price index by .50%, while the real per capita food consumption expenditure of low income households (0-20% of expenditure distribution) fall by 1.40% , that of high income households (80-100% of expenditure distribution) fall by only .50% on impact. I further note that the food consumption response of low-income households remains in the negative region for first four quarters then comes back to its original value at the beginning of the fifth quarter, while that of high-income households continue to remain in the negative range for the entire sample period (eighth quarters). The dynamic responses of the low-income and high-income households provide suggestive evidence, that the lower the expenditure class, the higher the sensitivity and the lower the persistence to policy shocks. Thus, there appears to be strong heterogeneity in the food consumption responses faced by different households. The heterogeneity becomes more prominent, when I plot the difference between the food consumption responses of the high-income and low income households (Figure 2.13). Using the difference between the 80th percentile and the 20th percentile of the log levels in the food consumption distribution as a measure of food consumption inequality, I find that food consumption inequality increases from expansionary monetary shocks to an economically meaningful extent (.90%) in rural India, with the largest impact in the initial quarters following the shock.

Next, I discuss the results for urban India (Figure 2.14). Strikingly, the results for urban India and rural India are highly symmetric. An expansionary monetary policy shock causes the interest rate to fall by 30 basis points, and the money supply to increase by .40% on

impact. Relative food price increases monotonically, reaching a peak impact of .50 at a one-quarter horizon, continues to remain high for the next two quarters, and then gradually starts falling. Consistent with rural India, I find that the distribution of food consumption responds negatively to expansionary monetary shocks. Results for urban India again point to expansionary monetary policy shocks having heterogeneous negative effects on food consumption which reduce food consumption at the lower end of the distribution far more than that at the upper end. Following the expansionary monetary shock, while the real per capita food consumption expenditure of low income households fall by 1.10%, that of high income households fall by .30% on impact.<sup>28</sup> Figure 2.15 plots the difference between the food consumption responses of high-income and low income households; the results again indicate that expansionary monetary policy shocks are associated with higher levels of food consumption inequality (.80%) in urban India.

### 2.6.2 WHY DO THE RICH AND POOR BEHAVE DIFFERENTLY?

In the previous subsection, I provide empirical evidence that expansionary monetary policy shocks negatively affect the distribution of food consumption, penalizing poor households more than the rich. In this sub-section, I analyse the reasons for the observed heterogeneity in the food consumption responses of the poor vis-a-vis the rich.

A very surprising finding in this study is that, even though poor households have very low levels of initial food consumption (*subsistence*) indicating that food is a necessity (*demand-inelastic*), yet following a monetary expansion the poor witness a much greater fall in food consumption than the rich. Results of this chapter indicate that poor households in India are

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<sup>28</sup>The food consumption response of low-income households remains in the negative region for first four quarters, then reverses course and turns positive in the fifth quarter, while that of high-income households remain in the negative range for first five quarters, then comes back to its original value at the end of six quarters suggestive of the evidence that the effects of these shocks are more persistent on high income households.

relatively more sensitive but less persistent to expansionary monetary shocks than the rich.<sup>29</sup>

The observed heterogeneity in the food consumption responses of rich and poor households seem to emerge from the differences in the characteristics and features of these households in India.<sup>30</sup> In particular, there are four differential characteristics that are noteworthy: (i) while poor households spend a disproportionate share of their total budget on food (almost 65-70%), rich households spend relatively less on food (only 25-35% ); (ii) while the rural poor rely heavily on cash purchases of food to meet their daily food requirements which makes them more sensitive to fluctuations in relative food prices, a huge fraction of the rural rich (farmers with large landholding) rely on self-produced food which plays a key role in dampening the effects, on them, of relative food price changes; (iii) while the poor live hand-to-mouth, i.e., they have no access to credit markets and simply consume their current labor income, the rich have significantly higher access to the formal financial institutions that hedge in some way against inflation; (iv) finally, while the poor households comprise the unskilled labor force in the informal sectors, the rich households comprise the educated workforce in the more skill-intensive formal sectors (Sen et al., 2013); higher relative food price acts as an implicit tax on the poor, engaged in the informal sector where wages are not indexed to inflation, and where workers don't have much bargaining power vis-a-vis their employers. (Easterly and Fischer, 2001; Rada, 2010; Gulati and Saini 2013; Rajan, 2016 ).

Due to the above influences, even though food is a *necessity* for the poor (because of their proximity to subsistence), but the privation imposed on them by rise in relative food prices from expansionary monetary shocks is such large that their food demand seems to be

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<sup>29</sup>Because of very low levels of initial food consumption, the fall in food consumption of the poor is observed for very few quarters.

<sup>30</sup>see section 2.

far more elastic with respect to price compared to the rich.<sup>31</sup> Therefore following monetary expansion, the poor witness a much greater fall in food consumption than the rich.

### 2.6.3 HOW MUCH VARIATION DO MONETARY POLICY SHOCKS EXPLAIN?

I now turn to the question of assessing the economic importance of monetary policy shocks in accounting for the dynamics of the food consumption distribution in India. I do so by studying the share of the variance in the food consumption distribution which can be accounted for by monetary policy shocks over the given time period. According to the median estimates shown in the middle lines of Figures 2.22-2.23, monetary policy shocks account for 15-20 % of the variation in relative food price index and the distribution of food consumption in most forecast horizons. Monetary policy shocks appear to have played a non-trivial role in accounting for fluctuations in food consumption of households in rural and urban India over the study period. Figures 2.22-2.23 also plot equivalent variance decompositions for all other macroeconomic variables over the same time period. Monetary policy shocks account for upto 15 % of the variation in real GDP, and upto 25% of the variations in interest rate and CPI at all horizons. The forecast error variance decompositions show that the contribution of monetary policy shocks to fluctuations in food consumption of poor households is of the same order of magnitude as the contribution of these shocks to other macroeconomic variables like GDP and inflation, suggestive of the evidence that these shocks are important.

In the next section, I discuss in detail the potential causal channel for my empirical findings.

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<sup>31</sup>My findings are also consistent with the findings of Mellor (1978) and many others, that in India the expenditures of the poor on food are far more elastic with respect to the income effects of price than are those of the rich (refer to literature).

## 2.7 THE FOOD PRICE CHANNEL: DISCUSSION

This chapter documents that the *relative* price of food responds positively and the distribution of food consumption responds negatively to expansionary monetary policy shocks in India. In addition, there appears to be strong heterogeneity in the food consumption responses faced by households across different expenditure classes to monetary policy shocks, where households at the lower end of the distribution witness a much larger decline in food consumption than those at the upper end. Because the food consumption at the lower end of the distribution falls more than that at the upper end, inequality in food consumption increases from monetary shocks to an economically meaningful extent in both rural and urban India.

Interestingly, results of this chapter point towards a plausible channel through which these distributional effects occur - "*the food price channel*". The underlying mechanism is that, in order to stimulate the economy when the central bank employs an expansionary monetary policy, food prices being relatively more flexible, adjust quicker than the overall price level in the economy. Thus, expansionary monetary policy shocks generate an increase in the *relative* prices of food. Further, the relative price increase is not uniform across the different food types. In particular, agricultural food prices like cereals (rice, wheat, jowar, bajra, maize, barley, ragi, gram), lentils (arhar, moong, masur, urad), vegetables, and fruits which are cheap sources of nutrition, and form the largest component of poor people's diet (more than 50%) increase more compared to manufactured food prices. Because poor households rely heavily on cash purchases of food and spend a large proportion of their income on food, this relative price response is equivalent to a large negative income effect. Because food is a *necessity* for the poor and essential for their welfare, poor households have limited ability to substitute into other less expensive good when relative price of food rises. Furthermore, financial constraints and informal employment cannot hedge against the marked rise in relative food prices. Consequently, expansionary monetary policy shocks via the increase in

relative food prices, reduce the subsistence food consumption of poor households, hurting them unintendedly. There does not appear to be much evidence of any factor that insulate the food consumption of the poor from the effects of policy shocks.<sup>32</sup> Relying on food based poverty measures (explained in the next section), this means that poverty increases from monetary expansion. In sum, results of this chapter provide empirical evidence of the impact of a “*food price channel*” of monetary policy on poverty and inequality in India.

## 2.8 POVERTY

Poverty is a multi-dimensional phenomenon and deprivation of food is one, most crucial component.<sup>33</sup> The Planning Commission of India uses alternative poverty measures based on food such as the hunger criterion, food-share criterion and calorie cut-off as criterion (Planning Commission 1993, 2014). These are standard poverty measures in many other low income countries also, like Bangladesh, Tanzania, Cambodia, Rwanda, and many of the other African countries.<sup>34</sup>

Typical to low income economies, this chapter adopts a food based poverty measure. The “*Poverty Gap Index*” measures the depth of poverty by considering how far, on average,

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<sup>32</sup>Similar to many papers (Carpenter and Rodgers, 2004; Heathcote et al., 2010; Coibion et al., 2012), where the employment channel of monetary policy explains the tendency of employment of lower incomes to be more sensitive to the business cycle and monetary policy shocks, in this chapter, the food price channel of monetary policy explains the tendency of food consumption of lower incomes to be more sensitive to monetary policy shocks.

<sup>33</sup>The idea of multi-dimensional poverty is that poverty manifests itself in multiple deprivations, such as lack of food, poor health, lack of education, absence of sanitation facilities, and various kinds of material deprivations. A person is counted as ‘multi-dimensionally poor if he or she experiences at least a certain proportion (say one third) of these deprivations. (Sen, 2001; Sen et al., 2013)

<sup>34</sup>With given tastes or preferences, the proportion of income spent on food diminishes as income increases. Poor living is characterised by a large proportion of the total consumer expenditure taken up by items such as food which are absolutely essential for sheer physical survival; the proportion of expenditure on food is therefore used as a measure of the welfare of the poor (Engel’s Law). Anand and Harris (1994) do a theoretical and empirical welfare analysis using Sri Lankan data, and find that of the four possible indicators of living standard (namely income per capita, total expenditure per capita, food expenditure per capita and the share of food in total expenditure), food expenditures per capita gives the best guidance to the households’ living standard.

the poor are from the poverty line: the greater the distance from the poverty line, the greater the depth of poverty in the country (Poverty Manual, Chapter 4, World Bank).<sup>35</sup>

The “*Poverty Gap Index*” is given by:

$$PGI = \frac{1}{N} \sum_{i=1}^N \left[ \frac{z - x_i}{z} \right] [I(x_i \leq z)] \quad (2.9)$$

The specifications of the variables in Eq. (2.9) are explained below.

1. *PGI* is the Poverty Gap Index.
2.  $x_i$  is the food intake, or more generally the caloric intake of poor households. In this chapter, it is measured by the real per capita food consumption expenditure of households who lie in the 0-20% of expenditure distribution, i.e, who lie below the national poverty line.<sup>36</sup>
3.  $z$  is the food component of the poverty line basket (*the food poverty line*) which is determined by policy makers and exogenous to monetary policy shocks.
4.  $I(\cdot)$  is an indicator function that is 1, if it’s argument is true and 0, otherwise. Because poor households are located below the poverty line, their food consumption is less than the food component of the poverty line basket; therefore  $(x_i \leq z)$  and  $I(\cdot) = 1$ .
5. Any further fall in  $x_i$ -the real per capita food consumption expenditure of the poor from the poverty line- $z$  is tantamount to an equivalent rise in the poverty gap index.

Relying on a food based poverty measure, this chapter documents that expansionary monetary shocks, via the “*food price channel*” increases the intensity (depth) of poverty in India.

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<sup>35</sup>The poverty gap as a poverty measure is an improvement over the poverty headcount because the latter simply counts the number of people below a poverty line and considers them equally poor whereas the former measures the extent to which individuals fall below the poverty line and indicates how poor the poor are. In other words poverty headcount gives a measure of the incidence of poverty but poverty gap gives a measure of the depth of poverty (Poverty Manual, Chapter 4, World Bank).

<sup>36</sup>Refer to data.

## 2.9 SUMMARY AND CONCLUSION

*“The analysts cheer every cut in interest rates because markets are assumed to have a Pavlovian positive response to them. Even the poor are inured to their fate of seeing real incomes erode, and are only aggrieved when the price of some food staple sky-rockets.”*

*Rajan, 2016*

Overall, results of this chapter provide evidence of the impact of a “*food price channel*” of monetary policy on the distribution of food consumption in India. The mechanism is that, in order to stimulate the economy when the central bank employs an expansionary monetary policy, food prices being relatively more flexible, adjust quicker than the overall price level in the economy. Thus, expansionary monetary policy shocks result in an increase in the *relative* prices of food (and more so for cereals and vegetables which form the staple diet of the poor). Because poor households rely heavily on cash purchases of food and spend a large proportion of their income on food, this relative price response is tantamount to a negative real income effect. Furthermore, financial constraints and informal wages cannot insure against the loss in real income. Due to the above influences, the privation imposed on the poor by rise in relative food prices from expansionary monetary shocks is large enough, that their food consumption falls significantly, despite being at a biological minimum (subsistence). I note this both in rural and urban India. There does not appear to be much evidence of any factor that insulate the food consumption of households at the lower end of the expenditure distribution from the effects of policy shocks. Interestingly, rich households are relatively less affected by the rise in relative food prices. This is primarily because first, they spend relatively little on food due to which the negative income effect, if any, may be insignificant; second, they mostly work in the formal sector, where wages tend to rise after expansionary monetary shocks; and finally, they are financially included due to which they can benefit from decline in interest rates following expansionary monetary shocks. Because rich households can gain from expansionary monetary shocks, it can offset

for any lost real income. Lower food share, formal employment and financial inclusion can be quite effective at insulating the food consumption of households at the upper end of the expenditure distribution from the effects of policy shocks.

Using household survey data and a factor augmented vector auto regression model (FAVAR) this chapter documents that expansionary monetary policy shocks have statistically significant *negative* effects on the distribution of food consumption in India; these shocks seem to play a non-trivial role in accounting for fluctuations in the distribution of food consumption. The effects on food consumption vary systematically across the expenditure distribution in rural and urban India: food consumption at the lower end of the distribution falls far more than that at the upper end. Expansionary monetary policy shocks are found to be associated with higher levels of food consumption inequality in the country.

In conclusion, results of this chapter imply that, while expansionary monetary policy is a potent tool to stimulate the economy, it may come with an unwanted side effect in India: decline in the subsistence food consumption of poor households and increase in food consumption inequality. To the extent, that Planning Commission of India relies on food based poverty measures such as the hunger criterion, food-share criterion, and calorie cut-off as criterion, the results also imply that expansionary monetary policy exacerbates poverty in the country.

In addition to the relevance for India, this chapter also points to potential implications of following expansionary monetary policy in other developing countries, where relative food prices play a dominant role. This chapter identifies empirical regularities regarding the impact of monetary policy on poverty and inequality in India, which could eventually serve as reference in the development of models for monetary policy analysis and formulation in other low-income countries. It is possible that the “*food price channel*” will be more

dominant in African economies, where poor households spend an even larger portion of their income on food (75%).

In the next chapter, I explore the “*food price channel*” in the context of another large emerging market economy, China.

## FIGURES AND TABLES

<i>Emerging Markets</i>		<i>Advanced Economies</i>	
Indonesia	53.0	Japan	14.7
Vietnam	49.8	Germany	11.5
India	48.8	Australia	10.8
China	36.7	Canada	9.3
Russia	33.2	United Kingdom	8.8
Malaysia	28.0	USA	5.7
<b>Average</b>	<b>41.6</b>	<b>Average</b>	<b>10.1</b>

Figure 2.1: Cross Country Comparison, Share of Food in Total Expenditure (%).

Source: Anand and Prasad, 2015.

<i>Selected EMs</i>	<i>Percent with access</i>	<i>Selected EMs</i>	<i>Percent with access</i>
Argentina	33	Nigeria	30
Brazil	56	Philippines	27
Chile	42	Poland	70
China	64	Russia	48
India	35	South Africa	54
Indonesia	20	Thailand	73
Kenya	42	Turkey	58
Malaysia	66		
<b>Median (29 Emerging Markets): 42</b>		<b>Median (27 Advanced Economies): 96</b>	

Figure 2.2: Cross Country Comparison, Financial Inclusion (%).

Source: Anand and Prasad, 2015.

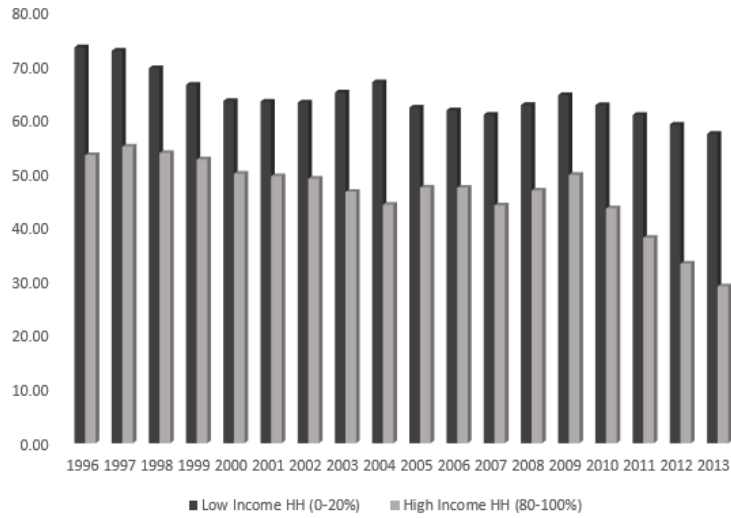


Figure 2.3: Share of Food in Total Expenditure, Rural India (%)

Source: Household Consumer Expenditure Survey Reports, NSSO, India.

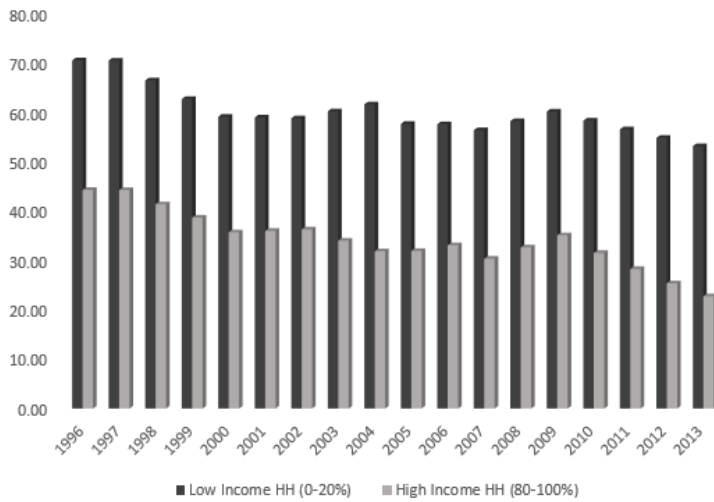


Figure 2.4: Share of Food in Total Expenditure, Urban India (%)

Source: Household Consumer Expenditure Survey Reports, NSSO, India.

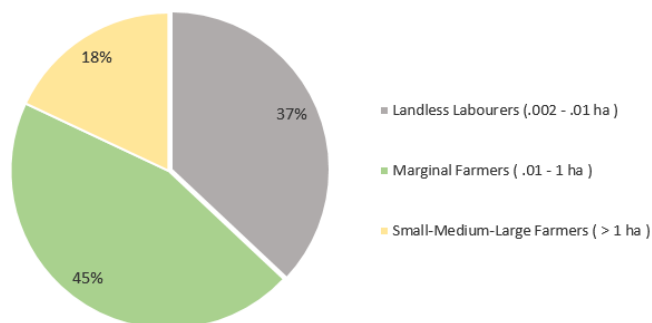


Figure 2.5: Net Buyers vs. Net Sellers of Food, Rural India

Source: Key Indicators of Land and Livestock Holdings in India, NSSO, India.

Notes: The bottom 37% of the rural population comprise the landless labourers (less than .002 hectare of land), and labourers with very little land (less than .01 hectare of land); they are classified into net buyers of food (Dev and Ranade, 1998; Kapila and Krishna, 2009).

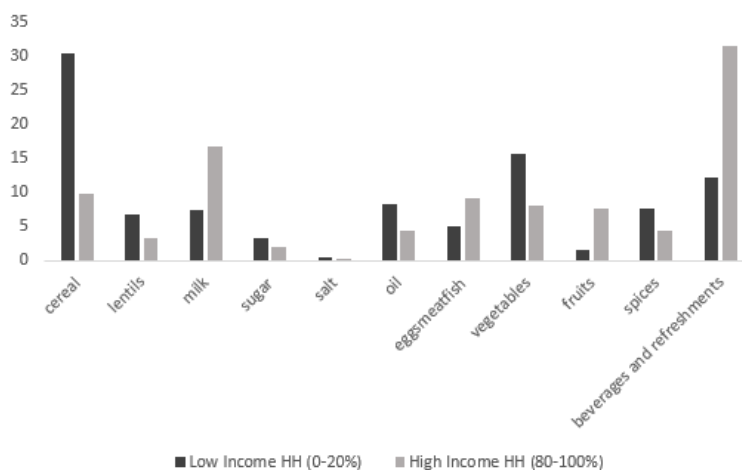


Figure 2.6: Composition of Food Budget, India (%)

Source: Household Consumer Expenditure Survey Reports, NSSO, India.

Notes: Composition of food budget for the rich vs. poor indicates the proportion of income allocated by the two expenditure classes towards different food types.



Figure 2.7: Public Distribution System, India (%)

Source: Household Consumer Expenditure Survey Reports, NSSO, India.

Notes: Proportion of income that poor households spend towards purchasing food (rice, wheat and sugar) from the market vs. fair price shops.

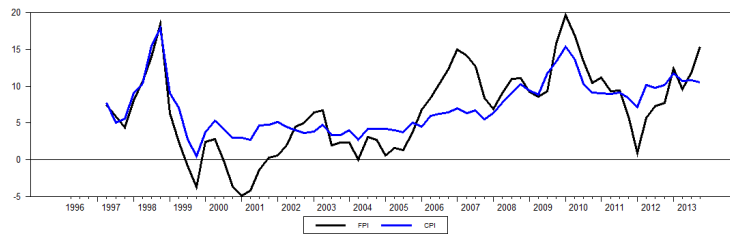


Figure 2.8: Growth Rate of FPI vs. CPI, India (%)

Source: Federal Reserve Bank of St. Louis Data Base (FRED).

Notes: FPI in this figure is the simple average of the nominal wholesale price indices of 98 different food articles. The full list of nominal food prices is reported in Table 2.3

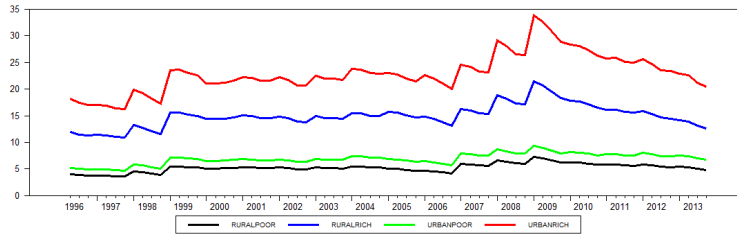


Figure 2.9: Distribution of Real Per Capita Food Consumption Expenditure, India

Source: Household Consumer Expenditure Survey Reports, NSSO, India.

Notes: Poor households feature those who lie in the 0-20% of expenditure distribution (bottom quintile or 20<sup>th</sup> percentile). Rich households feature those who lie in the 80-100% of expenditure distribution (top quintile or 80<sup>th</sup> percentile).

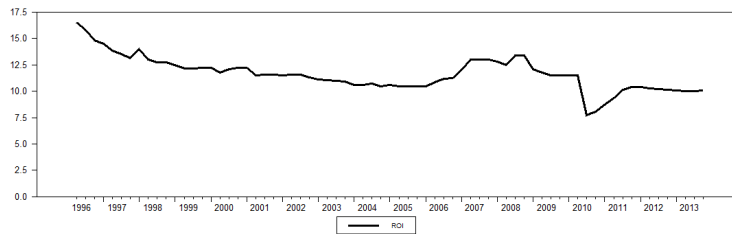


Figure 2.10: Prime Lending Rate, India (%)

Source: Federal Reserve Bank of St. Louis Data Base (FRED).

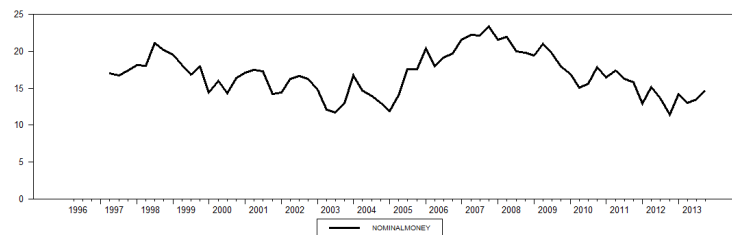


Figure 2.11: Growth Rate of Nominal Money Supply (M3), India (%)

Source: Federal Reserve Bank of St. Louis Data Base (FRED).

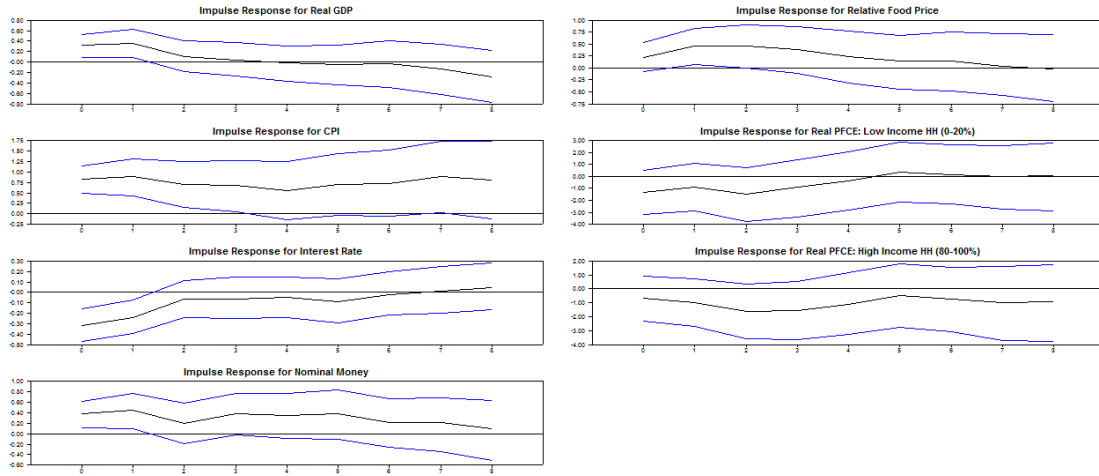


Figure 2.12: Impulse Responses to Expansionary Monetary Policy Shock, Rural India

Notes: Impulse responses to an expansionary monetary policy shock in rural India using pure sign restriction approach with  $K = 2$  (2 years). That is the responses of the CPI, the real GDP and nominal money supply has been restricted not to be negative and the interest rate not to be positive for quarters  $k, k=0,1,2$  after the shock. The three lines are 16 % quantile, the median and the 16 % quantile of the posterior distribution. Real PFCE refers to quarterly real per capita food consumption expenditures.

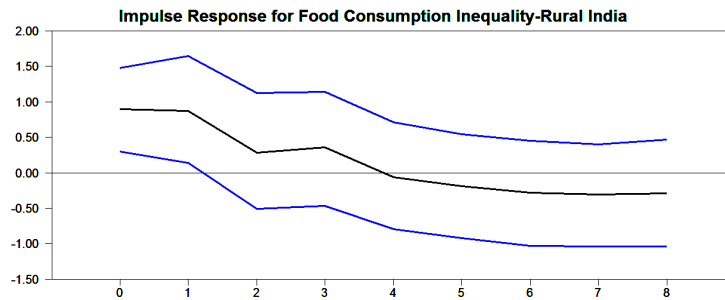


Figure 2.13: Impulse Response for Food Consumption Inequality, Rural India

Notes: Food consumption inequality is measured by the difference between the top quintile (80th percentile) and the bottom quintile (20th percentile) of the log levels in food consumption distribution.

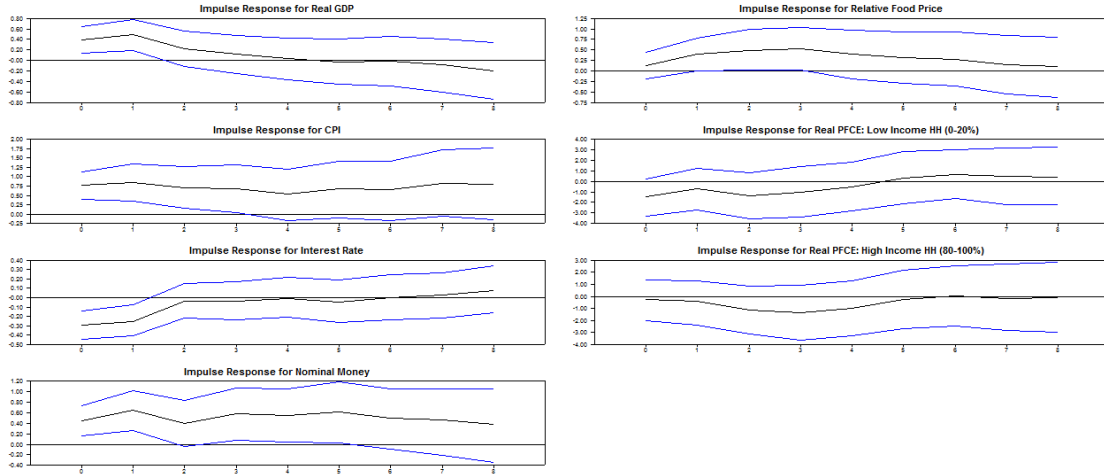


Figure 2.14: Impulse Responses to Expansionary Monetary Policy Shock, Urban India

Notes: Impulse responses to an expansionary monetary policy shock in urban India using pure sign restriction approach with  $K = 2$  (2 years). That is the responses of the CPI, the real GDP and nominal money supply has been restricted not to be negative and the interest rate not to be positive for quarters  $k, k=0,1,2$  after the shock. The three lines are 16 % quantile, the median and the 84 % quantile of the posterior distribution. Real PFCE refers to quarterly real per capita food consumption expenditures.

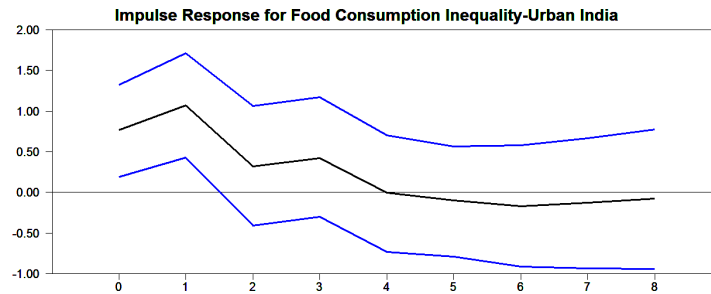


Figure 2.15: Impulse Response for Food Consumption Inequality, Urban India

Notes: Food consumption inequality is measured by the difference between the top quintile (80th percentile) and the bottom quintile (20th percentile) of the log levels in food consumption distribution.

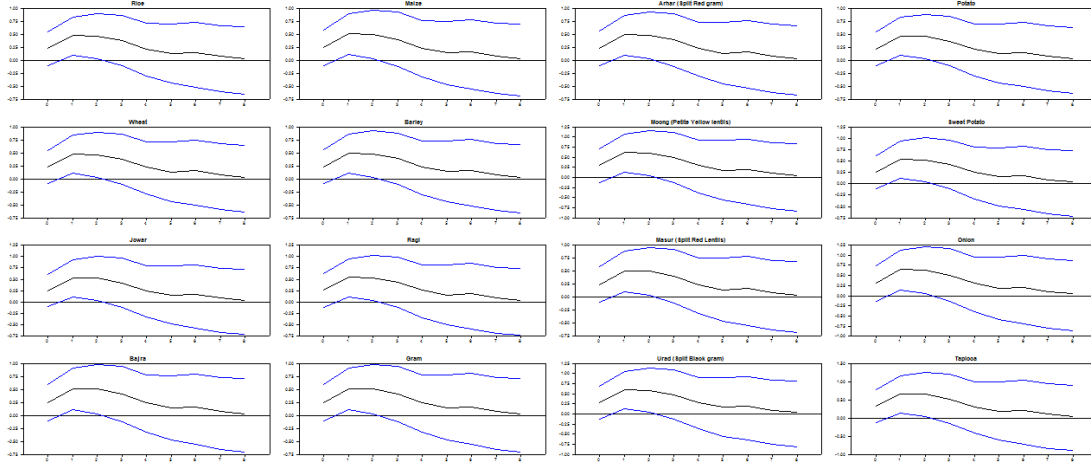


Figure 2.16: Impulse Responses for Relative Food Prices at the disaggregate level (01-16).

Notes: Impulse responses to an expansionary monetary policy shock using pure sign restriction approach with  $K = 2$  (2 years). The three lines are 16 % quantile, the median and the 16 % quantile of the posterior distribution.

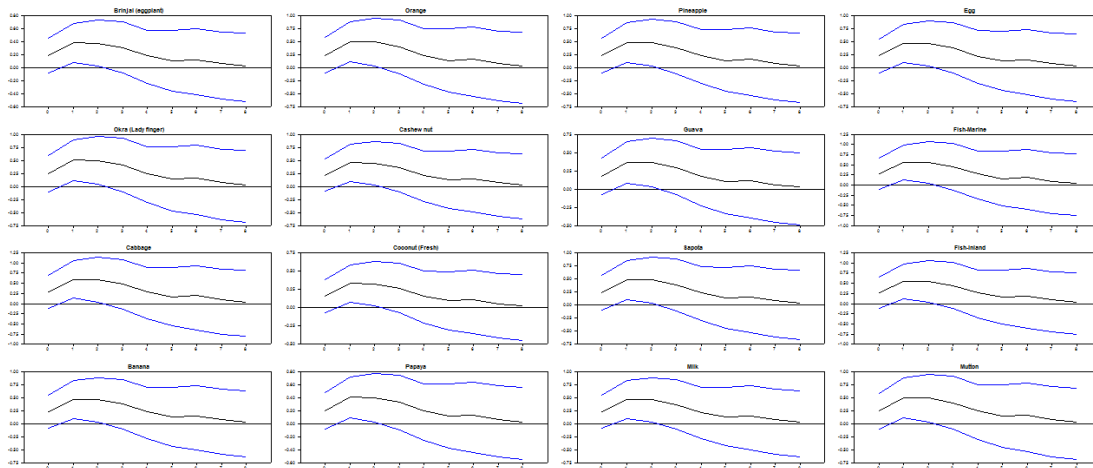


Figure 2.17: Impulse Responses for Relative Food Prices at the disaggregate level (17-32).

Notes: Impulse responses to an expansionary monetary policy shock using pure sign restriction approach with  $K = 2$  (2 years). The three lines are 16 % quantile, the median and the 16 % quantile of the posterior distribution.

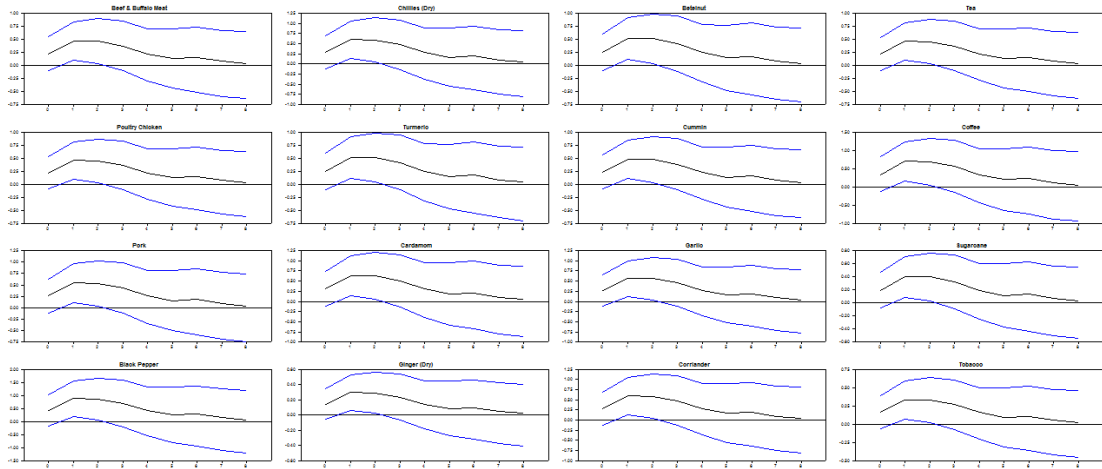


Figure 2.18: Impulse Responses for Relative Food Prices at the disaggregate level (33-48).

Notes: Impulse responses to an expansionary monetary policy shock using pure sign restriction approach with  $K = 2$  (2 years). The three lines are 16 % quantile, the median and the 16 % quantile of the posterior distribution.

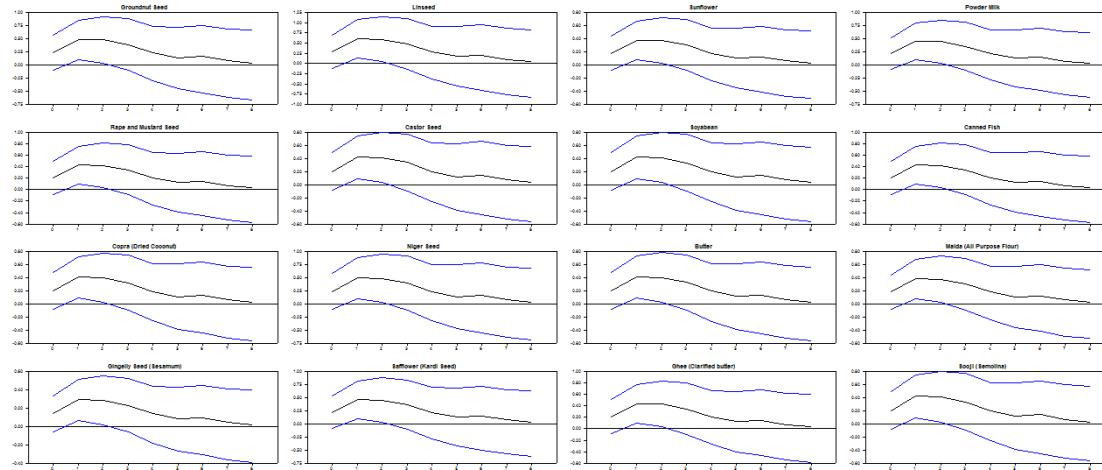


Figure 2.19: Impulse Responses for Relative Food Prices at the disaggregate level (49-64).

Notes: Impulse responses to an expansionary monetary policy shock using pure sign restriction approach with  $K = 2$  (2 years). The three lines are 16 % quantile, the median and the 16 % quantile of the posterior distribution.

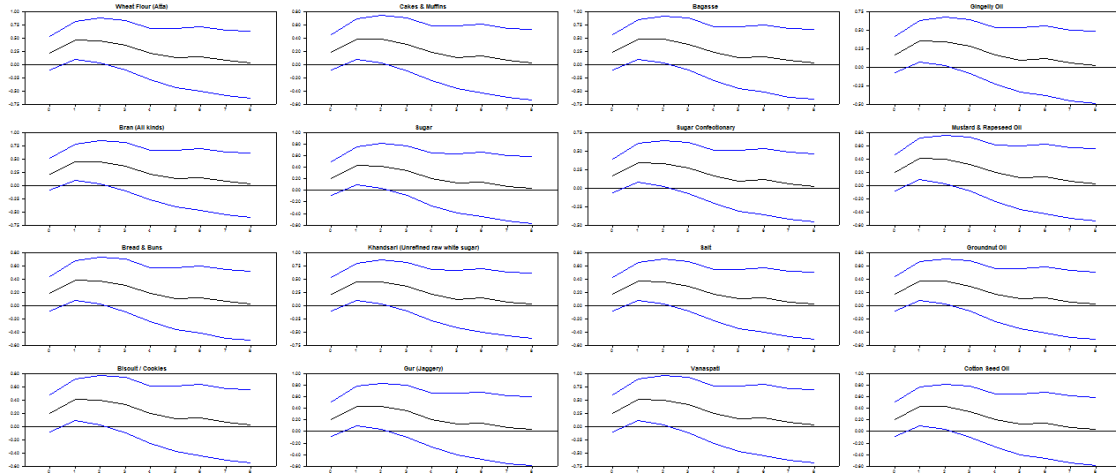


Figure 2.20: Impulse Responses for Relative Food Prices at the disaggregate level (65-80).

Notes: Impulse responses to an expansionary monetary policy shock using pure sign restriction approach with  $K = 2$  (2 years). The three lines are 16 % quantile, the median and the 16 % quantile of the posterior distribution.

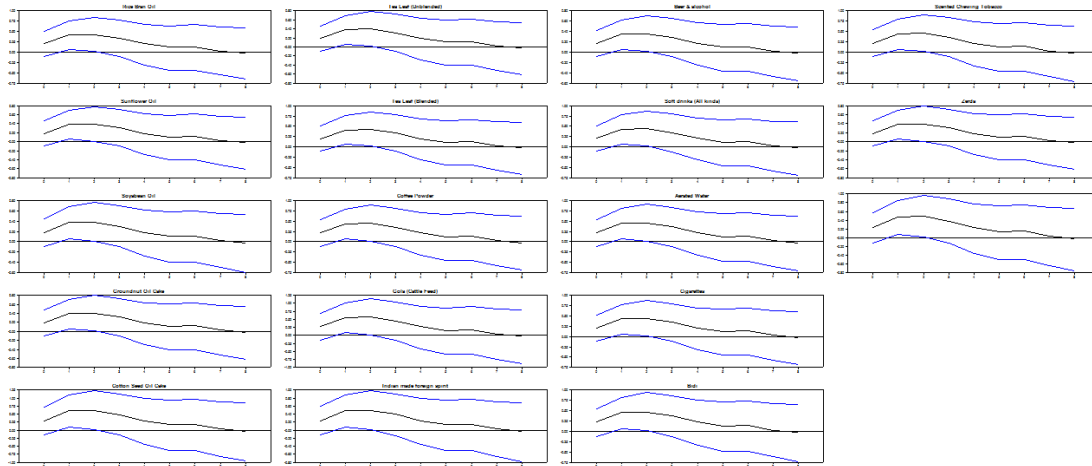


Figure 2.21: Impulse Responses for Relative Food Prices at the disaggregate level (81-98).

Notes: Impulse responses to an expansionary monetary policy shock using pure sign restriction approach with  $K = 2$  (2 years). The three lines are 16 % quantile, the median and the 16 % quantile of the posterior distribution.

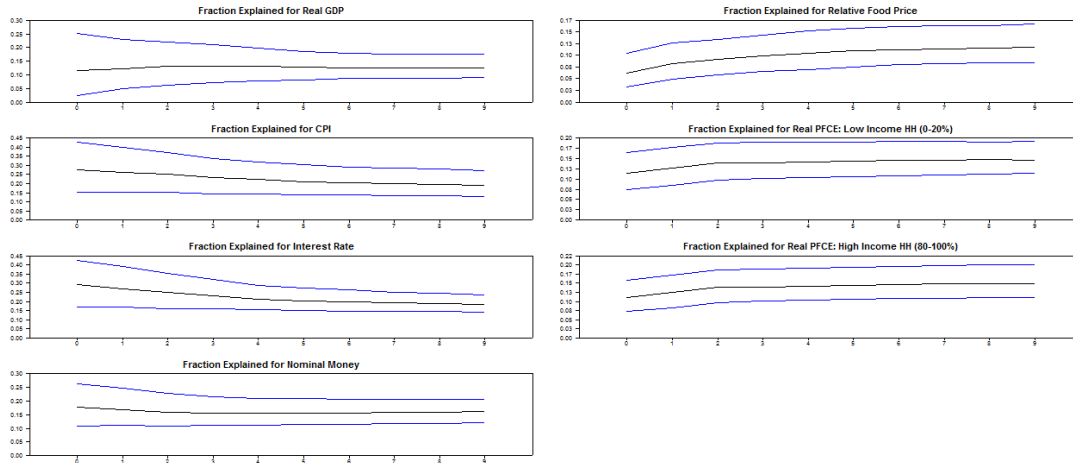


Figure 2.22: Fraction of the forecast error variance explained by monetary policy shock, Rural India.

Notes: These plots show the fraction of the variance of the  $k$  - step ahead forecast revision explained by a monetary policy shock, using pure sign restriction approach with  $K = 2$  (2 years). The three lines are 16 % quantile, the median and the 16 % quantile of the posterior distribution.

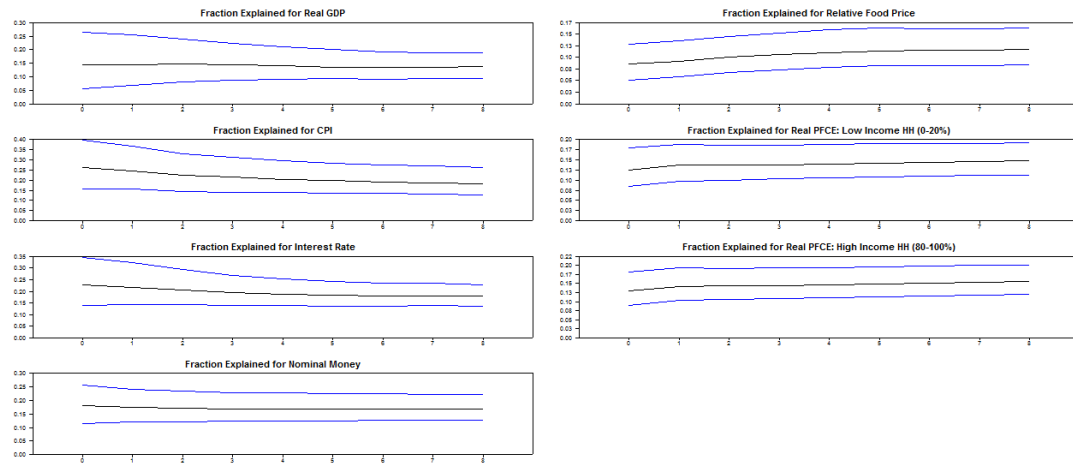


Figure 2.23: Fraction of the forecast error variance explained by monetary policy shock, Urban India.

Notes: These plots show the fraction of the variance of the  $k$  - step ahead forecast revision explained by a monetary policy shock, using pure sign restriction approach with  $K = 2$  (2 years). The three lines are 16 % quantile, the median and the 16 % quantile of the posterior distribution.

Table 2.1: Average Annual Growth Rate, India, 1996-2013

Variable	Growth Rate (%)
GDP	6.7
CPI	7.1
Nominal Money	16.5

Source: Federal Reserve Bank of St. Louis Data Base (FRED).

Table 2.2: Unit root tests, India, 1996-2013

Variable	Unit root test (PP Statistic)
GDP	-2.26
CPI	-0.003
Interest Rate	-3.15
Nominal Money	-1.53
Relative Food Price	-1.29
Real PFCE, Bottom Quintile, Rural India	-2.40
Real PFCE, Bottom Quintile, Urban India	-2.78
Real PFCE, Top Quintile, Rural India	-1.69
Real PFCE, Top Quintile, Urban India	-2.02
5% critical value	-3.47

Notes: PP stat = Phillips/Perron unit root test statistic (model includes deterministic trend). Real PFCE, Bottom Quintile indicates the real per capita food consumption expenditure of households who fall in the 0-20% of expenditure distribution (20th percentile), and Real PFCE, Top Quintile indicates the real per capita food consumption expenditure of households who fall in the 80-100% of expenditure distribution (80th percentile).

Table 2.3: Summary Statistics and Factor Loadings, Sample of Food Prices, India, 1996-2013.

S. No.	Food Article	Minimum	Maximum	Average	Std. Deviation	Growth Rate (%)	Factor Loading ( $\Lambda$ )
<b>1-59</b>	<b>Agricultural Food Articles</b>						
1	Rice	70	232	123	40	6.83	0.99134
2	Wheat	63	217	122	41	7.07	0.99019
3	Jowar	70	260	132	58	7.10	1.10471
4	Bajra	78	265	132	49	6.09	1.07649
5	Maize	72	257	129	50	6.74	1.06193
6	Barley	65	217	125	41	6.91	1.01336
7	Ragi	72	351	133	69	8.45	1.13232
8	Gram	52	288	132	52	8.29	1.08043
9	Arhar (Split Red gram)	69	238	126	50	4.89	1.03173
10	Moong (Petite Yellow lentils)	83	322	152	71	7.41	1.27421
11	Masur (Split Red Lentils)	70	238	129	52	5.89	1.05040
12	Urad (Split Black gram)	76	294	153	61	5.30	1.25033
13	Potato	41	279	122	56	8.81	0.98023
14	Sweet Potato	57	526	130	73	13.17	1.10720
15	Onion	48	680	152	117	14.63	1.34208
16	Tapioca	64	554	155	105	12.15	1.38407
17	Brinjal (Eggplant)	49	311	123	47	9.43	0.80569
18	Okra (Lady finger)	55	311	127	58	7.13	1.05580
19	Cabbage	42	494	148	85	12.18	1.25109
20	Banana	61	259	118	47	7.62	0.97332
21	Orange	39	244	126	54	9.72	1.04572
22	Cashew nut	85	214	118	37	5.27	0.94766
23	Coconut (Fresh)	57	157	91	19	4.48	0.69379
24	Papaya	38	255	102	50	8.07	0.85358
25	Pineapple	60	273	122	54	8.31	1.02158
26	Guava	15	236	94	46	7.89	0.76161
27	Sapota	59	262	122	52	8.49	1.01789
28	Milk	63	224	117	46	7.32	0.97076
29	Egg	78	227	124	36	5.13	0.98937
30	Fish-Marine	63	297	138	67	8.86	1.17292
31	Fish-Inland	46	405	131	85	12.83	1.16164
32	Mutton	71	249	126	50	7.21	1.04664
33	Beef & Buffalo Meat	37	216	119	46	10.27	0.98275
34	Poultry Chicken	91	178	130	23	1.25	0.95044
35	Pork	96	265	139	51	5.52	1.13743
36	Black Pepper	88	576	216	130	10.37	1.83917
37	Chillies (Dry)	73	291	153	60	4.23	1.24678
38	Turmeric	42	427	125	88	9.41	1.07587
39	Cardamom	61	396	156	85	9.25	1.32353
40	Ginger	45	127	79	25	5.46	0.62114
41	Betelnut/Areca nut	80	252	136	44	6.42	1.08526
42	Cummin	74	200	126	38	5.38	0.99573
43	Garlic	29	549	140	102	11.22	1.18922
44	Corriander	66	381	152	73	8.50	1.24863
45	Tea	75	214	123	38	4.98	0.97154
46	Coffee	85	337	181	70	3.17	1.45934
47	Sugarcane	52	199	103	38	7.78	0.84016
48	Tobacco	77	109	96	8	1.14	0.69914
49	Groundnut Seed	69	268	122	53	6.10	1.01459

S. No.	Food Article	Minimum	Maximum	Average	Std. Deviation	Growth Rate	Factor Loading ( $\lambda$ )
50	Rape & Mustard Seed	63	225	109	40	6.00	0.88964
51	Cotton Seed	66	183	108	29	5.77	0.85724
52	Copra (Dry Coconut)	43	129	79	19	4.44	0.60122
53	Gingelly Seed (Sesamum)	62	447	143	90	10.18	1.26465
54	Linseed	66	219	108	40	6.48	0.87834
55	Castor Seed	63	284	125	58	6.62	1.04535
56	Niger Seed	54	266	117	54	6.61	0.96023
57	Safflower (Kardi Seed)	58	162	99	30	5.48	0.78955
58	Sunflower	57	198	107	40	6.64	0.87702
59	Soybean	56	248	104	46	6.86	0.86646
<b>60-98</b>	<b>Manufactured Food Articles</b>						
60	Butter	75	181	114	33	4.99	0.91005
61	Ghee (Clarified butter)	73	196	116	38	5.60	0.93751
62	Powder Milk	61	186	109	39	5.89	0.89119
63	Canned Fish	53	160	99	37	5.97	0.80525
64	Maida (All Purpose Flour)	67	168	111	27	5.20	0.87600
65	Sooji (Semolina)	67	208	120	38	6.53	0.96389
66	Wheat Flour (Atta)	61	202	115	37	6.87	0.92780
67	Bran (All kinds)	66	141	105	20	4.13	0.80569
68	Bread & Buns	61	157	109	26	4.32	0.8516
69	Biscuit & Cookies	77	169	107	17	4.42	0.81546
70	Cakes & Muffins	69	187	112	29	5.70	0.88600
71	Sugar	79	203	118	37	4.96	0.94876
72	Khandsari (Unrefined raw white sugar)	77	189	115	35	4.91	0.91722
73	Gur (Jaggery)	56	238	120	55	7.84	1.00989
74	Bagasse	15	157	90	35	9.39	0.70812
75	Sugar Confectionary	79	135	102	15	2.82	0.77338
76	Salt	92	195	139	33	1.05	1.06033
77	Vanaspati	66	127	97	18	2.63	0.74346
78	Gingelly Oil	59	194	104	35	5.61	0.83768
79	Mustard & Rapeseed Oil	59	157	99	28	4.70	0.78598
80	Groundnut Oil	68	200	112	38	5.34	0.90355
81	Cotton Seed Oil	70	186	110	31	4.57	0.87133
82	Rice Bran Oil	49	155	101	34	5.11	0.80427
83	Sunflower Oil	63	140	101	23	3.16	0.78457
84	Soybean Oil	60	166	104	30	4.67	0.82300
85	Groundnut Oil Cake	54	360	145	87	10.20	1.27185
86	Cotton Seed Oil Cake	35	192	96	47	9.80	0.81216
87	Tea Leaf (Unblended)	55	200	110	33	7.11	0.87355
88	Tea Leaf (Blended)	55	195	113	36	7.33	0.91207
89	Coffee Powder	95	259	144	51	5.65	1.17198
90	Gola (Cattle Feed)	68	241	124	47	7.31	1.02304
91	Indian made foreign spirit	49	121	94	24	5.10	0.73126
92	Beer & alcohol	71	161	115	28	4.58	0.90052
93	Soft drinks (All kinds)	86	166	122	21	3.74	0.93677
94	Aerated Water	79	161	118	20	4.03	0.89889
95	Cigarettes	53	217	117	45	8.10	0.96170
96	Bidi	60	225	113	45	7.58	0.93565
97	Scented Chewing Tobacco	63	150	103	24	4.92	0.80835
98	Zerda	77	205	122	41	5.21	0.99113

Source: Ministry of Statistics and Programme Implementation, CSO, India.

## 2.10 APPENDIX: ROBUSTNESS CHECK

```

Likelihood Based Analysis of Cointegration
Variables: GDP CPI INR Nominal Money Relative Food Pr Real PFCE-BQ Real PFCE-TQ
Estimated from 1996:03 to 2013:04
Data Points 66 Lags 4 with Constant restricted to Cointegrating Vector

Unrestricted eigenvalues and -I log(1-lambda)
Rank  EigVal  Lambda-max  Trace  Trace-95%  LogL
0      0.0000  0.0000      0.0000  0.0000     -763.0467
1      0.5929  59.3171    194.1874  134.5400    -733.3881
2      0.4993  45.6509    134.8703  103.6800    -710.5627
3      0.3798  31.5255     89.2193   76.8100    -694.7999
4      0.2861  22.2447     57.6938   53.9400    -683.6776
5      0.2423  18.3086     35.4492   35.0700    -674.5233
6      0.1430  10.1821     17.1406   20.1600    -669.4322
7      0.1001   6.9585      6.9585    9.1400    -665.9530

Cointegrating Vector for Largest Eigenvalue
GDP  CPI  INR  Nominal Money Relative Food Pr Real PFCE-BQ Real PFCE-TQ Constant
0.092713 -0.015323 0.168196 -0.029651 -0.063308 -0.227337 0.243631 -202.671780
    
```

Figure 2.24: Cointegration Test, Rural India

Notes: Real PFCE, BQ indicates the real per capita food consumption expenditure of the bottom quintile and Real PFCE, TQ indicates the real per capita food consumption expenditure of the top quintile.

```

Likelihood Based Analysis of Cointegration
Variables: GDP CPI INR Nominal Money Relative Food Pr Real PFCE-BQ Real PFCE-TQ
Estimated from 1996:03 to 2013:04
Data Points 66 Lags 4 with Constant restricted to Cointegrating Vector

Unrestricted eigenvalues and -I log(1-lambda)
Rank  EigVal  Lambda-max  Trace  Trace-95%  LogL
0      0.0000  0.0000      0.0000  0.0000     -767.7814
1      0.5402  51.2865    188.8371  134.5400    -742.1381
2      0.4961  45.2414    137.5506  103.6800    -719.5174
3      0.3943  33.0908     92.3092   76.8100    -702.9720
4      0.2811  21.7820     59.2184   53.9400    -692.0810
5      0.2541  19.3510     37.4363   35.0700    -682.4055
6      0.1468  10.4771     18.0853   20.1600    -677.1670
7      0.1089   7.6082      7.6082    9.1400    -673.3629

Cointegrating Vector for Largest Eigenvalue
GDP  CPI  INR  Nominal Money Relative Food Pr Real PFCE-BQ Real PFCE-TQ Constant
0.293510 0.037533 0.330889 -0.145146 -0.208878 -0.237406 0.253519 -485.508137
    
```

Figure 2.25: Cointegration Test, Urban India

Notes: Real PFCE, BQ indicates the real per capita food consumption expenditure of the bottom quintile and Real PFCE, TQ indicates the real per capita food consumption expenditure of the top quintile.

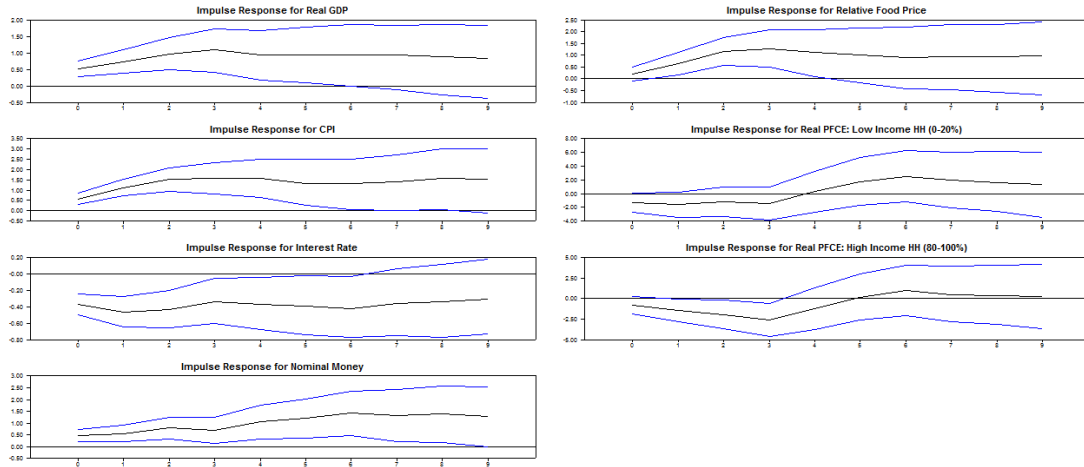


Figure 2.26: Impulse Responses from VAR in first differences, Rural India

Notes: Impulse responses to an expansionary monetary policy shock in rural India. All variables have been transformed to log first-differences except for interest rate which is just first differenced, to impose stationarity. The sign restrictions have been imposed on the accumulated IRF's.

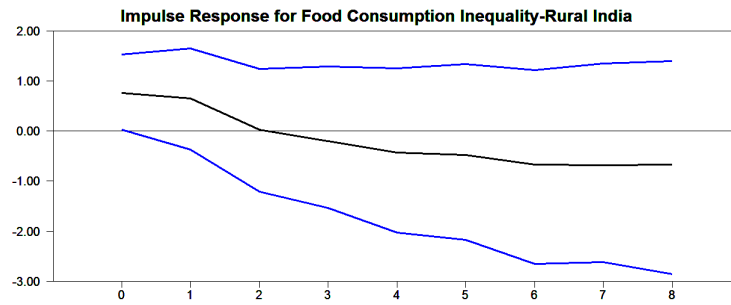


Figure 2.27: Food Consumption Inequality from VAR in first differences, Rural India

Notes: Impulse responses to an expansionary monetary policy shock in rural India. Food consumption inequality is measured by the difference between the top quintile (80th percentile) and the bottom quintile (20th percentile) of the log levels in food consumption distribution.

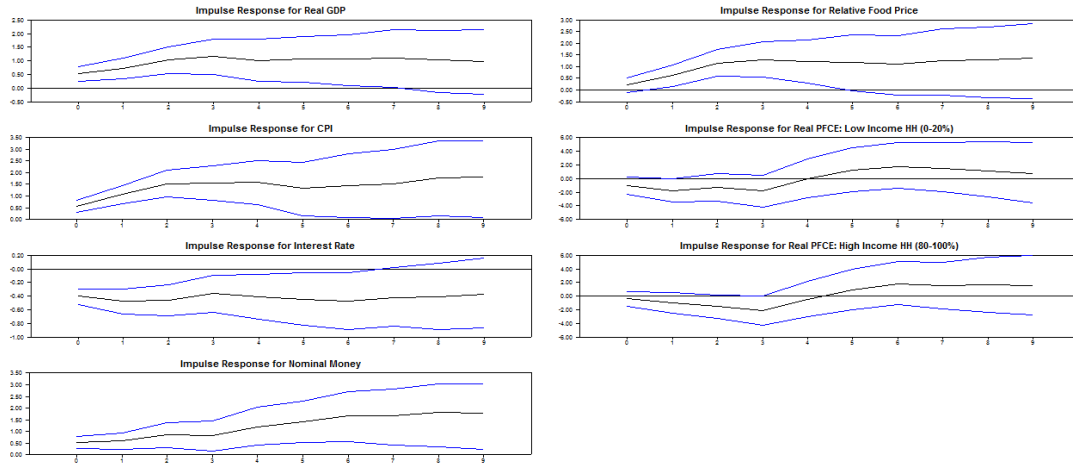


Figure 2.28: Impulse Responses from VAR in first differences, Urban India

Notes: Impulse responses to an expansionary monetary policy shock in urban India. All variables have been transformed to log first-differences except for interest rate which is just first differenced, to impose stationarity. The sign restrictions have been imposed on the accumulated IRF's.

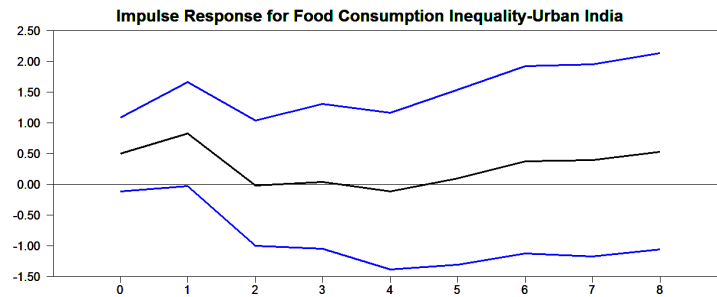


Figure 2.29: Food Consumption Inequality from VAR in first differences, Urban India

Notes: Impulse responses to an expansionary monetary policy shock in urban India. Food consumption inequality is measured by the difference between the top quintile (80th percentile) and the bottom quintile (20th percentile) of the log levels in food consumption distribution.

## CHAPTER 3

### MONETARY POLICY AND DISTRIBUTION OF FOOD CONSUMPTION IN CHINA: THE ROLE OF FOOD PRICES

#### 3.1 INTRODUCTION

In company with rapid economic growth, China has been facing strong upward pressure in food prices. Historically, China experienced huge fluctuations in food prices over the last two decades. Food price inflation measured by CPI of food, fluctuated more than the headline inflation measured by overall CPI in the economy (Figure 3.1). Whereas the period 1996 to 2003 witnessed a negative growth rate in food prices of .50%, the period 2004 to 2013 recorded a large and positive growth rate in food prices of 7%. The increase in food prices in China since 2004 raised concerns over food security in the country and the world.<sup>1</sup> With 1.3 billion inhabitants, the Chinese government places food security as a foremost priority in its domestic policy agenda, so that the domestic food market especially the grain market continues to remain heavily intervened, and still retains characteristics of a centrally planned economy (Wang, 2001; Yang et al., 2008; Tang et al., 2009; Yu and Jensen, 2010; Yu, 2014).<sup>2</sup> The food share of expenditures in China is less than the average in low-income countries, but more than six times the food budget share in the United States (Figure 3.2). Clearly, food

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<sup>1</sup>The most widely accepted definition of food security proposed during the 1996 World Food Summit defines it as follows: Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

<sup>2</sup>Even though through the past 20 years of reform, China's grain marketing system has been largely liberalised, however the state still plays an important role in the grain market. It is argued that due to the Cobweb Effect, the grain market is subject to large fluctuations without government intervention. The instability could have serious repercussions on the consumers and producers in China who rely heavily on foodgrains. The Government is therefore highly involved in the grain market to keep it steady and stable (Wang, 2001; Huang et al., 1993; Findlay and Chen, 2001 ).

represents a major expense for Chinese households especially the poor (Figures 3.3-3.4), and likely influences their spending on other items, and their overall welfare. Changes in relative food prices can have great impacts on Chinese farmers' income and consumers' cost of living (Peng, Marchant and Reed, 2004). Absorbing short run fluctuations in relative food prices and managing cash flow optimally can be a challenge especially for poor households due to *subsistence* and limited *substitutability* of food. There is also evidence of strong correlation between higher relative food prices, poverty, lower caloric intake, lower quality diet, and an increase in child malnutrition (Mellor, 1978; Ravallion, 1998; Friedman and Levinsohn, 2002; Alderman, Hoddinott, and Kinsey 2006; Christiaensen and Demery, 2007; Wodon et al. 2010).<sup>3</sup> All these could have potential long term impact on the human capital and productivity of the country, thereby reducing the pace and durability of economic growth (Dreze and Sen, 1989; Horton, 1999; Behrman et al., 2004; Deaton and Dreze, 2009; Dreze and Sen, 2013).

Traditionally, research studies have analysed fluctuations in food prices through supply and demand gap, however recent literature has also given a great deal of emphasis on the impact of macroeconomic variables, especially monetary and financial factors, on food prices (Chambers and Just, 1982; Orden, 1986; Orden and Fackler, 1989; Dorfman and Lastrapes, 1996; Cho et al., 2004, Lastrapes, 2006; and Balke and Wynne, 2007). These studies show that agricultural prices are relatively more flexible, and following a monetary expansion adjust quicker than the overall price level in the economy; therefore major changes in monetary policy can have *real* short run and long run effects on food prices.

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<sup>3</sup>Apart from reduction in food consumption, the loss in purchasing power affect buying of other goods and services which are essential for sheer physical survival such as water, sanitation, education, lighting, health care etc. Adjustment in wages, employment and capital flows to agriculture take time to reach the poor. The adverse impact of high food prices on poor is also seen in terms of (a) poor nutrition status of pregnant and lactating women and of pre-school children; (b) poor health status of women and children; (c) increase in child labour and withdrawal of children from school; (d) the distress sale of productive assets (Mahendra Dev, 2012).

Despite the dominant role played by relative food price changes in developing countries, and evidence of strong interlinkages between monetary policy variables and relative food prices, studies in empirical monetary economics have largely ignored the distributional consequences of monetary policy that could arise from *relative* food price distortions. To the best of my knowledge, there is no study that empirically investigated this causal channel i.e. the “*food price channel*” of monetary policy. It is conceivable that the distributional impacts of monetary policy from this channel could be negligible in developed countries given the small share of food in the CPI basket, however with almost 50% share of food in the CPI basket, these effects could be substantially large in developing countries.

In this chapter, I seek to fill the gaps in the literature by examining the impact of the “*food price channel*” of monetary policy on the distribution of food consumption in China. My primary reason for selecting China is because India and China currently stand as two of the fastest growing large economies of the world. Both developing countries, even though have recorded robust GDP growth rates in the last 20 years, are strikingly different with regards to their demography, structure, household characteristics, and economic policies. While the second chapter of my dissertation investigates the impact of the “*food price channel*” monetary policy on the distribution of food consumption in India, the current chapter conducts a similar empirical analysis for China; this allows me to compare and contrast the results for the two countries, and thereby draw conclusions about the relative importance of the “*food price channel*” in emerging market economies.

Using household survey data from 1996:Q1 to 2013:Q4, I estimate the dynamic effects of monetary policy shocks on the *relative* price of food and the distribution of food consumption in rural and urban China from a VAR model, and identify monetary policy shocks using the sign restriction approach of Uhlig (2005). VAR results show that expansionary monetary policy shocks increase the *relative* price of food and have heterogeneous *negative* effects

on household food consumption which vary systematically across the income distribution: food consumption at the lower end of the distribution falls less than that at the upper end. More specifically, in rural China food consumption at the lower end of the distribution remains unaffected (on average) while that at the upper end falls, and in urban China food consumption at the lower end of the distribution falls, but much less than that at the upper end. Using the difference between the 80th percentile and the 20th percentile of the log levels in the food consumption distribution as a measure of food consumption inequality, I find that expansionary monetary policy shocks reduce the observed inequality across households in food consumption in rural as well as urban China.<sup>4</sup>

Overall, I find evidence of the impact of the “*food price channel*” of monetary policy on the distribution of food consumption, and inequality in China. The mechanism is straightforward. Food prices being relatively more flexible, following a monetary expansion, adjust quicker than the overall price level in the economy. So, expansionary monetary shocks lead to an increase in the *relative* price of food. Poor households in China respond very little to the increase in *relative* food price, and consequently following the monetary expansion witness a much smaller decline in food consumption compared to the rich.<sup>5</sup> Two factors contribute to the above heterogeneous response. First, poor households have very low levels of initial food consumption (*subsistence*). Food is more a *necessity* for them and so their food demand is relatively price inelastic (Portillo et al., 2016). Second, rural poor households rely heavily on self-produced food (Figure 3.5); food self sufficiency appears to be quite effective at insulating the responses of many rural households in the bottom of the income distribution from the effects of policy shocks. Therefore, expansionary monetary shocks in China via the “*food price channel*” are found to decrease the observed inequality across households in food consumption.

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<sup>4</sup>Coibion et al. (2012) uses the difference between the 90th percentile and the 10th percentile of the log levels in income and consumption distribution as a measure of inequality.

<sup>5</sup>The rich households are identified as those who lie in the top 20% of income distribution (top quintile) and poor households in the bottom 20% (bottom quintile). See data section for details.

In my second chapter, relying on a factor augmented vector auto regression (FAVAR) model, I conduct a similar empirical study for India. Comparing the results of India with China, I do find evidence of the impact of “*food price channel*” of monetary policy on inequality in both emerging market economies, however the sign of the impact differs strikingly in the two economies.<sup>6</sup> While in India expansionary monetary shocks via the “*food price channel*” increase food consumption inequality, in China expansionary monetary shocks via the same channel reduce food consumption inequality. Results for India and China show that poor households (bottom quintile) in India are far more sensitive to the “*food price channel*” of monetary policy than those in China. This is primarily because of differences in certain characteristics and features of poor households across the two countries: (i) while in India the bottom quintile allocates on average roughly 65-70% of their total income towards food expenditures, in China they allocate about 50-55% ; (ii) while in India the rural poor rely largely on cash purchases of food (*food purchased from the market*) to meet their daily food requirements which make them more sensitive to fluctuations in relative food prices, in China they rely heavily on self-produced food which plays a key role in dampening the effects on them of relative food price changes; (iii) while in India the poor live hand-to-mouth, i.e., they have no access to credit markets and simply consume their current labor income, in China the poor have significantly higher access to the formal financial institutions that hedge in some way against inflation (Figure 3.6; Anand and Prasad, 2015; Sparreboom and Duflos, 2012; Fungacova et al., 2015). Due to differences in the degree of financial inclusion, poor households in the two countries differ significantly in terms of their ability to smooth consumption behaviour in the face of idiosyncratic shocks. Finally, India is characterized by the presence of a huge informal sector (90%) compared to China (50%); higher relative food price acts as an implicit tax for the Indian poor engaged in the informal sector where wages are not indexed to inflation, and where workers don’t have much bargaining power

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<sup>6</sup>see section for details 3.7.

vis-a-vis their employers. (Easterly and Fischer, 2001; Rada, 2010; Gulati and Saini 2013; Rajan, 2016).

The main point from the above discussion is that, even though food is a *necessity* for the poor in both countries (due to their subsistence caloric intake), however due to the above influences, the privation imposed on the poor in India by rise in relative food prices from expansionary monetary shocks is large enough that their food demand seems to be far more elastic with respect to price, than the poor in China. Expansionary monetary policy shocks, which increase the relative price of food, have stronger adverse effects on the Indian poor. Aside from the above mentioned factors, differences in other household characteristics (with regard to socioeconomic and demographic factors, such as age and education, rural-urban migration, income, wealth, employment status, tax and housing status, patterns of food consumption) between the two economies could also potentially have implications for differences in their responses to changes in monetary policy. Many mechanisms through which monetary policy affects households in different ways may be at play, and it is a daunting task to disentangle and identify these effects empirically (Yannick and Ekobena, 2014). Results for India and China suggest that in emerging market economies the impact of the “*food price channel*” of monetary policy on inequality is a priori ambiguous. The effects of monetary policy on the rich versus the poor is specific to the institutions and histories of each economy; in sum the question is an empirical one, and the answer may well differ among economies (Easterly and Fischer, 2001).

In the next section I give a brief review of the literature.

### 3.2 LITERATURE REVIEW

In addition to the large body of literature on the distributional consequences of monetary policy (Romer and Romer, 1998; Erosa and Ventura, 2002; Carpenter and Rodgers, 2004;

Doepke and Schneider, 2006; Albanesi, 2007; Heathcote et al., 2010; Coibion et al., 2012), this chapter is related to two separate literatures, that I summarize below:

### 3.2.1 MONETARY POLICY AND FOOD PRICE

The main question is whether food and non food prices adjust proportionately to monetary policy shocks or not. It is theoretically argued that as agricultural prices are less rigid, they respond faster to changes in money supply than non-agricultural prices (Frankel, 1986; Bordo, 1980). Chambers and Just (1981), Orden (1986), Orden and Fackler (1989), Cho et al. (1993), and Dorfman and Lastrapes (1996) provide empirical evidence of the tendency of agricultural (food) prices to be more flexible relative to the general price level in the economy. The authors show that an increase in money supply raises agricultural prices relative to the general price level in the economy. Further, Hercowitz (1982), Debell and Lamont (1997), Lastrapes (2006), and Balke and Wynne (2007) go beyond the relative price effects and also report that monetary disturbances lead to an increase in the dispersion of the cross-section distribution of prices. While most of the above studies focus on the US economy, several studies have also found similar evidence in many emerging market economies. In Hungary, Slovenia, South Africa, India, Pakistan, China, Korea, the Philippines, and Thailand, authors have shown that monetary changes have real short- and long-run effects on agricultural prices (Saghaian et al., 2002; Peng, Marchant and Reed, 2004; Asfaha and Jooste, 2007; Saghaian, Hye and Siddiqui, 2010; Khundrakpam and Das, 2011; Bakucs and Ferto, 2013).<sup>7</sup> In sum, the literature provides evidence of short run and long run monetary non-neutrality. Commodity prices do not respond proportionately to monetary shocks; in particular, food prices being relatively more flexible, adjust more quickly to changes in monetary disturbances than do prices of other goods.

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<sup>7</sup>In the case of China, Peng, Marchant and Reed (2004) find the existence of a long-run equilibrium relationship between monetary policy and food prices, however the author argues that in China the effects are stronger from money supply than interest rates due to controlled interest rate regime and underdeveloped nature of financial markets.

### 3.2.2 FOOD PRICE, POVERTY AND INCOME DISTRIBUTION

In low income countries, the most direct distributional consequence of change in relative food prices emerge from the differential income effects on the absolute and relative income levels of various household income classes. Mellor (1978), Ravallion (1998), Rao (1998), and Pons (2011), among many others, show that an increase in relative food prices increases poverty and inequality in low-income countries like India and Bangladesh, through adverse distributional effects on the real income of poor households. Research studies done on Latin American countries - Guatemala, Nicaragua, Honduras, and Peru show that an increase in relative food prices represents a negative shock for poor households, primarily, due to their disproportionately high share of food expenditure (Robles and Torero, 2010). Apart from differential effects on real income of the rich and the poor, higher relative food prices also generate differential effects on the real income of net buyers and net sellers of food. This has already been studied to some extent for low-income countries, and the results appear to be quite mixed, as household consumption choices and patterns, sources of income, and geography mattered greatly in determining the specific impact.<sup>8</sup> Friedman and Levinsohn (2002) investigate the welfare impact of large food price increases during the Indonesian currency crisis of 1997, both across geographical areas and along the income distribution, and find that the rural poor who rely largely on self produced food suffered a smaller welfare loss than the rural rich, while the urban poor who rely mainly on cash purchases of food, fared the worst under the price changes. In contrast to this, Barrett and Dorosh (1996) in their study of rice price changes in Madagascar find that up to one-third of the rural poor (rice farmers) lose, in net terms, from higher prices. Using data from a number of African

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<sup>8</sup>Understanding the net effect on rural households of a rise in relative food price is complex since rural households are both consumers and producers of food. High food prices reinforce the substitution effect of a price increase by encouraging farm households to sell their food produced to the market instead of consuming them on farm. However, higher food prices also benefit farmers by increasing their overall profits from farm sales. This income effect potentially increases farmers' demand for food, offsetting the substitution effect. The net effect of higher food prices on food consumption of rural households could be either positive or negative, depending on whether the substitution effect or income effect is larger (Singh et al., 1986; Han et al., 2001; Gale et al., 2005).

countries, Christiaensen and Demery (2007) study the second-round effects of relative food price changes by including an additional effect of increased farm productivity, and find that higher relative food prices lead to a rise in the poverty index in Africa, even after factoring in countervailing wage and productivity effects. Wodon et al. (2010) also provide empirical evidence that rise in relative food prices lead to higher poverty in Sub-Saharan Africa primarily because the negative impact on net consumers outweighed the benefits to producers.<sup>9</sup> Given these previous literatures as discussed above, a conclusion is reached: change in relative food prices is, in the short run, one of the most important determinants of change in the relative and absolute real income of poor households in developing countries, because they allocate a disproportionate share of their total expenditures towards food. The urban poor who are net buyers of food are more vulnerable to rising food prices; effects on the rural poor who may rely on self produced food are more country specific, but on average they are worse off when relative price of food rises.

Despite the dominant role played by changes in relative food prices in developing countries, and evidence of strong interlinkages between monetary policy variables and relative food prices in the literature, research studies in empirical monetary economics have largely ignored the distributional consequences of monetary policy that could arise from fluctuations in relative food prices. In this chapter, I seek to fill the gaps in the literature by investigating how monetary policy via distortions in *relative* food prices affect the distribution of food consumption in China - one of the fastest growing emerging market economies in the world. Results of my study provide empirical evidence of the impact of the “*food price channel*” of monetary policy on the distribution of food consumption, and inequality in China.

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<sup>9</sup>The authors note that the poor in rural areas were often constrained by small land holdings, input costs, and distance to markets, and hence were generally unable to produce the marketable surplus required to exceed their food expenditures.

### 3.3 DATA AND STYLIZED FACTS

The data sample I use for this study is quarterly and ranges from 1996:Q1 to 2013:Q4.<sup>10</sup> I measure aggregate output as real GDP, the general price level as the overall consumer price index, the food price as the consumer price index of food, the nominal interest rate as the less than 24 hour Central Bank Rate (the primary monetary policy instrument of the *People's Bank of China*), and the stock of nominal money as M2. I obtain the quarterly data on China's real GDP from Chen, Higgins, Waggoner, and Zha (2016). Quarterly data on all other macro-variables are taken from the Federal Reserve Bank of St. Louis Data Base (FRED). I compute the relative price of food as the consumer price index of food deflated by the overall consumer price index in the economy. Figure 3.1 compares the growth rates in CPI and the food price; I note that the food price in China fluctuated far more than the general price level in the economy. Table 3.1 reports the average annual growth rates of the macro variables over the sample period. I note that while real GDP and money supply grew at 9% and 17% per annum respectively, food prices grew at 3.5% per annum over the study period. Figures 3.7-3.8 plot the movements in interest rate and money supply growth respectively over the study period.

For data on the distribution of food consumption, I rely on the household consumer expenditure surveys published by National Bureau of Statistics of China (NBS). The surveys report the average annual nominal per capita food consumption expenditure in five income quintile across rural and urban China.<sup>11</sup> NBS defines the top quintile or high income households

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<sup>10</sup>The primary reason for selecting the given time period is to maintain consistency with a related empirical study conducted on India in my first chapter.

<sup>11</sup>All households in the sample are grouped, by per capita disposable income of the household, into groups of low income, lower middle income, middle income, upper middle income and high income, each group consisting of 20%, 20%, 20%, 20%, and 20% of all households respectively. Data for nominal food expenditures by income groups (discussed above) is available only from 2002-2012. So, for the years 1996-2001 and 2013 when the data was not available, I compute (interpolate) the annual figures for nominal food consumption expenditures using information (growth rates) from the total consumption expenditure series which is available from 1996-2013. By doing so, I make

(rich households) as those who fall in the 80-100% of income distribution (80<sup>th</sup> percentile), and the bottom quintile or low income households (poor households) as those who fall in the 0-20% of income distribution (20<sup>th</sup> percentile). I take the annual nominal per capita food consumption expenditures of the top and bottom quintile from NBS, then convert them into quarterly figures (assuming there is no quarterly variation in food expenditures for any given year), and finally deflate them by the consumer price index of food to obtain the quarterly real per capita food consumption expenditures of the respective quintile groups. Figure 3.9 plots the quarterly real per capita food consumption expenditures across the distribution in rural and urban China respectively. Following Coibion et al. (2012) who uses the difference between the 90th percentile and the 10th percentile of the log levels in consumption distribution, I use the difference between the 80th percentile and the 20th percentile of the log levels in food consumption distribution as a measure of food consumption inequality (*also popularly known as the Kuznets ratio*).

Household survey data in China suggests that food expenditures comprise the largest component of household budget especially among the poor, accounting for nearly half of their total expenditures. Figures 3.3-3.4 plot the share of food expenditure in the total budget of the top and bottom quintile in rural and urban China respectively. In rural China the bottom quintile allocates on average about 55% of their total consumption expenditures to food and the top quintile allocates about 35%, while in urban China the bottom quintile allocates roughly 45% and the top quintile 30%. Even though the food share in rural China is higher than in urban China, but food expenditures in absolute terms is very low in rural China. This is because Chinese rural households are able to meet most of their basic nutritional requirements at minimal expenses by consuming self-produced food, largely grains and vegetables. Households at all income levels in rural China rely on self-produced food, however this is especially higher for the lower income groups as they have limited cash (Gale

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an implicit assumption in my study that food consumption expenditures of households is roughly proportional to their total consumption expenditures.

et al., 2005).<sup>12</sup> Further, lack of market development constraints the consumption choices of Chinese rural low income households; in remote rural areas transportation costs may prevent market participation by driving a wedge between effective purchase prices and sale prices. Lack of off-farm cash-generating employment opportunities also may force poor households to rely on self-produced food. Therefore, food self-sufficiency is more a rational response to the lack of cash income and limited access to retail food markets for rural low income households in China (Gale et al., 2005).

Comparing the degree of food self-sufficiency between low-income and high-income households, I note that over the period 1996-2013 cash expenditures (*share of food purchased from market*) accounted for only 50% of total food expenditures for the rural low income households (Figure 3.5). The remaining 50 percent were noncash expenditures: the imputed value of food grown by the farm family itself plus the value of food obtained through informal exchange or other non-purchased sources. Relative to low income households, high income households had high cash and noncash food expenditures, but cash expenditures were particularly high accounting for 80 percent of their total food expenditures over the same sample period (Figure 3.5).<sup>13</sup>

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<sup>12</sup>China's rural poor spends very little on food, yet is very well-fed. More than 80 percent of grains, beans, and potatoes consumed are self-produced; and 70 percent of vegetables consumed are self-produced. Other important food items are also largely self-produced, including milk (68 percent), beef and mutton (54 percent), poultry and eggs (48 percent), pork (44 percent), fruit (39 percent), and edible oil (32 percent). Consumption of self-produced food frees up scarce cash income for non-food purchases like housing, schooling, transportation, and other nonfood goods and services (Gale et al., 2005).

<sup>13</sup>The share of self-produced food shows a declining trend from 1996 to 2013; the switch from self-produced to purchased food has been driven by structural changes in the rural economy over the past decade - a phenomenon referred to as *market development* (Huang and Rozelle, 1998). Better access to food markets as a result of better transportation and communications, greater mobility of the rural population, expansion of food retail outlets into rural areas, rural-urban migration, the rising ownership of home refrigerators, and other factors enabled rural households especially the rich to shift away from self production to the market for meeting their food requirements (Gale et al., 2005).

### 3.4 EMPIRICAL FRAMEWORK

#### 3.4.1 EMPIRICAL MODEL AND IDENTIFICATION

The aim of this chapter is to estimate the dynamic responses of relative food price and the distribution of food consumption to monetary policy shocks in China. To achieve my objective, I make use of a vector auto regression (VAR) framework. Let  $Y_t$  be the  $m$ -dimensional vector stochastic process of aggregate macroeconomic variables. Assume that  $Y_t$  follows the following linear dynamic process:

$$Y_t = B_1 Y_{t-1} + \dots + B_p Y_{t-p} + \epsilon_t \quad (3.1)$$

$$\Sigma = E \left( \epsilon_t \epsilon_t' \right) \quad (3.2)$$

$Y_t$  is a  $m \times 1$  vector of data at date  $t = 1, \dots, T$ ,  $B_i$  are coefficient matrices of size  $m \times m$  and  $\epsilon_t$  is the one-step ahead prediction error with variance-covariance matrix  $\Sigma$ . The system in Eq. (3.1) is the reduced form, from a dynamic structural model. My interest lies not in the reduced form shocks but in identifying how the variables in  $Y_t$  respond to the aggregate structural shocks.

The structural counterpart to Eq. (3.1) in moving average form is given by:

$$Y_t = (I - B_y L)^{-1} D_y u_t \quad (3.3)$$

$$Y_t = (D_0 + D_1 L + D_2 L^2 + \dots) u_t \quad (3.4)$$

where  $u_t$  is a vector of aggregate structural shocks,  $E(u_t u_t')$  is normalized to be the identity matrix.<sup>14</sup> The mapping from the reduced form to the structural form thus entails restrictions on the covariance structure:

$$\Sigma = E(\epsilon_t \epsilon_t') = D_y E(u_t u_t') D_y' = D_y D_y' \quad (3.5)$$

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<sup>14</sup>There are  $m$  fundamental innovations which are mutually independent and normalized to be of variance 1: they can therefore be written as a vector  $u_t$  of size  $m \times 1$  with  $E[u_t u_t'] = I_m$ .

Once I identify the  $m \times m$  matrix  $D_y$  from this mapping, I obtain the dynamic multipliers of interest from equation (3.1) using (3.3) and (3.4). In my study, I do not fully identify  $D_y$  because I am solely interested in the monetary policy shock.<sup>15</sup> So, I impose identifying restrictions to identify only the column of matrix  $D_y$  corresponding to the monetary policy shock.

I identify monetary policy shocks using the “sign-restriction” approach of Uhlig (2005).<sup>16</sup> I identify an expansionary monetary policy shock as one that does not lead to a decrease in real GDP, CPI and nominal money, or an increase in the interest rates over a selected horizon. My primary reason for adopting “sign-restriction” as a method of identification is because it eliminates any prize puzzle by construction.

In particular, I follow the “penalty-function” approach of sign restriction for my identification strategy instead of the “pure-sign restriction” approach (Uhlig 2005, Appendix B.2, pp. 413-417). This is because the “pure sign restriction” method fails to address the multiple models problem, which could result in excess uncertainty about the model’s estimates and ultimately incorrect policy inference (Fry and Pagan, 2007 and Liu and Theodoridis, 2012).<sup>17</sup> The “penalty function” approach on the other hand uniquely identifies the model by minimizing a penalty for the impulse responses that violate the sign restrictions, and

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<sup>15</sup>I do not identify the other  $m - 1$  fundamental innovations.

<sup>16</sup>Faust (1998) uses sign restrictions to identify monetary policy shocks, imposing them only at the time of impact, however Canova and De Nicol (2002) identify monetary shocks using sign restrictions on impulse response correlations. More recently, Dedola and Neri (2007) have used sign restrictions to identify technology shocks and Mountford (2005), Peersman (2005), Benati and Mumtaz (2007), Dungey and Fry (2009) and Fry and Pagan (2007) have addressed the issues pertaining to identification of multiple shocks using sign restrictions.

<sup>17</sup>Fry and Pagan (2011) note that the “pure sign-restriction” approach successfully identifies only the structure but not the model. There is a multiple models problem because there are many set of impulse vectors that satisfy the sign restrictions, and will yield the same VAR and give the same fit to the data. One solution to overcome the model identification problem suggested by Fry and Pagan (2011) is to use quantitative information about the magnitude of the impulse responses and reduce the set of models.

rewarding responses that satisfy the constraints. The penalty function is defined as follows (Uhlig 2005, Appendix B.2, pp. 413-417):

$$f(x) = \begin{cases} x & \text{if } x \leq 0 \\ 100 * x & \text{if } x \geq 0 \end{cases} \quad (3.6)$$

where  $x$  is the impulse response. It is important to note here that the penalty function explained above is asymmetric, in which wrong responses are penalized more times (at a slope 100 times larger) than correct responses are rewarded. Due to the asymmetry in the numerical specification, this method is able to select the best of all impulse vectors, i.e., given a choice among many candidate monetary impulse vectors it picks the one which generates the most decisive response of the variables (Uhlig 2005, p. 413).

In sum, the “penalty function” approach goes as far as possible in imposing the sign restrictions and delivers impulse response functions with small standard errors, thus reducing the uncertainty of the identification procedure (Liu and Theodoridis, 2012). I therefore adopt the “penalty-function” over the “pure-sign restriction” approach for identification in this chapter.

### 3.4.2 MODEL SPECIFICATION AND ESTIMATION

#### MODEL SPECIFICATION

Keeping in mind my objective i.e. estimate the dynamic responses of relative food price and the distribution of food consumption to monetary policy shocks in rural and urban China, I include the following seven endogenous variables in my baseline VAR model  $Y_t$ : real GDP, consumer price index, interest rate, nominal money supply, relative food price, and the real per capita food consumption expenditures of the top quintile and the bottom quintile respectively.

I have fitted a VAR with 4 lags in levels of the logs of all the series, except for using

the interest rate directly. I add a constant and a time trend to Eq. (3.1). The horizon over which I impose the sign restrictions to identify monetary policy shocks is  $k = 2$  quarters, including the initial period of the shock. These restrictions are imposed only on the real output, consumer price index, interest rate and nominal money supply.<sup>18</sup> I use a Bayesian method to estimate the posterior densities of the parameters of interest, conditional on observing the sample data, for the baseline model as well as alternatives to check for robustness of the model specification. None of the results in section 3.5 are sensitive to increasing the common lag in the VAR to five lags, and to assuming the sign-restriction horizon as three quarters. My results discussed in section 3.5, for the baseline VAR model are robust to changes in model specification.

#### ESTIMATION

I estimate the posterior density using the “penalty function” approach of Uhlig (2005, Appendix B.2, pp 409-417). Note in particular that  $B$  and  $\Sigma$  are directly identified from estimation of the parameters in Eq. (3.1) using OLS. I assume a Gaussian likelihood function and a standard diffuse (Jefferey’s) prior on the reduced form parameters  $B$  and  $\Sigma$ , which implies that the joint posterior density of the parameters is of the Normal-Wishart form (Uhlig 2005, pp. 409-410):<sup>19</sup>

$$\Sigma^{-1} \sim W \left[ \left( T \hat{\Sigma}^{-1} \right), T \right] \quad (3.7)$$

$$(B|\Sigma) \sim N \left[ \hat{B}, \Sigma \times \hat{\Omega} \right] \quad (3.8)$$

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<sup>18</sup>A problem confronting my estimation is that the variables in my model are all characterized as non-stationary  $I(1)$  variables (Table 3.2, Appendix Figures 3.18-3.19). Therefore, in the appendix I conduct a robustness check for my results; prior to estimation, I transform all data to log first-differences except for interest rate which is just first differenced to impose stationarity. Due to first differencing, I impose the sign restrictions on the cumulative impulse responses. I find that my results discussed in section 3.5 for the baseline VAR model (estimating the VAR using variables in log levels) are robust to changes in model specification (estimating the VAR using variables in log first differences) (Appendix Figures 3.20-3.23).

<sup>19</sup>see Uhlig(1994) for a detailed discussion on the properties of Normal-Wishart distribution.

where  $T$  is the time series sample,  $\hat{B}$  and  $\hat{\Sigma}$  are the OLS estimates of the dynamic factor model with observable factors, and  $\hat{\Omega} = \frac{1}{T} \sum_{t=1}^T Y_{t-1} Y_{t-1}'$ . The algorithm entails the following steps:

1. Estimate  $\hat{B}$  and  $\hat{\Sigma}$  from Eq. (3.1) by OLS. OLS is efficient given the restrictions of the model.
2. Draw  $\bar{B}$  and  $\bar{\Sigma}$  from the posterior distribution given by Eq. (3.7) and (3.8) and conditional on the OLS estimates from step 1.
3. Using the values from this draw, impose the sign restrictions to identify structural shocks using the “penalty function” approach of Uhlig (2005, Appendix B.2, pp 413-417)
  - (a) Draw a  $m \times m$  matrix  $M$ , element by element, from a standard normal density, and use its “Q-R” factorization to set  $M = QR$ , where  $Q$  is an orthogonal matrix ( $QQ' = I$ ) and  $R$  is normalized to have positive diagonal elements.
  - (b) Set  $D_y = \tilde{D}Q$  which from Eq. (3.4) implies values for  $\bar{D}_k$  for  $k = 1, \dots, K$ , where  $\tilde{D}$  denotes the lower-triangular Cholesky factor of  $\Sigma$ .
  - (c) Let  $d_{j,k}$  be the impulse responses of variable  $j$  at horizon  $k$  to the impulse vector  $\bar{D}_k$ , where  $k = 0, \dots, K$ .  $\sigma_j$  is the standard deviation of the variable  $j$ , such that the impulse responses are re-scaled.<sup>20</sup> Let  $l_j = 1$  if  $j$  is the index of interest rate, and else, let  $l_j = -1$ .<sup>21</sup> The monetary impulse vector  $\bar{D}_k$  is defined as one that minimizes the criterion function  $\psi(\bar{D}_k)$ , which penalizes negative impulse responses of real GDP, consumer price index, nominal money supply, and positive impulse responses of interest rate at horizons  $k = 0, \dots, K$ . The horizon over which I impose these restrictions is  $k = 2$  quarters, including the initial period of the

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<sup>20</sup>This makes it possible to compare deviations across the various impulse responses.

<sup>21</sup>Note that the sign of the penalty function is flipped for the interest rate.

shock.

$$\psi(\bar{D}_k) = \sum_{j \in \left\{ \begin{array}{l} \text{"real GDP"} \\ \text{"consumer price index"} \\ \text{"interest rate"} \\ \text{"nominal money supply"} \end{array} \right\}} \sum_{k=0}^K f\left(l_j \frac{d_{j,k}}{\sigma_j}\right) \quad (3.9)$$

4. Since the true VAR is not known, I find the monetary policy impulse vector for each draw from the posterior, and accordingly calculate the statistics based on all the draws.

I show the median as well as the 16% and the 84% quantiles for the impulse responses.

### 3.5 EMPIRICAL RESULTS

#### 3.5.1 DYNAMIC RESPONSES TO MONETARY POLICY SHOCKS

My interest is how the relative food price and the distribution of food consumption respond to monetary policy shocks. I run VAR estimation separately for rural and urban China. The impulse responses are presented in Figures 3.10-3.13. Figures 3.10-3.11 present the impulse responses for rural China, while Figures 3.12-3.13 present the same for urban China.

I first discuss the results for rural China (Figures 3.10-3.11). Given an expansionary monetary policy shock, the interest rate falls by roughly 15 basis points on impact, then begins a slow asymptote towards its original value. The money supply increases by .40% on impact (liquidity effect), and further by .60% over the next two quarters. Output responds positively reaching a peak impact of .25% at a two-quarter horizon, and then makes a gentle descent back to its original value at the end of five quarters. The overall consumer price index also responds positively to the monetary policy shock. The peak elasticity is approximately .35, meaning that an expansionary monetary policy shock which results in a decline in interest rate by 15 basis points increases the general price level in the economy by .35% at a

four-quarter horizon. The impulse responses of the interest rate, nominal money, GDP, and CPI series conform with standard dynamic macroeconomic theory, lending validity to the identification scheme employed in this chapter (sign-restriction), and suggesting reliability in the results for the other series i.e., relative food price and the distribution of food consumption.

The estimated response functions for relative food price and the distribution of food consumption series is the main focus of this chapter. The relative price of food rises fairly monotonically reaching a peak impact of .50 at a four-quarter horizon, and then gradually approaches its original response at the end of seven quarters. Consistent with several earlier studies, this study provides empirical evidence that food price is relatively more flexible than the overall price level, and so expansionary monetary policy shocks cause an increase in the *relative* price of food. Given an expansionary monetary shock, that leads to an increase in the *relative* price of food, the per capita real food consumption expenditures of low-income households (bottom quintile) remain unchanged (on average), however that of high-income (top quintile) households fall and remain in the negative region for roughly six quarters. The peak negative impact for high income households is .75 at a four-quarter horizon. Results for rural China are suggestive of the evidence that the food demand of low income households is more price inelastic compared to high income households. There are two reasons contributing to this result. First, low income households who are close to *subsistence* caloric intake have very limited ability to substitute into other less expensive goods when *relative* price of food increases. Food is more a *necessity* for them and consequently their food demand is price inelastic (Portillo et al., 2016). Second, household food self-sufficiency among the rural low income households allow them to minimize their food expenditures, and at the same time meet their *subsistence* nutritional needs without having to rely on risky markets.

Thus, I observe strong heterogeneity in the food consumption responses faced by households

across different income classes. Figure 3.11 plots the difference between the estimated food consumption responses of high-income and low income households in rural China. Using the difference between the 80th percentile and the 20th percentile of the log levels in the food consumption distribution as a measure of food consumption inequality, this chapter reports that food consumption inequality decreases from expansionary monetary shocks to an economically meaningful extent in rural China.

Second, I look at urban China (Figures 3.12-3.13). An expansionary monetary policy shock causes the interest rate to fall by roughly 5-10 basis points, and the money supply to increase by .70% on impact. The *relative* price of food increases monotonically, reaching a peak impact of .60 at a two-quarter horizon, continues to remain high for the next two quarters, and then gradually starts falling. In response to the expansionary monetary shock, I note that the real food consumption expenditures of both low-income and high-income households fall, however the latter falls more than the former. While the peak decline in food consumption is .80 for the top quintile, it is .60 for the bottom quintile at the two-quarter horizon.

Thus, results for urban China point to expansionary monetary shocks having heterogeneous negative effects on the distribution of food consumption which reduce food consumption at the lower end of the distribution much less than that at the upper end, again suggestive of the evidence that low income households who survive on subsistence food are more price inelastic compared to high income households. Figure 3.13 plots the difference between the estimated food consumption responses of high-income and low income households in urban China. Because food consumption at the lower end of the distribution falls less than that at the upper end, inequality in food consumption decreases from expansionary monetary shocks in urban China as well.

Overall, results of my study provide empirical evidence in favor of the impact of the “*food price channel*” of monetary policy on the distribution of food consumption in China. I find evidence of somewhat stronger impact in urban China compared to rural China, reflecting the protective effect of agricultural activities.

### 3.5.2 HOW MUCH VARIATION DO MONETARY POLICY SHOCKS EXPLAIN?

In this sub section, I consider the extent to which monetary policy shocks in China can account for the dynamics of the food price fluctuations and the distribution of food consumption. That is, whereas the previous sub section focused on characterizing whether monetary policy shocks affect relative food prices and the distribution of food consumption, I now turn to the question of assessing the economic importance of this relationship. I do so by studying the share of the variance in the food consumption distribution which can be accounted for by monetary policy shocks over the given time period. According to the median estimates shown in the middle lines of Figures 3.14-3.15 , monetary policy shocks account for 15-20 % of the variation in relative food price index, and the distribution of real per capita food consumption expenditure for majority of the forecasting horizons. Monetary policy shocks appear to have played a non-trivial role in accounting for fluctuations in food consumption distribution in rural and urban China over the study period. Figures 3.14-3.15 also plot equivalent variance decompositions for all other macroeconomic variables over the same time period. The contribution of monetary policy shocks to the variance of these variables is also in the 10-20 percent range for most horizons. The forecast error variance decompositions show that the contribution of monetary policy shocks to fluctuations in the distribution of food consumption is of the same order of magnitude as the contribution of these shocks to other macroeconomic variables like GDP and inflation.

### 3.6 COMPARISON: INDIA AND CHINA

In my second chapter, relying on a factor augmented vector auto regression (FAVAR) model, I study the dynamic effects of monetary policy shocks on relative food prices and the distribution of household food consumption in India over the same sample period i.e. 1996-2013, and find empirical evidence of the impact of “*food price channel*” of monetary policy on the distribution of food consumption in the country.

Comparing the results of India with China, I find that the relative food price responds *positively* and the distribution of food consumption responds *negatively* to expansionary monetary policy shocks in both countries, however the differential effects of policy shocks on the rich vs. poor are strikingly different in the two emerging market economies. Following an expansionary monetary policy shock, while in India, I find that the food consumption of the poor falls markedly more than the rich, in China I find the exact opposite. This means that while in India “*the food price channel*” of monetary policy increases food consumption inequality, in China the same channel reduces inequality (Figures 3.16-3.17).

Results for India and China also show that poor households (bottom quintile) in India are far more sensitive to the “*food price channel*” of monetary policy than those in China. This difference could be attributed to the high degree of heterogeneity in the characteristics of poor households across the two countries. In particular, there are four differential features that are noteworthy: (i) while in India the bottom quintile (poor households) allocate on average roughly 65-70% of their total budget towards food, in China they allocate about 50-55%; (ii) while in India the rural poor rely largely on cash purchases of food (*food purchased from the market*) to meet their daily food requirements which make them more sensitive to fluctuations in relative food prices, in China they rely heavily on self-produced food which plays a key role in dampening the effects of relative food price changes on them; (iii) while in India the poor live hand-to-mouth, i.e., they have no access to credit markets

and simply consume their current labor income, in China the poor have significantly higher access to the formal financial institutions that hedge in some way against inflation (Anand and Prasad, 2015; Fungacova et al., 2015; Sparreboom and Duflos, 2012). Due to differences in the degree of financial inclusion, poor households in the two countries differ significantly in terms of their ability to smooth consumption behaviour in the face of idiosyncratic shocks. Finally, India is characterized by the presence of a huge informal sector (90%) compared to China (50%); higher relative food price acts as an implicit tax for the Indian poor engaged in the informal sector where wages are not indexed to inflation, and where workers don't have much bargaining power vis-a-vis their employers. (Easterly and Fischer, 2001; Rada, 2010; Gulati and Saini 2013; Rajan, 2016). Due to the above factors, the privation imposed on the poor in India, by rise in relative food prices from expansionary monetary shocks is large enough, that their food consumption (despite being at subsistence) seems to be far more elastic with respect to price, than the poor in China. Therefore, in response to monetary expansion poor households in India witness a much greater fall in food consumption than poor households in China.

### 3.7 SUMMARY AND CONCLUSION

*“The relative effects of inflation on the rich versus the poor must be specific to the institutions and histories of each economy. The question must be an empirical one, and the answer may well differ among economies.”*

*Easterly and Fischer, 2001*

Using household survey data and vector auto regression (VAR) framework, this chapter empirically investigates the impact of monetary policy shocks on the distribution of food consumption in China. Results of this study show that expansionary monetary policy shocks in China have heterogeneous *negative* effects on the distribution of food consumption which reduce food consumption at the upper end of the distribution more than that at the lower

end. There seems to be evidence of the presence of the “*food price channel*” of monetary policy, through which these distributional effects occur. The mechanism is simple: food prices being relatively more flexible, following a monetary expansion, adjust quicker than the overall price level in the economy. So, expansionary monetary policy shocks generate an increase in the *relative* price of food. Rich households in China respond significantly more to this *relative* food price change compared to the poor. The poor in China are found to be much more demand inelastic with respect to food price primarily because of their subsistence caloric intake (*necessity*) and high degree of food self-sufficiency. Therefore, following monetary expansion poor households witness a much smaller decline in food consumption than the rich, leading to an overall decline in inequality.

This chapter documents that expansionary monetary policy shocks in China via the “*food price channel*” have statistically significant *negative* effects on food consumption inequality. Interestingly, the results observed for China are a striking contrast to those observed for India. In India while expansionary monetary shocks via the “*food price channel*” increase food consumption inequality, in China expansionary monetary shocks via the same channel reduce inequality. This observed difference in the results between India and China could be attributed to the differences in the characteristics and features of poor households across the two countries. Relative to China, poor households in India are characterized by a higher share of food in total budget, dependence on cash purchases of food, financial constraints, and informal employment; all these make them more vulnerable to fluctuations in relative food prices. Consequently expansionary monetary policy shocks, which increase the relative price of food, have stronger adverse effects on the Indian poor.

Aside from these factors, other differences in household characteristics (with regard to socioeconomic and demographic factors, such as age and education, rural-urban migration, income, wealth, employment status, tax and housing status, patterns of food consumption)

between the two economies could also potentially have implications for their response to changes in monetary policy. Many mechanisms through which monetary policy affects households in different ways may be at play, and it is a daunting task to disentangle and identify these effects empirically (Yannick and Ekobena, 2014). In conclusion, results for India and China suggest that in emerging market economies the impact of “*food price channel*” of monetary policy on inequality is ambiguous, and rather specific to the household characteristics, institutions and histories of each economy.

## FIGURES AND TABLES

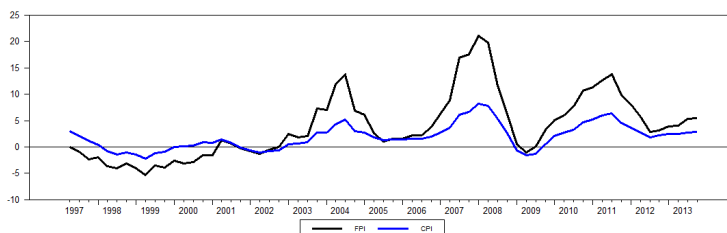


Figure 3.1: Growth Rate of FPI vs. CPI, China (%)

Source: Federal Reserve Bank of St. Louis Data Base (FRED).

Notes: FPI (food price index) is the consumer price index of food; CPI is the overall consumer price index in the economy.

<i>Emerging Markets</i>		<i>Advanced Economies</i>	
Indonesia	53.0	Japan	14.7
Vietnam	49.8	Germany	11.5
India	48.8	Australia	10.8
China	36.7	Canada	9.3
Russia	33.2	United Kingdom	8.8
Malaysia	28.0	USA	5.7
<b>Average</b>	<b>41.6</b>	<b>Average</b>	<b>10.1</b>

Figure 3.2: Cross Country Comparison, Share of Food in Total Expenditure (%)

Source: Anand and Prasad, 2015

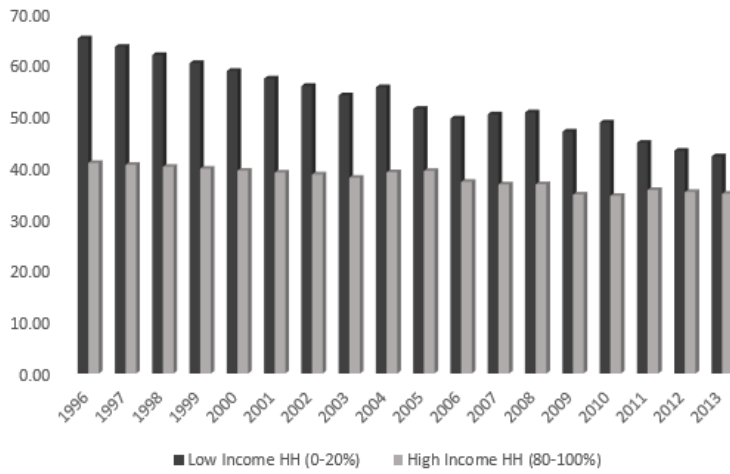


Figure 3.3: Share of Food in Total Expenditure, Rural China (%)

Source: National Bureau of Statistics, China

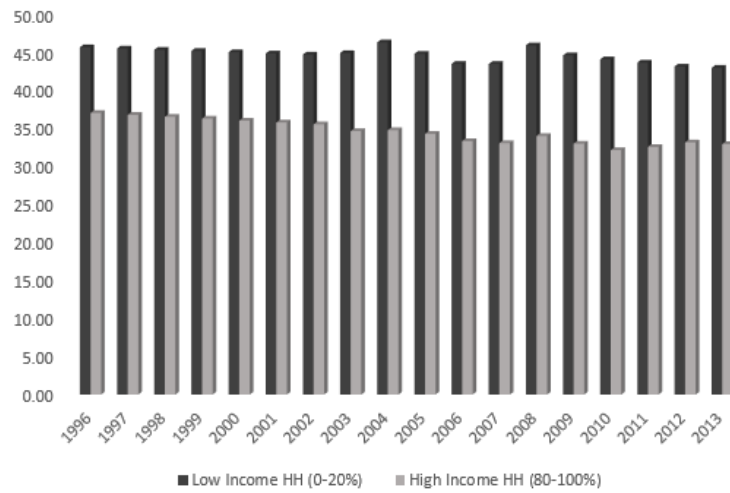


Figure 3.4: Share of Food in Total Expenditure, Urban China (%)

Source: National Bureau of Statistics, China

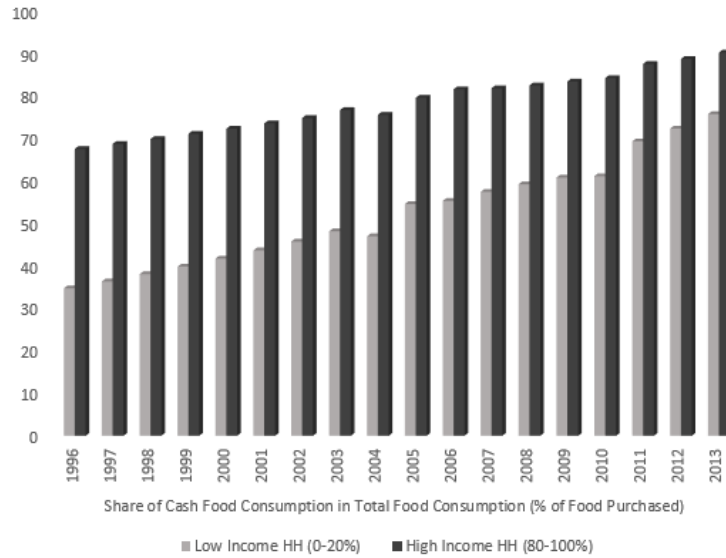


Figure 3.5: Share of Cash Food in Total Food Expenditure, Rural China (%)

Source: National Bureau of Statistics, China

Notes: Share of Cash Food indicates the share of food purchased from market.

<i>Selected EMs</i>	<i>Percent with access</i>	<i>Selected EMs</i>	<i>Percent with access</i>
Argentina	33	Nigeria	30
Brazil	56	Philippines	27
Chile	42	Poland	70
China	64	Russia	48
India	35	South Africa	54
Indonesia	20	Thailand	73
Kenya	42	Turkey	58
Malaysia	66		
<b>Median (29 Emerging Markets): 42</b>		<b>Median (27 Advanced Economies): 96</b>	

Figure 3.6: Cross Country Comparison, Financial Inclusion (%)

Source: Anand and Prasad, 2015

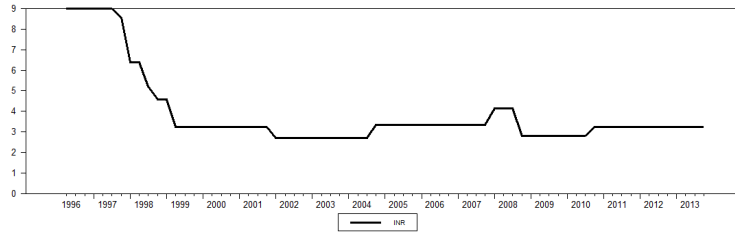


Figure 3.7: Central Bank Rate, China (%)

Source: Federal Reserve Bank of St. Louis Data Base (FRED).

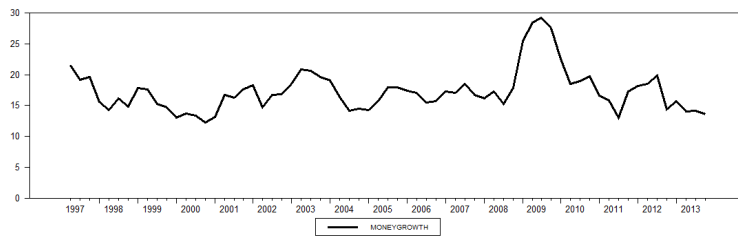


Figure 3.8: Growth Rate of Nominal Money Supply (M2), China (%)

Source: Federal Reserve Bank of St. Louis Data Base (FRED).

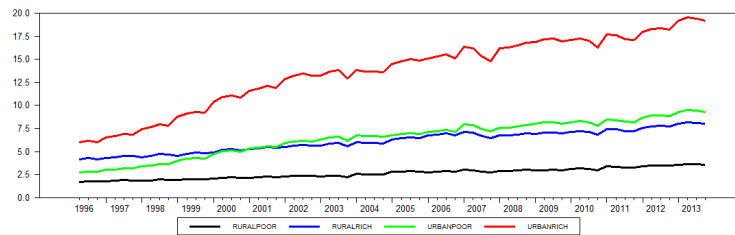


Figure 3.9: Distribution of Real Per Capita Food Consumption Expenditure, China

Source: National Bureau of Statistics, China.

Notes: Poor households feature those who lie in the 0-20% of income distribution (bottom quintile or 20<sup>th</sup> percentile). Rich households feature those who lie in the 80-100% of income distribution (top quintile or 80<sup>th</sup> percentile).

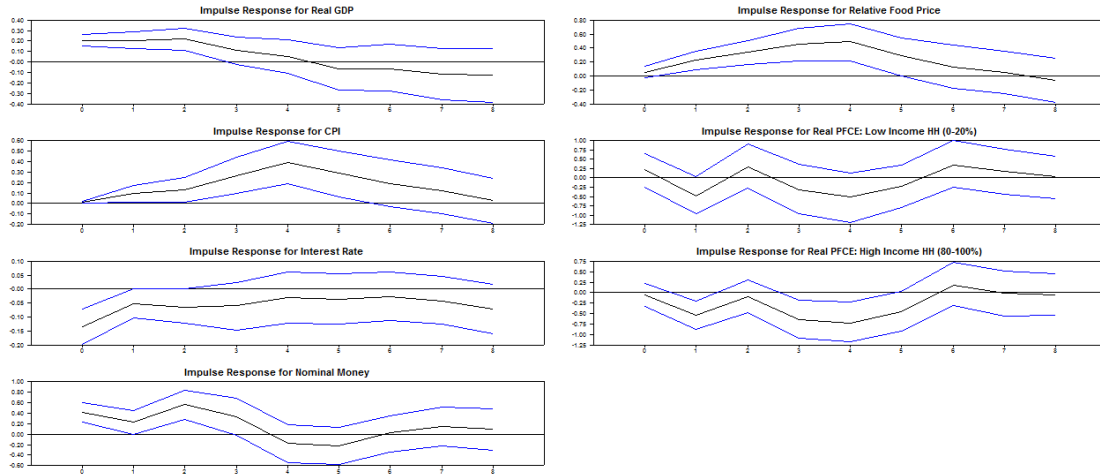


Figure 3.10: Impulse Responses to Expansionary Monetary Policy Shock, Rural China

Notes: Impulse responses to an expansionary monetary policy shock in rural China using penalty function approach with  $K = 2$  (2 years). The responses of the CPI, the real GDP and nominal money supply has been restricted not to be negative and the interest rate not to be positive for quarters  $k$ ,  $k=0,1,2$  after the shock. The three lines are 16 % quantile, the median and the 84 % quantile of the posterior distribution. Real PFCE refers to quarterly real per capita food consumption expenditures.

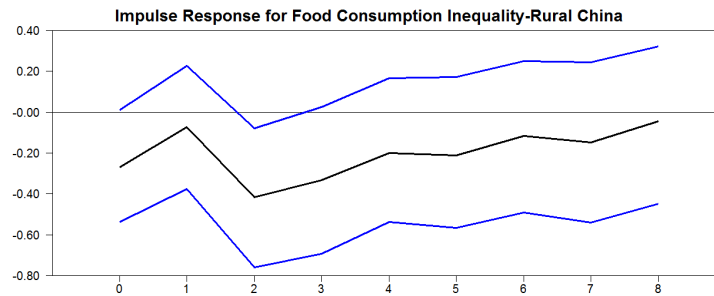


Figure 3.11: Impulse Response for Food Consumption Inequality, Rural China

Notes: Food consumption inequality is measured by the difference between the top quintile (80th percentile) and the bottom quintile (20th percentile) of the log levels in food consumption distribution.

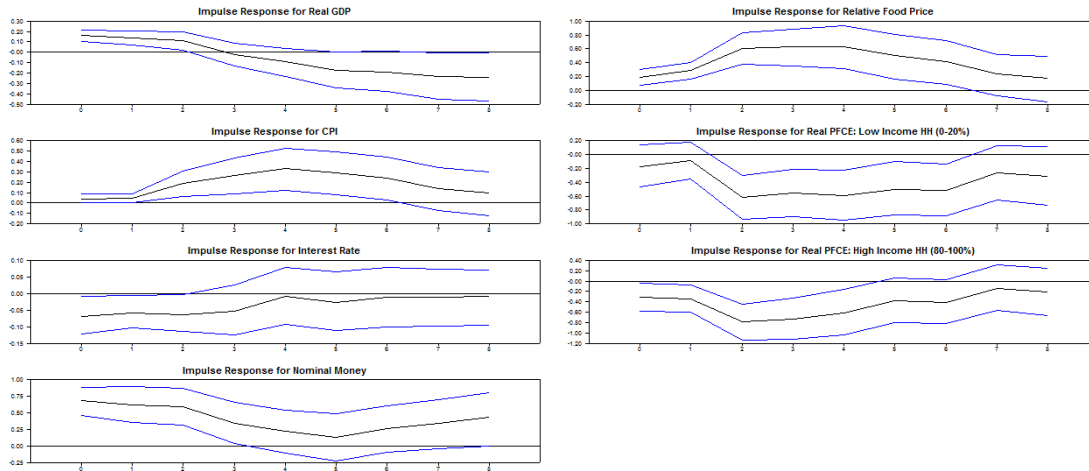


Figure 3.12: Impulse Responses to Expansionary Monetary Policy Shock, Urban China

Notes: Impulse responses to an expansionary monetary policy shock in urban China using penalty function approach with  $K = 2$  (2 years). The responses of the CPI, the real GDP and nominal money supply has been restricted not to be negative and the interest rate not to be positive for quarters  $k$ ,  $k=0,1,2$  after the shock. The three lines are 16 % quantile, the median and the 84 % quantile of the posterior distribution. Real PFCE refers to quarterly real per capita food consumption expenditures.

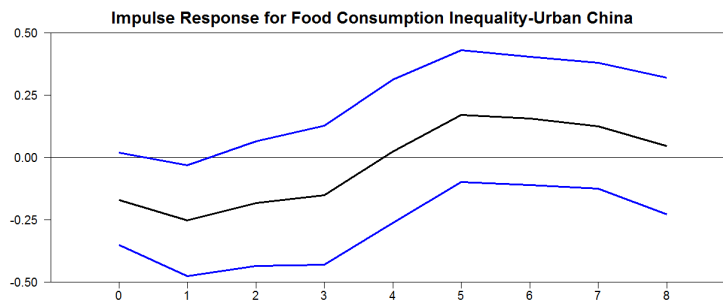


Figure 3.13: Impulse Response for Food Consumption Inequality, Urban China

Notes: Food consumption inequality is measured by the difference between the top quintile (80th percentile) and the bottom quintile (20th percentile) of the log levels in food consumption distribution.

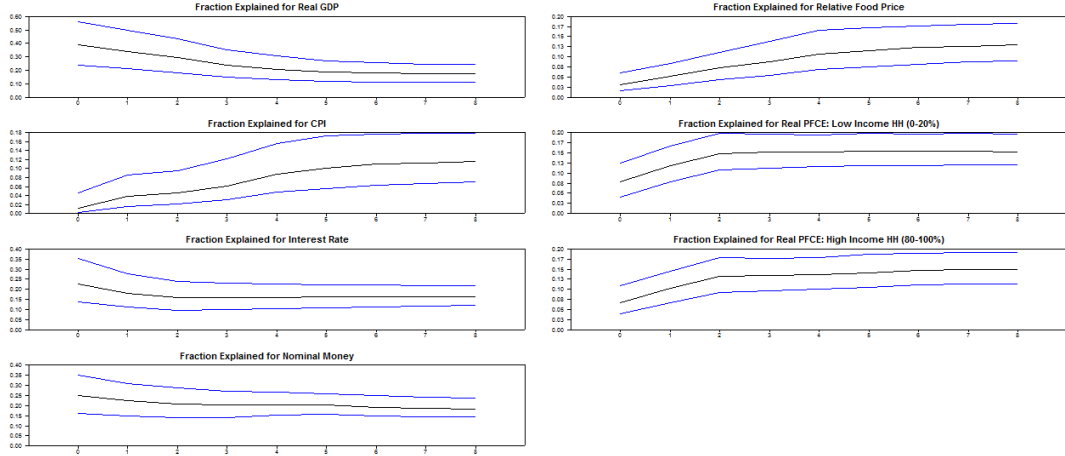


Figure 3.14: Fraction of the forecast error variance explained by monetary policy shock, Rural China

Notes: These plots show the fraction of the variance of the  $k$  - step ahead forecast revision explained by a monetary policy shock, using penalty function approach with  $K = 2$  (2 years). The three lines are 16 % quantile, the median and the 16 % quantile of the posterior distribution. Real PFCE refers to quarterly real per capita food consumption expenditures.

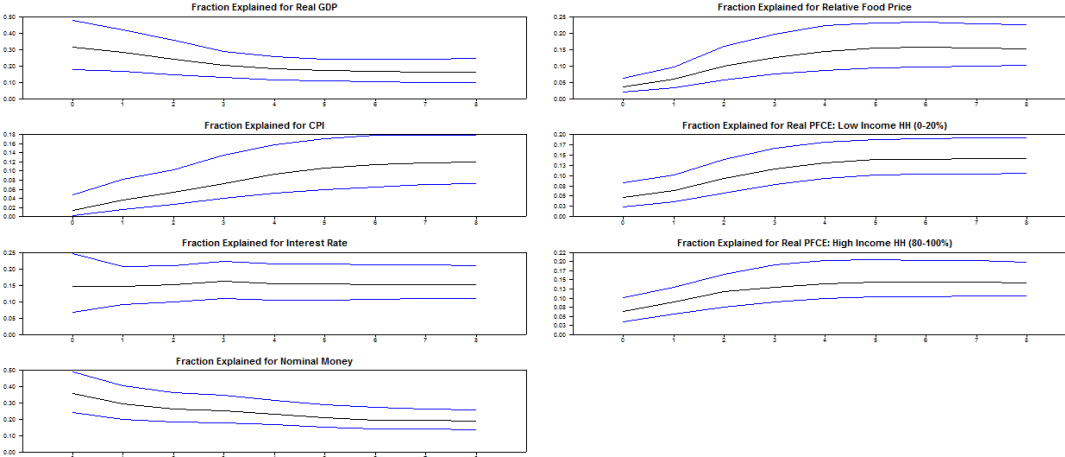


Figure 3.15: Fraction of the forecast error variance explained by monetary policy shock, Urban China

Notes: These plots show the fraction of the variance of the  $k$  - step ahead forecast revision explained by a monetary policy shock, using penalty function approach with  $K = 2$  (2 years). The three lines are 16 % quantile, the median and the 16 % quantile of the posterior distribution. Real PFCE refers to quarterly real per capita food consumption expenditures.

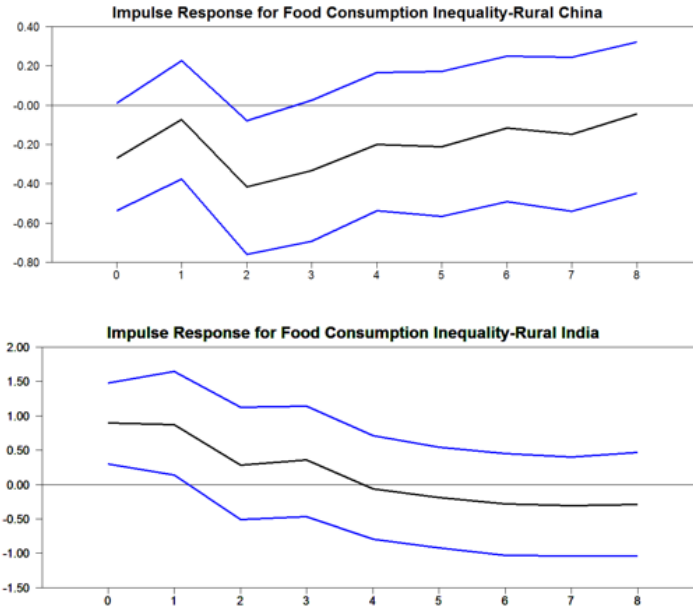


Figure 3.16: Food Consumption Inequality, Rural China vs. Rural India

Notes: Impulse response of food consumption inequality to an expansionary monetary policy shock, rural China vs. rural India.

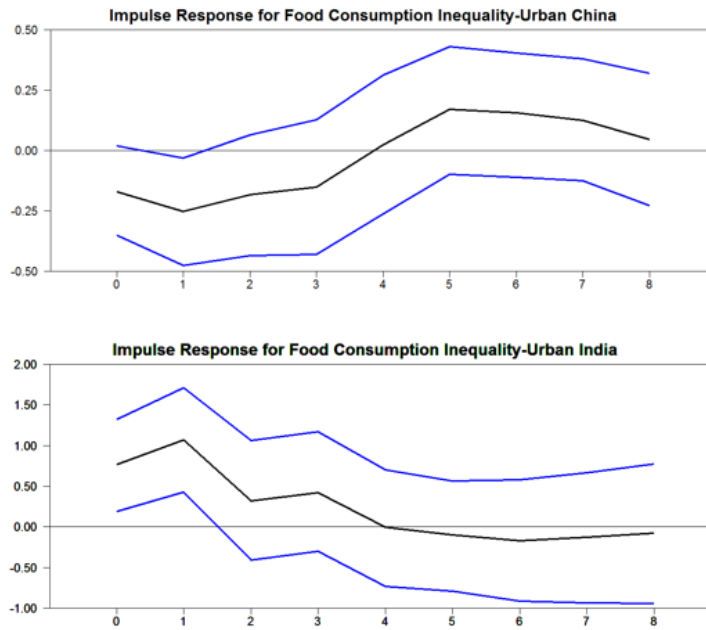


Figure 3.17: Food Consumption Inequality, Urban China vs. Urban India

Notes: Impulse response of food consumption inequality to an expansionary monetary policy shock, urban China vs. urban India.

Table 3.1: Average Annual Growth Rate, China, 1996-2013

Variable	Growth Rate (%)
GDP	9.10
CPI	1.99
Nominal Money	17.10
Food Price	3.50
Real PFCE, Bottom Quintile, Rural China	4.06
Real PFCE, Bottom Quintile, Urban China	6.92
Real PFCE, Top Quintile, Rural China	3.63
Real PFCE, Top Quintile, Urban China	6.61

Source: Federal Reserve Bank of St. Louis Data Base (FRED); National Bureau of Statistics (NBS), China.

Notes: Real PFCE, Bottom Quintile indicates the real per capita food consumption expenditure of households who fall in the 0-20% of income distribution (20th percentile), and Real PFCE, Top Quintile indicates the real per capita food consumption expenditure of households who fall in the 80-100% of income distribution (80th percentile).

Table 3.2: Unit root tests, China, 1996-2013

Variable	Unit root test (PP Statistic)
GDP	-1.61
CPI	-1.40
Interest Rate	-2.23
Nominal Money	-1.87
Relative Food Price	-2.57
Real PFCE, Bottom Quintile, Rural China	-4.76
Real PFCE, Bottom Quintile, Urban China	-1.79
Real PFCE, Top Quintile, Rural China	-3.22
Real PFCE, Top Quintile, Urban China	-1.85
5% critical value	-3.47

Notes: PP stat = Phillips/Perron unit root test statistic (model includes deterministic trend). Real PFCE, Bottom Quintile indicates the real per capita food consumption expenditure of households who fall in the 0-20% of income distribution (20th percentile), and Real PFCE, Top Quintile indicates the real per capita food consumption expenditure of households who fall in the 80-100% of income distribution (80th percentile).

### 3.8 APPENDIX: ROBUSTNESS CHECK

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Likelihood Based Analysis of Cointegration
Variables: GDP CPI INR Nominal Money Relative Food Pr Real PFCE-BQ Real PFCE-TQ
Estimated from 1996:03 to 2013:04
Data Points 66 Lags 4 with Constant restricted to Cointegrating Vector

Unrestricted eigenvalues and -T log(1-lambda)
Rank  EigVal  Lambda-max  Trace  Trace-95%  LogL
0
1  0.7677  96.3551  272.8105  134.5400  -459.0681
2  0.5973  60.0264  176.4553  103.6800  -380.8773
3  0.4601  40.6778  116.4290  76.8100  -360.5384
4  0.3838  31.9590  75.7512  53.9400  -344.5589
5  0.3103  24.5157  43.7922  35.0700  -332.3011
6  0.1721  12.4637  19.2765  20.1600  -326.0693
7  0.0981  6.8129  6.8129  9.1400  -322.6628

Cointegrating Vector for Largest Eigenvalue
GDP  CPI  INR  Nominal Money Relative Food Pr Real PFCE-BQ Real PFCE-TQ Constant
-0.385618  0.124953  -1.457702  -0.010385  0.631951  -0.110718  0.552534  199.683002
    
```

Figure 3.18: Cointegration Test, Rural China

Notes: Real PFCE, BQ indicates the real per capita food consumption expenditure of the bottom quintile and Real PFCE, TQ indicates the real per capita food consumption expenditure of the top quintile.

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Likelihood Based Analysis of Cointegration
Variables: GDP CPI INR Nominal Money Relative Food Pr Real PFCE-BQ Real PFCE-TQ
Estimated from 1996:03 to 2013:04
Data Points 66 Lags 4 with Constant restricted to Cointegrating Vector

Unrestricted eigenvalues and -T log(1-lambda)
Rank  EigVal  Lambda-max  Trace  Trace-95%  LogL
0
1  0.8081  108.9390  274.2082  134.5400  -395.8915
2  0.5474  52.3158  165.2693  103.6800  -369.7336
3  0.4947  45.0455  112.9534  76.8100  -347.2108
4  0.3238  25.8202  67.9079  53.9400  -334.3007
5  0.2882  22.4381  42.0877  35.0700  -323.0816
6  0.1650  11.8986  19.6495  20.1600  -317.1323
7  0.1108  7.7509  7.7509  9.1400  -313.2568

Cointegrating Vector for Largest Eigenvalue
GDP  CPI  INR  Nominal Money Relative Food Pr Real PFCE-BQ Real PFCE-TQ Constant
-0.372790 -0.128393  0.915093  0.228308  -0.031844  -0.371733  0.476619  70.176867
    
```

Figure 3.19: Cointegration Test, Urban China

Notes: Real PFCE, BQ indicates the real per capita food consumption expenditure of the bottom quintile and Real PFCE, TQ indicates the real per capita food consumption expenditure of the top quintile.

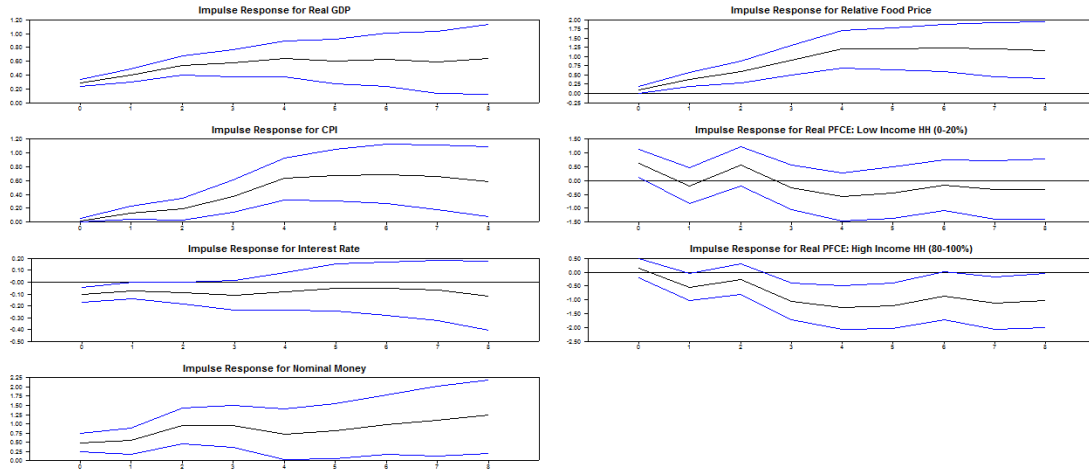


Figure 3.20: Impulse Responses from VAR in first differences, Rural China

Notes: Impulse responses to an expansionary monetary policy shock in rural China. All variables have been transformed to log first-differences except for interest rate which is just first differenced, to impose stationarity. The sign restrictions have been imposed on the accumulated IRF's.

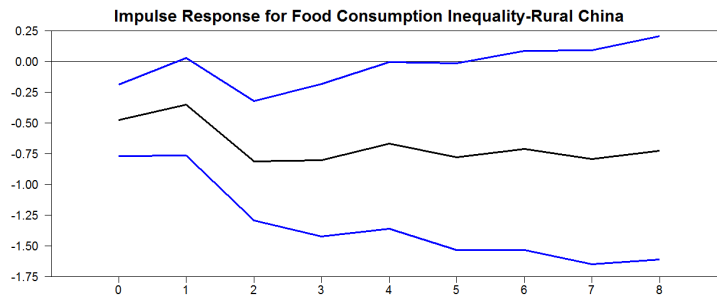


Figure 3.21: Food Consumption Inequality from VAR in first differences, Rural China

Notes: Impulse responses to an expansionary monetary policy shock in rural China. Food consumption inequality is measured by the difference between the top quintile (80th percentile) and the bottom quintile (20th percentile) of the log levels in food consumption distribution.

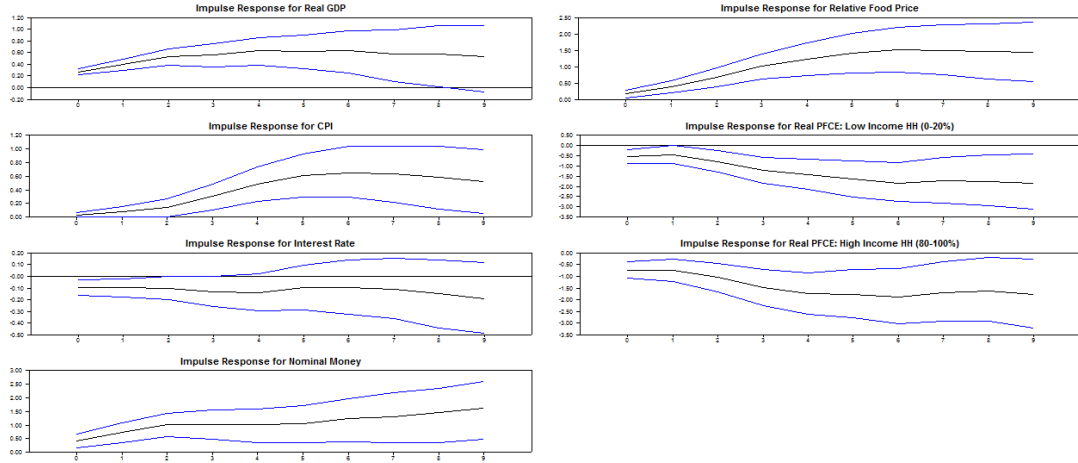


Figure 3.22: Impulse Responses from VAR in first differences, Urban China

Notes: Impulse responses to an expansionary monetary policy shock in urban China. All variables have been transformed to log first-differences except for interest rate which is just first differenced, to impose stationarity. The sign restrictions have been imposed on the accumulated IRF's.

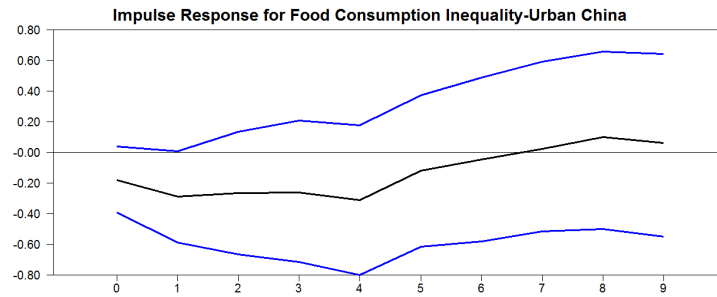


Figure 3.23: Food Consumption Inequality from VAR in first differences, Urban China

Notes: Impulse responses to an expansionary monetary policy shock in urban China. Food consumption inequality is measured by the difference between the top quintile (80th percentile) and the bottom quintile (20th percentile) of the log levels in food consumption distribution.

## CHAPTER 4

### THE FOOD PRICE CHANNEL IN INDIA REVISITED

#### 4.1 INTRODUCTION

How does monetary policy affect relative food prices and the distribution of food consumption in India? This question is very important, especially in the Indian context, where 25% of the population or roughly 300 million people live below the national poverty line and about 15% of the population or approximately 194.6 million people are undernourished, which accounts for the highest number of people suffering from hunger in any single country (State of Food Security in the World, FAO, 2015). Poor households in India spend remarkably high on food, about 65-70% of their income, and yet live significantly below the biological minimum (subsistence) caloric intake.<sup>1</sup> Fluctuations in relative food prices can undermine the food security and livelihoods of the most vulnerable by disrupting their already limited purchasing power and pose a threat to food and nutrition security of the country. Despite concerns of food security, this question remains relatively unaddressed in the monetary policy literature in India.

In the second chapter, I attempt to answer this question by relying on household survey data and a factor-augmented vector auto regression (FAVAR) framework. FAVAR results show that the relative price of food responds *positively*, and the distribution of food consumption responds *negatively* to expansionary monetary policy shocks in India. There appears to be

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<sup>1</sup>Despite a very high share of expenditure on food, the bottom quartile is substantially food deprived. The per capita per day intake of calories for this group is 1,500 Kcal in rural India and 1,577 Kcal in urban India, which is significantly below the biological minimum intake of 2,400 Kcal in rural areas and 2,100 Kcal in urban areas.

strong heterogeneity in the food consumption responses faced by households across different expenditure classes. Following monetary expansion, households at the lower end of the distribution witness a much larger decline in food consumption than those at the upper end. Overall, results from my second chapter provide evidence of the impact of a “*food price channel*” of monetary policy on the distribution of food consumption in India - food prices being relatively more flexible, adjust quicker than the overall price level in the economy, so monetary expansion increases the *relative* prices of food. Because food comprises a disproportionate share of the income of the poor and has limited substitutability, this relative price response is tantamount to a *negative* income shock for them.<sup>2</sup> Therefore, expansionary monetary policy shocks which increase the relative price of food reduce the *subsistence* food consumption of poor households, hurting them unintendedly. The policy shocks end up penalizing the poor households much more than the rich.

In the current chapter, I revisit the “*food price channel*” of monetary policy by attempting to answer the same question using a dynamic stochastic general equilibrium (DSGE) model. In particular, I build the “*food price channel*” into a DSGE framework with heterogeneous agents whose behaviour regarding food consumption differs across households. While the empirical analysis (which is essentially a reduced form approach) in the second chapter establishes a general set of results and conclusions from the relevant data, the theoretical exercise in the current chapter attempts to provide a more precise understanding of the mechanisms at work. For my purpose, I closely follow Portillo et al. (2016) who study the welfare effects of monetary policy at different levels of development, by introducing food subsistence into a simple new-Keynesian model with flexible food and sticky non-food prices. Consistent with microeconomic evidence (e.g., Cardoso 1981; Bils and Klenow, 2004; Dhyne et al., 2006; and Nakamura and Steinsson, 2008), the authors assume that food

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<sup>2</sup>In my second chapter, the rich households are identified as those who lie in the top 20% of expenditure distribution (top quintile) and poor households in the bottom 20% (bottom quintile). Refer to Chapter 2.

prices are flexible and non-food prices are sticky. The model encompasses both rich and poor nations and does a reasonably good job of replicating the stylized facts and bringing out the heterogeneous structural characteristics of countries across the development spectrum, including the dominant role played by changes in relative price of food in poor countries. Motivated by the same and keeping in mind my objective of investigating the “*food price channel*” of monetary policy in India, I adapt the closed economy DSGE model of Portillo et al. (2016) by introducing heterogeneous agents (rich and poor households) who differ in their *proximity to subsistence* food threshold, and calibrate it for India. The *distance from subsistence* is critical to the model; it endogenously produces key features of the rich and poor households (with regards to their food share, price elasticity, labor productivity etc.) and holds implications for households’ response to changes in monetary policy.

I conclude two key results from my calibrated DSGE analysis. First, expansionary monetary policy shocks lead to increase in the *relative* prices of food. Following an exogenous monetary policy loosening the food sector featuring flexible prices records the highest rise in prices. Second, expansionary monetary shocks have *negative* heterogeneous effects on food consumption which reduce food consumption at the lower end of the distribution much less than that at the upper end. The observed heterogeneity in the food consumption responses is due to the difference in the respective *elasticities* of the two groups of households. Due to very low levels of initial food consumption, food is a *necessity* for the poor. Proximity to subsistence reduces (increases) the income and price elasticities of demand in the food sector (non-food sector), and also reduces the inter-temporal elasticity of substitution (increases the risk aversion or degree of habit formation). Therefore, poor households are far more risk averse and demand inelastic with respect to food price compared to the rich. Consequently their food consumption does not change much in response to policy shocks. So, following monetary expansion poor households witness a much smaller decline in food consumption than the rich.

Consistent with my FAVAR analysis in the second chapter, the DSGE analysis in the current chapter also provide evidence in favor of the impact of the “*food price channel*” of monetary policy on the distribution of food consumption in India. However contrary to the FAVAR analysis, the DSGE exercise points towards monetary expansion reducing the observed inequality across households in food consumption via the “*food price channel*” (instead of increasing). Understanding why the theoretical and empirical framework in the second and current chapter produce different results could be complex, however in understanding this, careful consideration needs to be given to how well the theoretical model is able to replicate the real economy. While the empirical framework (FAVAR) uses actual real time data which reflects many heterogeneous features of households like differential wages, labor market segmentation, informal sector employment, financial inclusion etc., the theoretical exercise (DSGE) relies only on *proximity to subsistence* and abstracts away from many of the other aforementioned heterogeneous household characteristics. Incorporating some of the other heterogeneous features of households in the DSGE model like financial inclusion and labor market segmentation could be helpful in making the two models more comparable, however this is beyond the scope of the current chapter and forms an avenue for future research.

## 4.2 LITERATURE REVIEW

In addition to the literature on structural transformation (e.g. Chenery and Syrquin, 1975; Caselli and Coleman, 2001; Ngai and Pissarides, 2007; Herrendorf et al., 2014; Anand and Prasad, 2015; and Portillo et al., 2016) this chapter is closely linked to two other strands of literature, which I summarize below.

### 4.2.1 ROLE PLAYED BY FOOD PRICES

There is a large body of literature that investigate the distributional consequences of changes in relative food price in low income countries. The first and most important distributional

consequence of a rise in relative food price is through a reduction in real income. In low income countries, changes in relative food price is an important determinant of changes in the relative and absolute real income of poor people, because they spend a disproportionate share of their budget on food. Mellor (1978), Ravallion (1998), Rao (1998), and Pons (2011), among many others find that in India an increase in relative prices of food generate a large negative real income effect for poor households, and the bulk of adjustment to reduced food supplies is made by low-income people. The authors show that higher relative food prices exacerbate problems of poverty and inequality through adverse distributional effects on the real income of poor households. Similar research studies done on Latin American countries - Guatemala, Nicaragua, Honduras, and Peru show that an increase in relative food prices represent a negative shock for poor households; given the disproportionate share of budget allocated to food, the increase in relative food prices erodes the real purchasing power of the poor (Robles and Torero, 2010).

The next important distributional consequence of a rise in relative food prices is through its differential effects on net buyers and net sellers of food. Dev and Ranade (1998) investigate the distributional consequence of a rise in relative food prices in India, through its effects on net buyers vs. net sellers of food. The authors find that by a very conservative estimate, the entire urban population and at least 50 per cent of the total rural population is adversely affected by an increase in relative prices of food. Adjustment in wages, employment and capital flows to agriculture takes time to reach the poor. Using time series data Rashid (2002) finds that since the mid-1980s changes in relative foodgrain prices have had a negligible impact on agricultural wages in Bangladesh. Using data from a number of African countries, Christiaensen and Demery (2007) study the second-round effects by including an additional effect of increased farm productivity arising from the increase in relative price of food staples. Their main conclusion is that higher relative food prices are likely to increase poverty, even after factoring in countervailing wage and productivity effects. Similar research studies done

on Zimbabwe and Sub-Saharan Africa also confirm that there are clear links between higher relative food prices, lower caloric intake, poverty, and increase in child malnutrition (Wodon et al. 2010; Alderman, Hoddinott, and Kinsey, 2006). The impact on poverty is also seen in terms of (a) poor nutrition status of pregnant and lactating women and of pre-school children; (b) poor health status of women and children; (c) increase in child labour and withdrawal of children from school; (d) the distress sale of productive assets. All these have potential long term impact and reduce the ability of individuals and households to get out of poverty trap (Mahendra Dev, 2012).

The literature concludes that, in low-income countries changes in relative prices of food play a dominant role in the welfare of the poor, for whom spending on food comprises a large budget share. Increase in relative prices of food represent an overall negative income shock for poor households.

#### 4.2.2 ROLE PLAYED BY MONETARY FACTORS

In new-Keynesian literature the relative importance of monetary non-neutralities have been the focus of intensive research (e.g. Goodfriend and King, 1997; Clarida, Gali and Gertler, 1999; Christiano, Eichenbaum and Evans 1999; Woodford, 2005; and Gali, 2015).<sup>3</sup> The central idea is that infrequent price adjustments cause mark-ups to fluctuate, and distort relative prices, thus generating real effects of money in the short run. Bordo (1980), Chambers and Just (1981), Orden and Fackler (1989), Frankel (1986), Orden (1986), Cho et al. (1993) and Dorfman and Lastrapes (1996) have given empirical and theoretical explanations for the tendency of agricultural (food) prices to be more flexible relative to the general price level in the economy. The authors show that agricultural prices respond more quickly to changes in monetary policy than do prices of other goods, providing evidence of real

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<sup>3</sup>Richard Cantillon, in "*An Essay on the Nature of Trade in General*" published in 1755 was the first to point out the idea that price level changes are caused by increases in the quantity of money, which in turn depends on the way new money is injected into the economy and actually where it affects prices first.

short-run and long-run effects of monetary changes on agricultural prices.<sup>4</sup>

Given the dominant role played by changes in relative food prices in low income countries, a recent body of work has given a great deal of focus on the interlinkages between monetary policy, inflation and the role of food in low income countries for e.g. Walsh (2011), Anand and Prasad (2015), Portillo and Zanna (2015), and Portillo et al. (2016). The authors find that food inflation is not only higher but more persistent to expansionary monetary and productivity shocks than non-food inflation, thus holding potential implications for household welfare in low-income countries. In this chapter, I study the interlinkages between monetary policy, relative food prices, and household food consumption (an important component of standard welfare measures in low-income countries) in India by drawing on to the above literature.

### 4.3 STYLIZED FACTS: EMERGING MARKET ECONOMIES

In this section, I present some stylized facts that highlight the importance of food for monetary policy analysis and formulation in low income countries.

#### 4.3.1 ENGEL'S LAW

Engel's law states that as average household income increases, the average share of food expenditure in total household expenditure declines. Figure 4.1 presents the food and non-food share across the expenditure distribution in India. Households at the lower end of the distribution have a much larger share of food expenditure compared to those at the upper end. Figure 4.1 is a clear example of Engel's law. If Engel's law is extended to countries, then it would imply that the share of food in the CPI basket will be higher in low-income countries compared to advanced countries. Figure 4.2 presents the food share for a selected

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<sup>4</sup>In related studies, Hercowitz (1982), Debell and Lamont (1997), Lastrapes (2006), and Balke and Wynne (2007) also show that monetary disturbances result in a positive correlation between inflation and the dispersion of relative prices.

group of low- and high-income countries. As expected, food expenditure shares are markedly higher in emerging market economies. The inverse relationship between food expenditure shares and income levels, proposed by Engel’s law, is one of the primary features that will reflect in the model.

#### 4.3.2 FOOD PRICES ARE MORE FLEXIBLE THAN NON-FOOD PRICES

New-Keynesian literature provides microeconomic evidence that food prices are relatively more flexible than the overall price level in the economy (Bils and Klenow, 2004; Dhyne et al., 2006; and Nakamura and Steinsson, 2008). Figure 4.3 presents the average frequencies of price changes, for all products, finished and unprocessed food in a group of selected countries.<sup>5</sup> Three patterns are noteworthy, first, food prices change more frequently than the general price level in the economy; second, unprocessed food prices change with much higher frequency than overall food prices; third, the difference in flexibility between food prices and overall prices is more prominent in developing countries (like Chile and Brazil) and low-income countries (like Sierra Leone), implying that the assumption about price flexibility is particularly relevant to low-income countries (Portillo et al., 2016). This constitutes an important feature of the DSGE model in this chapter (presented in the next section).

#### 4.4 THE MODEL: MAIN EMPIRICAL ANALYSIS

The objective of this chapter is to study the impact of the “*food price channel*” of monetary policy on the distribution of food consumption in India, using an appropriate analytical framework. Keeping in mind my objective, I adapt the closed economy DSGE model in Portillo et al. (2016).<sup>6</sup> In particular, I introduce heterogeneous agents (rich and poor households) with *subsistence* requirements in food consumption into a simple new-Keynesian model with

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<sup>5</sup>This has been obtained from the literature and summarized by Portillo et al. (2016).

<sup>6</sup>My primary reason for adapting Portillo et al. (2016) is because the model is able to draw out the stylized facts and structural characteristics of rich and poor nations across the development spectrum, including the dominant role played by changes in relative price of food in poor countries, which makes it very suitable for my study on India.

flexible food and sticky non-food prices. Households differ significantly with respect to their *distance from subsistence*; poor households are much closer to *subsistence* than the rich. What implications does households' *proximity to subsistence* hold for their responses to changes in monetary policy? The model aims to answer this question.

#### 4.4.1 HOUSEHOLDS (HH)

The economy consists of a continuum of infinitely-lived households of two types: (i) a fraction  $\lambda > 0$  of households who are rich or high-income HH with superscript  $r$  and (ii)  $1 - \lambda > 0$  of households who are poor or low-income HH with superscript  $p$ . The representative households in each group choose a consumption basket  $c_t^{o*}$ , labor hours  $n_t^o$  and holdings of a nominal bond  $B_{t+1}^o$  to maximize lifetime utility:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[ \ln(c_t^{o*}) - \frac{(n_t^o)^{1+\psi}}{1+\psi} \right], o \in [r, p] \quad (4.1)$$

#### RICH HH

The representative households in the first group maximizes Eq. (4.1) subject to the budget constraint below:

$$P_{F,t}c_{F,t}^r + P_{N,t}c_{N,t}^r + B_{t+1}^r = W_t n_t^r + \Pi_{F,t} + \Pi_{N,t} + R_{t-1}B_t^r \quad (4.2)$$

$c_t^{r*}$  is the composite consumption index of rich household in period  $t$ , including food and non-food goods. It is defined as

$$c_t^{r*} = (c_{F,t}^r - \bar{c}_F)^{\alpha_F} c_{N,t}^{r,1-\alpha_F} \quad (4.3)$$

The pair  $(c_{F,t}^r, c_{N,t}^r)$  denotes consumption of food and non food, measured at nominal prices  $P_{F,t}$  and  $P_{N,t}$  respectively. Since food is a necessity, households must consume a minimum amount  $\bar{c}_F$  of food for survival. The parameter  $\bar{c}_F$  therefore indicates the *subsistence* level of food consumption, a threshold below which food consumption cannot fall. Rich households own firms both in the food and non-food sectors, and also supply labor to both sectors,

therefore they earn nominal wages from working and nominal profits from ownership of firms.  $W_t$  is the nominal wage rate,  $\Pi_{F,t}$  and  $\Pi_{N,t}$  are profits from food and non-food sectors.  $R_{t-1}$  is the gross nominal interest rate paid on bonds  $B_t^r$ . Utility maximization leads to the following first order necessary conditions:

$$(c_t^{r*})^{-1} = \beta E_t \left[ \frac{R_t (c_{t+1}^{r*})^{-1}}{\pi_{t+1}^*} \right] \quad (4.4)$$

$$(n_t^r)^\psi = w_t^* (c_t^{r*})^{-1} \quad (4.5)$$

$$P_t^* = P_{F,t}^{\alpha_F} P_{N,t}^{1-\alpha_F} \quad (4.6)$$

$$c_{F,t}^r = \bar{c}_F + \alpha_F \left[ \frac{c_t^{r*}}{p_{F,t}^*} \right] \quad (4.7)$$

$$c_{N,t}^r = (1 - \alpha_F) \left[ \frac{c_t^{r*}}{p_{N,t}^*} \right] \quad (4.8)$$

where  $p_{F,t}^* = \frac{P_{F,t}}{P_t^*}$ ,  $p_{N,t}^* = \frac{P_{N,t}}{P_t^*}$ ,  $\pi_t^* = \frac{P_t^*}{P_{t-1}^*}$  and  $w_t^* = \frac{W_t}{P_t^*}$  are the food price index, non-food price index, gross inflation rate and the real wage rate relative to the consumer price index  $P_t^*$ .<sup>7</sup>

## POOR HH

The composite consumption index of poor households is given by:

$$c_t^{p*} = (c_{F,t}^p - \bar{c}_F)^{\alpha_F} c_{N,t}^{p,1-\alpha_F} \quad (4.9)$$

It is important to note here that all households always have enough income to buy the *subsistence* level of food. However rich and poor households differ significantly with respect to their distance from *subsistence*. Poor households are much closer to subsistence compared to the rich. The distance from subsistence endogenously brings out key features of rich and poor households in the steady state (with regards to their food share, price elasticity, labor productivity etc.) and is therefore critical to understanding the heterogeneity in their responses to changes in monetary policy.

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<sup>7</sup>Variables with an asterisk, are relevant for consumer decisions but are not actually observed in contrast with the variables without an asterisk, which is their observed counterparts.

Poor households maximize a similar utility function but subject to a different budget constraint. Poor households do not own firms, but only supply labor to the food and non-food sectors. Therefore they only earn nominal wages but no nominal profits. Poor HH maximize Eq. (4.1) subject to Eq. (4.10) below:

$$P_{F,t}c_{F,t}^p + P_{N,t}c_{N,t}^p + B_{t+1}^p = W_t n_t^p + R_{t-1}B_t^p \quad (4.10)$$

Utility maximization leads to similar first order necessary conditions:

$$(c_t^{p*})^{-1} = \beta E_t \left[ \frac{R_t (c_{t+1}^{p*})^{-1}}{\pi_{t+1}^*} \right] \quad (4.11)$$

$$(n_t^p)^\psi = w_t^* (c_t^{p*})^{-1} \quad (4.12)$$

$$c_{F,t}^p = \bar{c}_F + \alpha_F \left[ \frac{c_t^{p*}}{p_{F,t}^*} \right] \quad (4.13)$$

$$c_{N,t}^p = (1 - \alpha_F) \left[ \frac{c_t^{p*}}{p_{N,t}^*} \right] \quad (4.14)$$

As discussed before,  $p_{F,t}^* = \frac{P_{F,t}}{P_t^*}$ ,  $p_{N,t}^* = \frac{P_{N,t}}{P_t^*}$ ,  $\pi_t^* = \frac{P_t^*}{P_{t-1}^*}$  and  $w_t^* = \frac{W_t}{P_t^*}$  are the food price index, non-food price index, gross inflation rate and the real wage rate relative to the consumer price index  $P_t^*$ .

#### 4.4.2 FIRMS

##### THE FOOD SECTOR

The food sector features perfect competition and flexible prices. Food production is given by:

$$y_{F,t} = A_{F,t} (A n_{F,t})^\alpha K_F^{1-\alpha} \quad (4.15)$$

where  $K_F$  is the level of capital allocated to the food sector,  $A$  is the labor productivity in the food sector,  $n_{F,t}$  is the demand for labor in the food sector,  $\alpha$  is the labor share, and  $A_{F,t}$  is a TFP shock in the food sector.

## THE NON-FOOD SECTOR

The non-food sector is composed of a continuum of monopolistic competitors, each providing a variety  $y_{N,t}(i)$  with  $i \in [0, 1]$ . Consumers combine the varieties into a Dixit-Stiglitz aggregate given by the following:

$$y_{N,t} = \left[ \int y_{N,t}(i)^{\frac{\epsilon-1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}} \quad (4.16)$$

where  $\epsilon$  is the elasticity of substitution between the differentiated goods. Cost minimization results in the following demand for the differentiated good( $i$ ):

$$y_{N,t}(i) = \left[ \frac{P_{N,t}(i)}{P_{N,t}} \right]^{-\epsilon} y_{N,t} \quad (4.17)$$

where  $P_{N,t}(i)$  is the price charged by firm ( $i$ ) and  $P_{N,t}$  is the composite price index for the entire non-food sector:

$$P_{N,t} = \left[ \int P_{N,t}(i)^{1-\epsilon} di \right]^{\frac{1}{1-\epsilon}} \quad (4.18)$$

Production of the differentiated good in the non-food sector is given by:

$$y_{N,t}(i) = [An_{N,t}(i)]^\alpha K_N^{1-\alpha} \quad (4.19)$$

Following Calvo (1983), a fraction  $\theta \in (0, 1)$  cannot change their price in each period. Firms that are free to change the price at time  $t$  choose a price  $\bar{P}_{N,t}(i)$  to maximize the discounted stream of expected profits given by:

$$Max E_t \left\{ \sum_{\tau=t}^{\infty} (\beta\theta)^{\tau-t} \lambda_{t,\tau} \left[ \left( \frac{\bar{P}_{N,t}(i)}{P_{N,\tau}} \right)^{-\epsilon} y_{N,\tau} [\bar{P}_{N,t}(i) - MC_{N,\tau}(i)] \right] \right\} \quad (4.20)$$

where  $\lambda_{t,\tau}$  is the stochastic discount factor and  $MC_{N,t}(i)$  is firm  $i$ 's nominal marginal cost given by  $MC_{N,t}(i) = \frac{W_t}{\alpha n_{N,t}(i)^{\alpha-1} A^\alpha K_F^{1-\alpha}}$ .

The aggregate price index in the non-food sector is a weighted average of those prices that were revised (fraction  $1 - \theta$ ) and those that were not revised (fraction  $\theta$ ):

$$P_{N,t} = [(1 - \theta) \bar{P}_{N,t}^{1-\epsilon} + \theta P_{N,t-1}^{1-\epsilon}]^{\frac{1}{1-\epsilon}} \quad (4.21)$$

#### 4.4.3 MARKET CLEARING CONDITIONS: GOODS MARKET AND LABOR MARKET

Market clearing conditions for food, non-food and labor market are given the following set of equations:

$$c_{F,t} = \lambda c_{F,t}^r + (1 - \lambda) c_{F,t}^p \quad (4.22)$$

$$c_{N,t} = \lambda c_{N,t}^r + (1 - \lambda) c_{N,t}^p \quad (4.23)$$

$$c_t = c_{F,t} + c_{N,t} = (\lambda) c_t^r + (1 - \lambda) c_t^p \quad (4.24)$$

where,  $c_t^r = c_{F,t}^r + c_{N,t}^r$  and  $c_t^p = c_{F,t}^p + c_{N,t}^p$

$$c_{F,t} = y_{F,t} \quad (4.25)$$

$$c_{N,t} = y_{N,t} \quad (4.26)$$

$$n_{F,t} = \lambda n_{F,t}^r + (1 - \lambda) n_{F,t}^p \quad (4.27)$$

$$n_{N,t} = \lambda n_{N,t}^r + (1 - \lambda) n_{N,t}^p \quad (4.28)$$

where  $n_{N,t} = \int n_{N,t}(i) di$ .

$$n_t = n_{F,t} + n_{N,t} \quad (4.29)$$

Measured output (real GDP) and consumption is given by:

$$c_t = y_t = p_F y_{F,t} + p_N y_{N,t} \quad (4.30)$$

where  $p_F = \frac{P_F}{P}$  and  $p_N = \frac{P_N}{P}$  denote the steady-state relative prices of food and non-food respectively.

#### 4.4.4 THE STEADY STATE

Due to the presence of a subsistence floor for food consumption, key features of households emerge endogenously in the model. The distance from subsistence plays a critical role in bringing out the heterogeneous features of the rich and the poor.

Using equations (4.7-4.8), (4.13-4.14), (4.22-4.26) and (4.30) a simple linear relationship between  $c$  and  $c^*$  is obtained in the steady state:

$$c^r = \bar{c}_F + c^{r*} \quad (4.31)$$

$$c^p = \bar{c}_F + c^{p*} \quad (4.32)$$

$$c = (\lambda)c^{r*} + (1 - \lambda)c^{p*} = \bar{c}_F + c^* \quad (4.33)$$

Using equations (4.5), (4.12), (4.27-4.29), and (4.33), the supply of labor satisfies:<sup>8</sup>

$$n^\psi = \frac{w}{c - \bar{c}_F} = \chi \left( \frac{A}{c - \bar{c}_F} \right) \quad (4.34)$$

$$A = \frac{n^\psi}{\chi} (c - \bar{c}_F) \quad (4.35)$$

The above equation shows that proximity to subsistence reduces lower labor productivity. Therefore poor households will tend to have a lower labor productivity compared to the rich. A simple explanation is that food intake below the biological minimum leads to undernutrition, malnutrition, and mortality, which represent a direct loss to the physical productivity of labour and, thereby, employment and wages (Dasgupta, 1995; Haddard and Bouis, 1991; Sahn and Alderman, 1988; Behrman and Deolalikar, 1988; Dasgupta and Ray, 1986; Stiglitz, 1976).

### *Engel's Law*

Engel's law states that with given tastes or preferences, the proportion of income spent on food diminishes as income increases. Poor living is characterised by a large proportion of the total consumer expenditure taken up by items such as food which are absolutely essential for sheer physical survival.

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<sup>8</sup>By equating the marginal product of capital and labor with the steady state rental rate and real wage rate respectively, a linear relationship between real wages and aggregate labor productivity is obtained:  $w = \left[ \frac{\alpha^\alpha (1-\alpha)^{1-\alpha}}{(1/\beta-1)^{1-\alpha}} \right]^{1/\alpha} A = [\chi] A$

Using equations (4.7), (4.13), (4.31-4.33), a relationship describing the Engel's law is obtained:

$$\gamma_F^r = \frac{c_F^r}{c^r} = (1 - \alpha_F) \frac{\bar{c}_F}{c^r} + \alpha_F \quad (4.36)$$

$$\gamma_F^p = \frac{c_F^p}{c^p} = (1 - \alpha_F) \frac{\bar{c}_F}{c^p} + \alpha_F \quad (4.37)$$

$$\gamma_F = \frac{c_F}{c} = (1 - \alpha_F) \frac{\bar{c}_F}{c} + \alpha_F \quad (4.38)$$

where  $\gamma_F^r$  is the food share of rich households;  $\gamma_F^p$  is the food share of poor households and  $\gamma_F$  is the average food share in the economy. The above equations show that poor households who are much closer to subsistence (for whom  $\frac{\bar{c}_F}{c^p} \simeq 1$ ) allocate a much larger proportion of their budget to food expenditure in order to meet their subsistence needs.<sup>9</sup> Presence of subsistence brings out the key features of rich and poor households, thus playing an indispensable role in this model.

#### 4.4.5 EQUILIBRIUM DYNAMICS

The two key building blocks of calibrating a New Keynesian model are the dynamic IS curve (DIS) and the New-Keynesian Phillips curve (NKPC) which are given by equations (4.39) and (4.40) respectively. The NKPC (Eq. 4.39) determines the sticky price non-food inflation given a path for the output gap, whereas the DIS equation determines the output gap given a path for the interest rate (Eq. 4.40).<sup>10</sup>

$$\tilde{y}_t = -\Theta E_t \left( \hat{R}_t - \hat{\pi}_{N,t+1} - \hat{r}_t^{flex} \right) + E_t \tilde{y}_{t+1} \quad (4.39)$$

$$\hat{\pi}_{N,t} = \beta E_t \hat{\pi}_{N,t+1} + \kappa_y \tilde{y}_t \quad (4.40)$$

Overall headline inflation in the economy is given by:

$$\hat{\pi}_t = \gamma_F \hat{\pi}_{F,t} + (1 - \gamma_F) \hat{\pi}_{N,t} \quad (4.41)$$

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<sup>9</sup>Eq. (4.36) and (4.37) is used to calibrate  $(\alpha_F, \bar{c}_F)$  from the data for India.

<sup>10</sup>This is the log-linearized version of the model i.e. a hat on top of a variable ( $\hat{*}$ ) indicates percent deviations from the steady state.

$\hat{R}_t$  is the nominal interest rate;  $\tilde{y}_t$  is the output gap, that is, the log deviation of output from its flexible counterpart, and given by  $\tilde{y}_t = \hat{y}_t - \hat{y}_t^{flex}$ ; similarly  $\tilde{p}_{F,t}$  is the relative food price gap, and given by  $\tilde{p}_{F,t} = \hat{p}_{F,t} - \hat{p}_{F,t}^{flex}$ ;  $\hat{r}_t^{flex}$  is the natural rate of interest, that is, the real interest rate that would prevail in the flexible price equilibrium.  $\hat{\pi}_{F,t}$  is the flexible price food inflation rate;  $\gamma_F$  is the average food share and  $\hat{\pi}_{N,t}$  is the sticky price non-food inflation rate. The composite parameters  $(\Theta, \kappa_y, \xi)$  are defined as follows:  $\Theta = \frac{\sigma^{-1}}{1+\sigma^{-1}\phi\Omega}$ ,  $\kappa_y = k\Gamma$ ,  $\xi = \frac{\gamma_F}{1-\gamma_F}$ .<sup>11</sup>

In order to close the model, the NKPC and DIS equations must be supplemented with an equation determining the evolution of the nominal interest rate  $\hat{R}_t$  overtime, that is, provide a description of how monetary policy is conducted. This is explained in the next sub-section.

#### 4.4.6 EXOGENOUS SHOCK PROCESSES

##### MONETARY POLICY SHOCK

Given the presence of nominal rigidities, the equilibrium path for real variables cannot be determined independently of monetary policy. In other words, *monetary policy is non-neutral*.

The equilibrium is analyzed under an interest rate rule of the form:

$$\hat{R}_t = \hat{r}_t^{flex} + \xi \hat{\pi}_{F,t} + \zeta \hat{\pi}_{N,t} + u_{MP,t} \quad (4.42)$$

$$u_{MP,t} = \rho_{MP} u_{MP,t-1} + \epsilon_{MP,t} \quad (4.43)$$

where  $\xi$  and  $\zeta$  are the responses to food and non-food inflation in the monetary policy rule respectively. The response coefficient to food inflation is given by:  $\xi = \frac{\gamma_F}{1-\gamma_F}$ , where  $\gamma_F$  is the average food share in a country. This means that central banks in low income countries (with high food share) assign a larger weight to food inflation. A negative realization of  $\epsilon_{MP,t}$

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<sup>11</sup>where,  $\Omega = \Gamma \left[ \frac{\gamma_F \Upsilon - (\sigma-1) \frac{1-\alpha}{\alpha} (1-\gamma_F)}{\xi(1+\delta \frac{1-\alpha}{\alpha}) \Upsilon + (\sigma-1) \frac{1-\alpha}{\alpha} \phi} \right]$ ,  $\Gamma = \left[ \frac{\frac{1-\alpha}{\alpha} (\sigma-1) \phi + (1+\delta \frac{1-\alpha}{\alpha}) \xi \Upsilon}{\gamma_F \phi + (1+\delta \frac{1-\alpha}{\alpha}) \xi (1-\gamma_F)} \right]$ ,  $\Upsilon = \frac{\psi+1-\alpha}{\alpha} + \sigma$ ,  $\phi = \xi(1-\alpha_F) - \alpha_F$ ,  $\delta = \frac{\alpha_F}{\gamma_F}$ ,  $\sigma = \frac{1-\alpha_F}{1-\gamma_F}$ . For complete details refer to Portillo et al. (2016).

indicates an exogenous monetary policy loosening by the central bank, which can be thought of as an expansionary monetary policy shock and will affect aggregate demand, employment, relative food prices and inflation, thus generating real effects from monetary changes.

## PRODUCTIVITY SHOCK

Technology in the food sector follows an AR process of order 1:

$$\hat{A}_{F,t} = \rho_A \hat{A}_{F,t-1} + \epsilon_{A_{F,t}} \quad (4.44)$$

An exogenous food productivity shock is given by a positive shock to  $\epsilon_{A_{F,t}}$ .

## 4.5 MODEL SIMULATIONS: MAIN EMPIRICAL ANALYSIS

In the previous section, I described the model. In this section, I simulate the model using data on India and study the behaviour of the impulse response functions.

### 4.5.1 PARAMETER SELECTION

In order to calibrate this model for India, I need to make assumption about the proportion of rich and poor households in the population. The financial inclusion in India is roughly 40% (refer to chapter 2, figure 2.2) and to the extent that this is typical of high income or rich HH, the degree of financial inclusion can be a reasonable measure of the fraction of high income households in the population. Based on this rationale, I assume that 40% of households are rich or high-income HH and 60% are poor or low-income HH. This assumption is also consistent with those of Anand and Prasad (2015).

The main challenge in this model is to calibrate the values of  $(\alpha_F, \bar{c}_F)$ . The choice of  $(\alpha_F, \bar{c}_F)$  needs to be such that the model encompasses the food share observed for rich (top 40%) and poor (bottom 60%) households in India. I therefore use equations 4.36 and 4.37 to calibrate the values of  $(\alpha_F, \bar{c}_F)$  in the model. I normalize the consumption (income) of

the rich households to 1. Rewriting Eq. (4.36-4.37) below:

$$\gamma_F^r = (1 - \alpha_F) \bar{c}_F + \alpha_F \quad (4.45)$$

$$\gamma_F^p = (1 - \alpha_F) \frac{\bar{c}_F}{c^{p/r}} + \alpha_F \quad (4.46)$$

where  $c^{p/r}$  indicates the consumption or income of poor households (bottom 60%) relative to the rich (top 40%). Consumption of poor households (bottom 60%) in India is roughly .53 times that of rich (top 40%), and the food expenditure shares of the rich and poor, i.e.,  $(\gamma_F^r, \gamma_F^p)$  are (.35, .60) respectively.<sup>12</sup> Given these values, the calibration of  $(\alpha_F, \bar{c}_F)$  ensures that the above equations hold.<sup>13</sup> Standard deviation of monetary policy shocks, given by  $\sigma_{MP}$ , for India is obtained from Chapter 2. Labor income share for India is obtained from *The India KLEMS Database*. The values of the rest of the key parameters have been obtained from the existing new- Keynesian literature on developing economies (Basu and Fernald, 1995; Christiano et al., 1999; Rotemberg and Woodford, 1997; Mohanty and Klau, 2005; Devereux et al., 2006; Aguiar and Gopinath, 2007; Garcia-Ciccco et al., 2010; Gali et al., 2015; Anand and Prasad, 2015; Portillo et al., 2016). The calibration is summarized in Table 4.1.

#### 4.5.2 IMPULSE RESPONSE FUNCTIONS

##### MONETARY POLICY SHOCK ( $\epsilon_{MP,t} < 0$ )

I first study the effect of an expansionary monetary policy shock in India which is captured by a negative shock to  $\epsilon_{MP,t}$ . The effect of this shock is shown in Figure 4.4. Consistent with several earlier studies, I find that following an exogenous monetary policy loosening the food sector featuring flexible prices records the highest rise in prices. An expansionary monetary policy shock, that is, a decline in interest rates by 30 basis points generates an increase

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<sup>12</sup>This data has been taken from the Household Consumer Expenditure Surveys, published by India's National Sample Survey Organization. Median food share in India is roughly .48.

<sup>13</sup>According to the USDA estimate, on average one third of households' steady state food consumption is required for subsistence (Anand and Prasad, 2015). The calibrated value of subsistence food consumption in my study is close to the USDA estimate.

in the *relative* price of food by 1.5%. The non-food sector featuring sticky prices shows a relative price increases of .45%. Because food forms a significant proportion of the CPI basket (about 50%), so headline inflation goes up by 1%. Finally, expansionary monetary policy, that would be neutral under fully flexible prices, in the presence of nominal rigidities results in an overall increase in output by .45%. There are sectoral differences, however, an increase in relative prices of food leads to a contraction of food sector output, reflecting a fall in aggregate demand of food, and an expansion of the non-food sector output, reflecting an overall shift in aggregate demand from food to non-food.

My main interest is how the distribution of food consumption responds to expansionary monetary shocks in India (Figure 4.5). Given an expansionary monetary policy shock, which increases the relative price of food by 1.5%, while the food consumption of rich households (top 40%) fall by .27%, that of poor households (bottom 60%) fall by only .1%. These results point to expansionary monetary shocks having heterogeneous negative effects on food consumption which reduce food consumption at the lower end of the distribution much less than that at the upper end. The primary contributing factor to the observed heterogeneity is the difference in the respective *elasticities* of the two groups of households which emerge from the presence of *subsistence* in the model. Proximity to subsistence reduces (increases) the income and price elasticities of demand in the food sector (non-food sector), and also reduces the inter-temporal elasticity of substitution (increases the risk aversion or degree of habit formation). Therefore, poor households are far more risk averse and demand inelastic with respect to food price compared to the rich. Their food consumption does not change much in response to policy shocks. Consequently poor households witness a much smaller decline in food consumption than the rich.

In my second chapter, I conduct a similar analysis, where I estimate the dynamic responses of relative food price and the distribution of food consumption to expansionary monetary

policy shocks in India, by relying on household survey data and a factor augmented vector auto regression (FAVAR) model. Comparing the results from my FAVAR analysis and DSGE analysis, I do find evidence that the relative price of food responds positively and the distribution of food consumption responds negatively to expansionary monetary policy shocks, however the heterogeneity in the response of the rich and poor households obtained from the two analysis are a striking contrast. While in my FAVAR analysis, I find that poor households witness a larger decline in food consumption than the rich, in the current DSGE analysis I find the opposite.

Figure 4.6 plots the response of the *relative price of food* to a 30 basis point decline in interest rate in India from the FAVAR analysis (chapter 2) and DSGE analysis (current chapter) respectively. Figure 4.7 plots *the food consumption of the rich relative to the poor* from the two empirical methods respectively. Overall, consistent with my second chapter, results of this chapter also provide evidence in favor of the impact of the “*food price channel*” of monetary policy on the distribution of food consumption in India. However, whereas the second chapter points to the causal channel widening the gap between the rich and poor following a monetary expansion, the current chapter seems to be pointing at the result otherwise (Figure 4.7). Understanding why such a contradiction is arising from the two methods can be complex, however in understanding this, careful consideration needs to be given to how closely the theoretical model can replicate the real economy. While the empirical model in chapter 2 uses actual real time data from household surveys in India which reflect the heterogeneity between the rich and poor households with regards to many factors other than *proximity to subsistence* like differential wages, labor market segmentation, informal sector employment, financial inclusion and other features; the theoretical model in the current chapter relies only on *proximity to subsistence* and abstracts away from many of the other aforementioned heterogeneous characteristics. This is primarily done to keep the model simple and tractable. Incorporating some of the other heterogeneous features of households

in the DSGE model like financial inclusion and labor market segmentation could make the two models more analogous to each other, however this is beyond the scope of the current chapter and forms an avenue for future research.

PRODUCTIVITY SHOCK ( $\epsilon_{A_{F,t}} > 0$ )

I now study the effect of a positive TFP shock to the food sector in India which is captured by a positive shock to  $\epsilon_{A_{F,t}}$ . The impulse response function is presented in Figure 4.8. In response to a 1% increase in technology in the food sector, output in the food sector increases by .1%, and aggregate output increases by .6% respectively. Relative food price falls by .5%, and headline inflation falls by .3%. Following the food productivity shock, I note that while the food consumption of rich households increase by .23%, that of poor households increase by .1%. Again I find evidence that poor households are more risk averse and price inelastic compared to rich households.

#### 4.6 THE MODEL: SENSITIVITY ANALYSIS

In this section, I conduct a sensitivity analysis of my main empirical model and results by structuring the model slightly differently. I explain this in detail below. The model consists of two economies (i) a developed economy (ii) an underdeveloped economy.

##### 4.6.1 HOUSEHOLDS

Each economy consists of a continuum of infinitely-lived households. Representative households in each economy choose a consumption basket  $c_t^*$ , labor hours  $n_t$  and holdings of a nominal bond  $B_{t+1}$  to maximize lifetime utility:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[ \ln(c_t^*) - \frac{(n_t)^{1+\psi}}{1+\psi} \right] \quad (4.47)$$

subject to the budget constraint:

$$P_{F,t}c_{F,t} + P_{N,t}c_{N,t} + B_{t+1} = W_t n_t + \Pi_{F,t} + \Pi_{N,t} + R_{t-1}B_t \quad (4.48)$$

$c_t^*$  is the composite consumption index of household in period  $t$ , including food and non-food goods. It is defined as

$$c_t^* = (c_{F,t} - \bar{c}_F)^{\alpha_F} c_{N,t}^{1-\alpha_F} \quad (4.49)$$

The pair  $(c_{F,t}, c_{N,t})$  denotes consumption of food and non food, measured at nominal prices  $P_{F,t}$  and  $P_{N,t}$  respectively. Since food is a necessity, households must consume a minimum amount  $\bar{c}_F$  of food for survival. The parameter  $\bar{c}_F$  is the subsistence level of food consumption, a threshold below which food consumption cannot fall. Households in both economies always have enough income to buy the subsistence level of food. However it is important to note here that households in the developed and underdeveloped economy differ significantly with respect to their distance from *subsistence*. Households in the underdeveloped economy are much closer to subsistence compared to those in the developed economy. Consistent with my main empirical model, the distance from subsistence endogenously brings out key features of households in the developed and underdeveloped economy and is indispensable to understanding their responses to changes in monetary policy.

Agents in both economies supply labor to the food and non-food sector for which they earn nominal wages  $W_t$ . Additionally, agents in both economies own firms in the food and non-food sectors and therefore receive profits  $\Pi_{F,t} + \Pi_{N,t}$ . Finally, they pay a gross nominal interest rate  $R_{t-1}$  on bonds  $B_t$ . Utility maximization in both economies lead to similar first order necessary conditions:

$$(c_t^*)^{-1} = \beta E_t \left[ \frac{R_t (c_{t+1}^*)^{-1}}{\pi_{t+1}^*} \right] \quad (4.50)$$

$$(n_t)^\psi = w_t^* (c_t^*)^{-1} \quad (4.51)$$

$$P_t^* = P_{F,t}^{\alpha_F} P_{N,t}^{1-\alpha_F} \quad (4.52)$$

$$c_{F,t} = \bar{c}_F + \alpha_F \left[ \frac{c_t^*}{P_{F,t}^*} \right] \quad (4.53)$$

$$c_{N,t} = (1 - \alpha_F) \left[ \frac{c_t^*}{P_{N,t}^*} \right] \quad (4.54)$$

where  $p_{F,t}^* = \frac{P_{F,t}}{P_t^*}$ ,  $p_{N,t}^* = \frac{P_{N,t}}{P_t^*}$ ,  $\pi_t^* = \frac{P_t^*}{P_{t-1}^*}$  and  $w_t^* = \frac{W_t}{P_t^*}$  are the food price index, non-food price index, gross inflation rate and the real wage rate relative to the consumer price index  $P_t^*$ .<sup>14</sup>

#### 4.6.2 FIRMS

The model in this subsection, i.e., with respect to the features of the firms is exactly the same as the main empirical one in sub-section 4.4.2. Food sector in each economy features perfect competition and flexible prices, whereas the non-food sector features monopolistic competition and sticky prices. Supply in both sectors is driven from profit maximization.

#### 4.6.3 GOODS AND LABOR MARKET EQUILIBRIUM

The market clearing conditions in the two economies are given the following set of equations:

$$c_{F,t} = y_{F,t} \tag{4.55}$$

$$c_{N,t} = y_{N,t} \tag{4.56}$$

$$n_{F,t} + n_{N,t} = n_t \tag{4.57}$$

where  $n_{N,t} = \int n_{N,t}(i) di$ .

Measured output (real GDP) and consumption is given by:

$$c_t = y_t = p_F y_{F,t} + p_N y_{N,t} \tag{4.58}$$

where  $p_F = \frac{P_F}{P}$  and  $p_N = \frac{P_N}{P}$  denote the steady-state relative prices of food and non-food respectively.

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<sup>14</sup>Variables with an asterisk, are relevant for consumer decisions but are not actually observed in contrast with the variables without an asterisk, which is their observed counterparts.

#### 4.6.4 STEADY STATE

Due to the presence of a subsistence floor for food consumption, key features of households in the two economies emerge endogenously in the model. Using equations (4.53-4.56), and (4.58) the linear relationship between  $c$  and  $c^*$  is obtained in the steady state (which is analogous to Eq. 4.33 in my main empirical model):

$$c = \bar{c}_F + c^* \quad (4.59)$$

Using equations (4.51), (4.57), and (4.59), the labor supply equation is obtained (which is analogous to Eq. 4.34 in my main empirical model):<sup>15</sup>

$$n^\psi = \frac{w}{c - \bar{c}_F} = \chi \left( \frac{A}{c - \bar{c}_F} \right) \quad (4.60)$$

In the underdeveloped economy, proximity to subsistence ensures that income effects dominate substitution effects in the supply of labor, and households work more in order to meet their subsistence requirements. As aggregate productivity and income increases, households reduce their labor supply, which allows them to enjoy more leisure at the cost of marginal increases in consumption (Portillo et al., 2016).

#### *Engel's Law*

Using equations (4.53) and (4.59), the relationship describing the Engel's law is obtained (which is analogous to Eq. 4.38 in my main empirical model):

$$\gamma_F = \frac{c_F}{c} = (1 - \alpha_F) \frac{\bar{c}_F}{c} + \alpha_F \quad (4.61)$$

where  $\gamma_F$  is the average food share in each economy.

The underdeveloped economy which is much closer to subsistence ( $\frac{\bar{c}_F}{c} \simeq 1$ ), compared

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<sup>15</sup>By equating the marginal product of capital and labor with the steady state rental rate and real wage rate respectively, a linear relationship between real wages and aggregate labor productivity is obtained:  $w = \left[ \frac{\alpha^\alpha (1-\alpha)^{1-\alpha}}{(1/\beta-1)^{1-\alpha}} \right]^{1/\alpha} A = [\chi] A$

to the developed economy, allocate a larger proportion of their budget to food expenditure in order to meet their subsistence needs.

The rest of the model with respect to equilibrium dynamics and exogenous shock processes is exactly the same as the main empirical one (refer to sub-sections 4.4.5-4.4.6).

## 4.7 MODEL SIMULATIONS: SENSITIVITY ANALYSIS

### 4.7.1 PARAMETER SELECTION

I use Equation 4.61 to calibrate the values of  $(\alpha_F, \bar{c}_F)$  in the model. I normalize the consumption of households in the developed economy to 1, and rewrite Eq. 4.61 for the developed and underdeveloped economy below:

$$\gamma_F^d = (1 - \alpha_F) \bar{c}_F + \alpha_F \quad (4.62)$$

$$\gamma_F^u = (1 - \alpha_F) \frac{\bar{c}_F}{c^{u/d}} + \alpha_F \quad (4.63)$$

where  $\gamma_F^d$  is the average food share in the developed economy,  $\gamma_F^u$  is the average food share in the underdeveloped economy, and  $c^{u/d}$  indicates the consumption or income of households in the underdeveloped economy as a fraction of that in the developed economy.

In order to compare the results obtained from the DSGE analysis in the current chapter with those obtained from the FAVAR analysis in Chapter 2 to the best of precision, I assume that the developed economy features those households who belong to the top 20% of expenditure distribution in India (top quintile or 80<sup>th</sup> percentile), and the underdeveloped economy features those who belong to the bottom 20% of expenditure distribution in the country (bottom quintile or 20<sup>th</sup> percentile). Given this assumption, the food expenditure shares of the developed and underdeveloped economies, i.e.,  $(\gamma_F^d, \gamma_F^u)$  are (.25, .70) respectively (refer to chapter 2, data, subsection 2.4.2). The income or consumption of households in the bottom 20% in India is roughly .28 times that of the top 20%, meaning that  $c^{u/d} = .28$ . The rest

of the calibration parameters remain the same. The calibration is summarized in Table 4.2. The impulse responses from the sensitivity analysis are discussed in the next sub-section.

#### 4.7.2 IMPULSE RESPONSE FUNCTIONS

My interest is how the relative price of food and the distribution of food consumption in the developed and underdeveloped economy respond to an exogenous monetary policy loosening. Figures 4.9-4.10 present the impulse responses for the developed and underdeveloped economies respectively. Consistent with my main empirical results, I find that the relative price of food responds positively and the distribution of food consumption responds negatively to an expansionary monetary policy shock in both economies. Further, I also note that the food consumption of households in the underdeveloped economy fall less (.04%) compared to those in the developed economy (.28%), again suggestive of the evidence that households in the underdeveloped economy (poor HH) are relatively more price inelastic compared to the developed (rich HH).

Figures 4.11-4.12 compare and contrast the food consumption responses of the top quintile (HH belonging to the 80<sup>th</sup> percentile of expenditure distribution) and bottom quintile (HH belonging to the 20<sup>th</sup> percentile of expenditure distribution) to a 30 basis point decline in interest rates in India from FAVAR (Chapter 2) and DSGE (Chapter 4) analysis respectively.<sup>16</sup> Figure 4.13 plots the responses of food consumption inequality from the two empirical methods respectively, where food consumption inequality is measured as the difference between the top and bottom quintile of the log levels in the food consumption distribution.

Comparing the food consumption responses of the top quintile and the bottom quintile

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<sup>16</sup>As noted above households in the developed economy feature those belonging to the top quintile of expenditure distribution in India and households in the underdeveloped economy feature those belonging to the bottom quintile.

in India from the FAVAR and DSGE analysis, two key differences emerge noteworthy (i) first, while both methods confirm that expansionary monetary shocks via “*food price channel*” negatively impacts the distribution of food consumption, the negative effects appear to be stronger from the FAVAR analysis (following expansionary monetary shocks, the FAVAR analysis reports a negative impact of .38% on the top quintile and 1.30% on the bottom quintile, while the DSGE analysis reports a negative impact of .28% on the former and .04% on the latter respectively, refer to figures 4.11-4.12); (ii) second, while results from FAVAR analysis point to expansionary monetary shocks having heterogeneous negative effects on food consumption which reduce food consumption at the lower end of the distribution far more than that at the upper end, results from the current DSGE analysis seem to be pointing at the heterogeneous negative effects across the distribution otherwise. Therefore in conclusion, while both methods document the presence of a “*food price channel*” of monetary policy in India, the FAVAR analysis points towards monetary expansion via the “*food price channel*” leading to a rise in food consumption inequality and the DSGE analysis points towards the same channel leading to a fall in food consumption inequality in the country (Figure 4.13).

#### 4.8 SUMMARY AND CONCLUSION

*“In a developing country context, inflation tolerance in India is fairly low and within the overall inflation, food price inflation is least tolerated as bulk of the population spend majority of their income on food items.”*

*Khundrakpam and Das, Reserve Bank of India, 2011*

In this chapter, I study the dynamic effects of monetary policy on relative food prices and the distribution of food consumption in India using a dynamic stochastic general equilibrium (DSGE) model. The DSGE analysis is based on a two sector new-Keynesian model with flexible food and sticky non-food prices, and heterogeneous agents who differ in their

proximity to subsistence food threshold. Two key findings emerge from the DSGE analysis. First, expansionary monetary policy shocks generate an increase in the *relative* price of food and a decrease in the food consumption of households. Second, there is strong heterogeneity in the food consumption responses faced by households across different income classes: lower the income class, lower the sensitivity to policy shocks. Because proximity to subsistence reduces the income and price elasticities of demand in the food sector, and also reduces the inter-temporal elasticity of substitution (increases the risk aversion), poor households are far more demand inelastic with respect to food price compared to the rich. Consequently their food consumption does not show much variation in response to policy shocks. So, following expansionary monetary shocks, poor households witness a much smaller decline in food consumption compared to rich households. I note this both in my main empirical analysis as well as alternate sensitivity analysis.

In conclusion, consistent with my FAVAR analysis in the second chapter, the DSGE analysis in the current also provides evidence in favor of the impact of the “*food price channel*” of monetary policy on the distribution of food consumption in India. However contrary to the FAVAR analysis, the DSGE exercise points towards monetary expansion reducing the observed inequality across households in food consumption via the “*food price channel*” (instead of increasing). An important factor that could be contributing to this contradiction is that, while the empirical analysis in the second chapter is based on actual real time data which includes many heterogeneous features of households like differential wages, labor market segmentation, financial inclusion etc., the theoretical exercise in the current chapter relies only on *proximity to subsistence* and abstracts away from all other aforementioned heterogeneous household characteristics. Incorporating some of the other heterogeneous features of households in the DSGE model like financial inclusion and labor market segmentation could be helpful in making the two approaches (empirical and theoret-

ical) more comparable, however this is beyond the scope of the current chapter and forms an avenue for future research.

FIGURES AND TABLES

MAIN EMPIRICAL ANALYSIS

Table 4.1: Calibration I-DSGE, Main Empirical Analysis, India

Parameter	Definition	Value
$\lambda$	Fraction of rich households	.40
$\gamma_F^r$	Share of food expenditures, rich HH (top 40%)	.35
$\gamma_F^p$	Share of food expenditures, poor HH (bottom 60%)	.60
$c^{p/r}$	Income of poor households as a fraction of rich	.53
$\bar{c}_F$	Subsistence level of food consumption	.3025
$\alpha_F$	Non-Subsistence food consumption share	.0680
$\alpha$	Labour Income share	.7
$\beta$	Discount Factor	.99
$\theta$	Probability of not being able to reset price	.75
$\zeta$	Response Coefficient to non-food inflation in the monetary policy rule	1.5
$\psi$	Inverse of Frisch Elasticity of Labor Supply	5
$\epsilon$	Elasticity of Substitution between different varieties	6
$\rho_A$	Parameter in the AR(1) process for food productivity shock	.8
$\sigma_{A_F}$	Standard deviation of food productivity shocks	.6
$\rho_{MP}$	Persistence in the AR(1) process for monetary policy shock	.8
$\sigma_{MP}$	Standard deviation of monetary policy shocks	.75

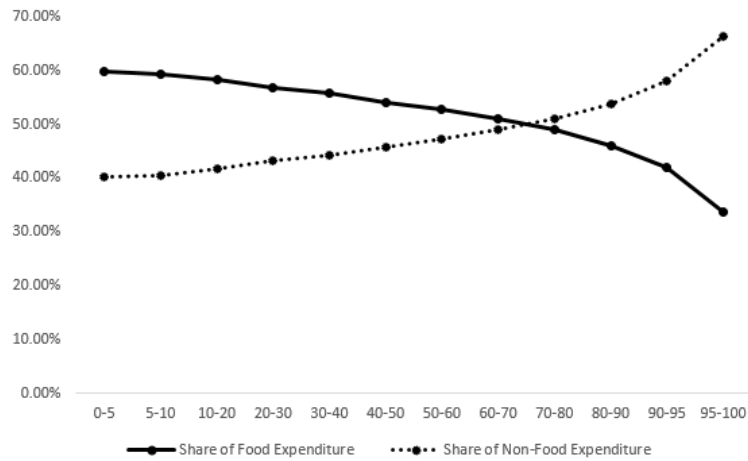


Figure 4.1: Evidence of Engel's Law, Households

Source: Household Consumer Expenditure Survey Reports, NSSO, India.

Notes: The household consumer expenditure surveys, published by India's National Sample Survey Organization, report the distribution of average nominal monthly per capita consumption expenditure for different expenditure classes in India. The horizontal axis describes the expenditure class, whereas the vertical axis measures their food share.

<i>Emerging Markets</i>		<i>Advanced Economies</i>	
Indonesia	53.0	Japan	14.7
Vietnam	49.8	Germany	11.5
India	48.8	Australia	10.8
China	36.7	Canada	9.3
Russia	33.2	United Kingdom	8.8
Malaysia	28.0	USA	5.7
<b>Average</b>	<b>41.6</b>	<b>Average</b>	<b>10.1</b>

Figure 4.2: Evidence of Engel's Law, Countries

Source: Anand and Prasad, 2015

Country	Paper	Sample	All	Mean Frequency	
				Food	Unprocessed Food
Austria	Baumgartner <i>et al.</i> (2005)	1996-2003	15.1	17.3	24
Belgium	Aucremanne and Dhyne (2004)	1989-2001	16.9	23.1	31.8
Brazil	Barros <i>et al.</i> (2009)	1996-2008	37.2	49.1	51.1
	Gouvea (2007)	1996-2006	37	42	-
Chile	Medina <i>et al.</i> (2009)	1999-2005	46.1	99.5	-
Denmark	Hansen and Hansen (2006)	1997-2005	17.3	23.2	39.8
Euro Area	Dhyne <i>et al.</i> (2005)	1996-2001	15.1	-	28.3
Finland	Vilmunen and Laakkonen (2005)	1997-2003	16.5	-	52
France	Baudry <i>et al.</i> (2007)	1994-2003	18.9	19.2	21
Germany	Hoffmann and Kurz-Kim (2006)	1998-2004	11.3	-	29.6
Hungary	Gabriel and Reiff (2008)	2001-2007	21.5	24.9	50.4
Israel	Baharad and Eden (2004)	1991-1992	24.5	-	-
Italy	Fabiani <i>et al.</i> (2006)	1996-2003	10	-	19.5
Japan	Saita <i>et al.</i> (2006)	1999-2003	22.9	-	69
Luxembourg	Lunnemann and Matha (2005)	1999-2004	17	19	26
Mexico	Gagnon (2009)	1994-2004	29.4	-	-
Netherlands	Jonker <i>et al.</i> (2004)	1998-2003	16.5	23.23	32.42
Norway	Wulfsberg (2009)	1975-2004	23.7, 19.6	34.5, 23.6	47.3, 34.5
Portugal	Dias <i>et al.</i> (2004)	1992-2001	22.2	37.2	47.2
Sierra Leone	Kovanen (2006)	1999-2003	51.5	71.7	-
Slovakia	Coricelli and Horvath (2006)	1997-2001	34	39	-
South Africa	Creamer and Rankin (2008)	2001-2006	16.8	20.5	-
Spain	Alvarez and Hernando (2004)	1993-2001	15	-	50
United Kingdom	Bunn and Ellis (2009)	1996-2006	18.8	21.8	20
United States	Bils and Klenow (2004)	1995-1997	26.1	25.3	-
	Klenow and Kryvtsov (2008)	1988-2005	29.9	-	-
	Nakamura and Steinsson (2008)	1988-2005	21.1	-	25.4

Notes. Jonker *et al.* (2004) splits the sample into a high inflation period (1975-1989) and a low inflation period (1990-2004). The latter period is reported in parentheses. Wulfsberg (2009), Klenow and Kryvtsov (2008) and Nakamura and Steinsson (2008) also report frequencies excluding temporary sales. We include temporary sales here for the sake of consistent comparison.

Figure 4.3: Average Frequency of Price Changes (Portillo et al., 2016).

Notes: Three features are noteworthy. First, food prices change more frequently than the general price level in the economy; second, unprocessed food prices change with much higher frequency than overall food prices; third, the difference in flexibility between food prices and overall prices is most prominent in developing countries (like Chile and Brazil) and low-income countries (like Sierra Leone).

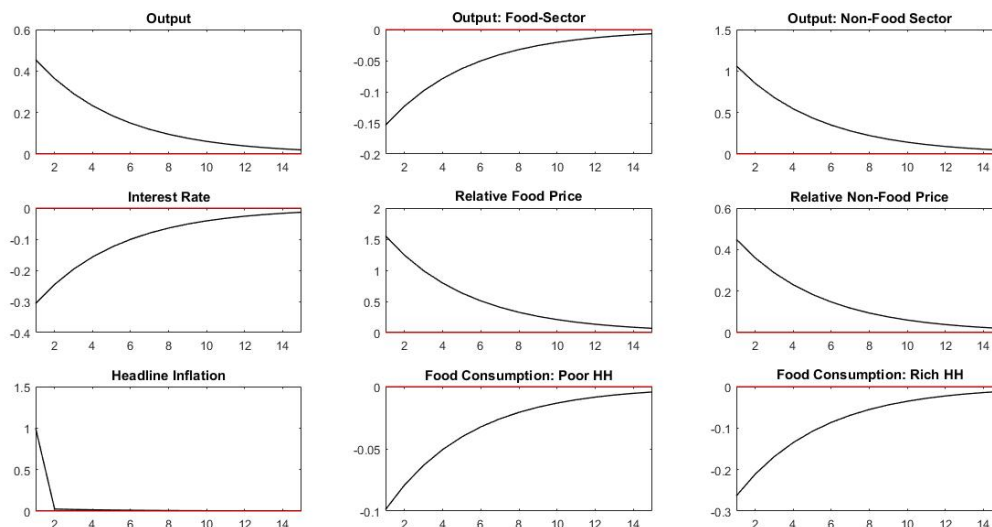


Figure 4.4: Impulse Responses to Expansionary Monetary Policy Shock, India.

Notes: Impulse response functions over 16 quarters to a 30 basis point decline in interest rate in India. Rich HH are indicated by those who belong to the top 40% of expenditure distribution and poor HH are indicated by those who belong to the bottom 60% of expenditure distribution.

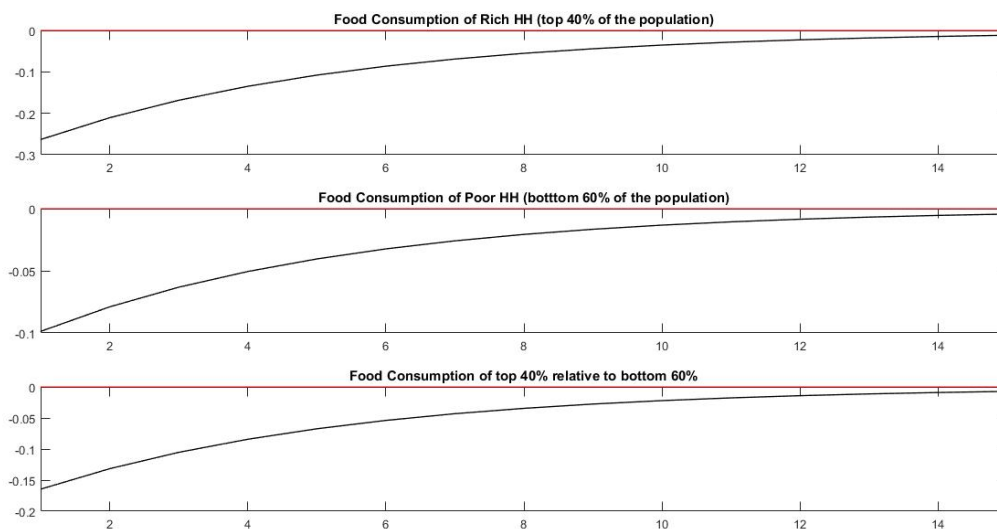


Figure 4.5: Impulse Response for the Distribution of Food Consumption, India.

Notes: Impulse response functions over 16 quarters to a 30 basis point decline in interest rate in India. Rich HH are indicated by those who belong to the top 40% of expenditure distribution and poor HH are indicated by those who belong to the bottom 60% of expenditure distribution.

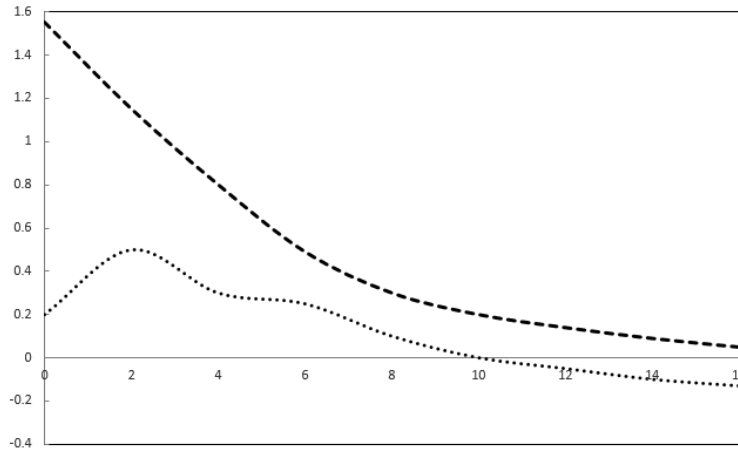


Figure 4.6: Relative Food Price Response, India, FAVAR vs. DSGE

Notes: The response of the *relative* price of food to a 30 basis point decline in interest rate in India from FAVAR and DSGE analysis. The impulse response from FAVAR analysis is given by the dotted line whereas that from DSGE analysis is given by the dashed line. Both are plotted against the primary axis.

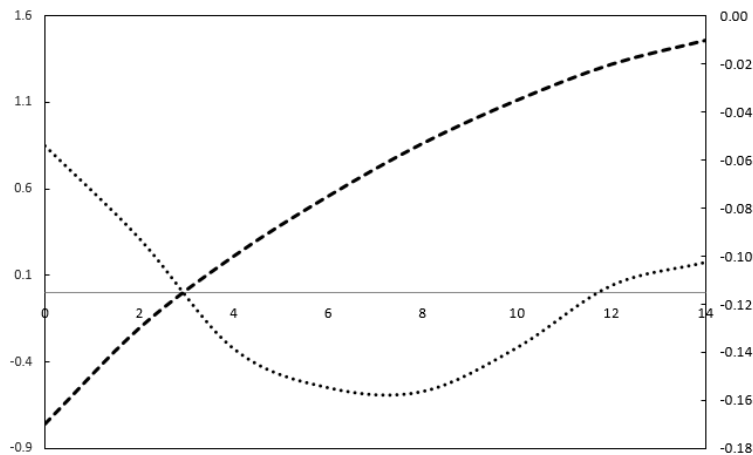


Figure 4.7: Food Consumption Response of the Rich relative to the Poor, India, FAVAR vs. DSGE

Notes: Food consumption response of rich HH *relative* to poor HH to a 30 basis point decline in interest rate in India from FAVAR and DSGE analysis. The impulse response from FAVAR analysis is given by the dotted line whereas that from DSGE analysis is given by the dashed line. The former is plotted against the primary axis or the left-hand axis, while the latter is plotted against the secondary axis or the right hand axis. The dotted line (from FAVAR analysis) represents the food consumption response of the top 20% relative to the bottom 20%, while the dashed line (from DSGE analysis) represents the food consumption response of the top 40% relative to the bottom 60%.

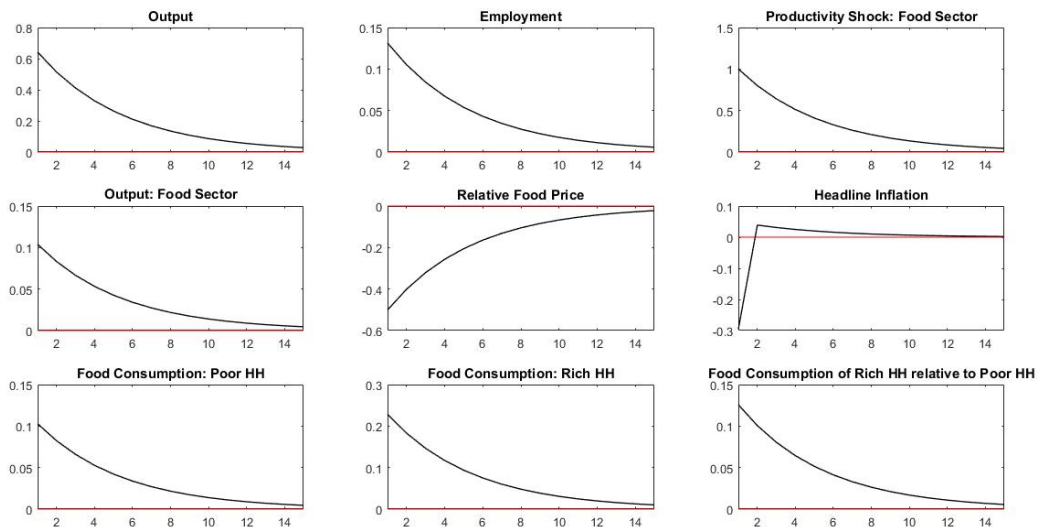


Figure 4.8: Impulse Responses to Productivity Shock, India.

Notes: Impulse response functions over 16 quarters to a productivity shock in India. Rich HH are indicated by those who belong to the top 40% of expenditure distribution and poor HH are indicated by those who belong to the bottom 60% of expenditure distribution.

## SENSITIVITY ANALYSIS

Table 4.2: Calibration II-DSGE, Sensitivity Analysis, India

Parameter	Definition	Value
$\gamma_F^d$	Share of food expenditures, Developed economy (top 20%)	.25
$\gamma_F^u$	Share of food expenditures, Underdeveloped economy (bottom 20%)	.70
$c^{u/d}$	Income of households in the underdeveloped economy relative to the developed	.28
$\bar{c}_F$	Subsistence level of food consumption	.1891
$\alpha_F$	Non-Subsistence food consumption share	.075
$\alpha$	Labour Income share	.7
$\beta$	Discount Factor	.99
$\theta$	Probability of not being able to reset price	.75
$\zeta$	Response Coefficient to non-food inflation in the monetary policy rule	1.5
$\psi$	Inverse of Frisch Elasticity of Labor Supply	5
$\epsilon$	Elasticity of Substitution between different varieties	6
$\rho_A$	Parameter in the AR(1) process for food productivity shock	.8
$\sigma_{AF}$	Standard deviation of food productivity shocks	.6
$\rho_{MP}$	Persistence in the AR(1) process for monetary policy shock	.8
$\sigma_{MP}$	Standard deviation of monetary policy shocks	.75

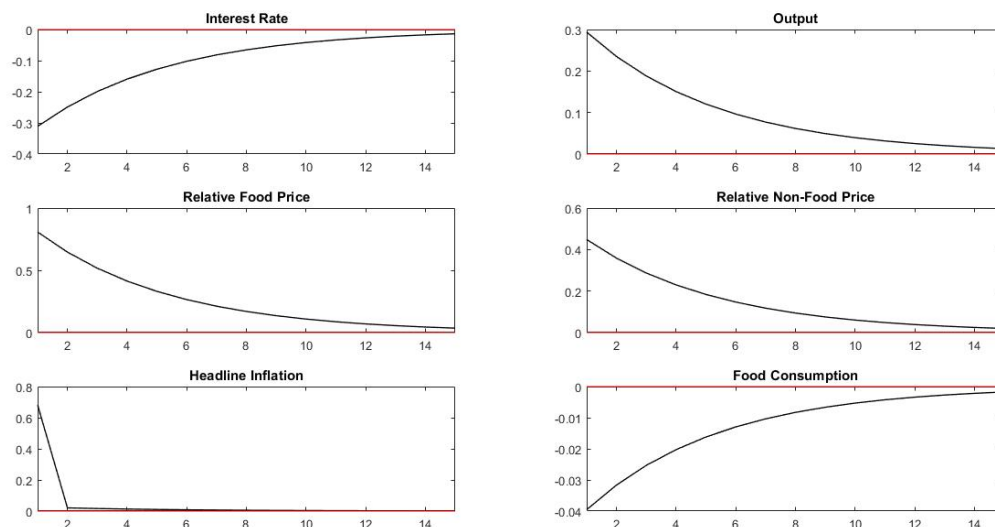


Figure 4.9: Impulse Responses to Expansionary Monetary Policy Shock, Underdeveloped Economy (Sensitivity Analysis).

Notes: Impulse response functions over 16 quarters to a 30 basis point decline in interest rate. The underdeveloped economy features households who belong to the bottom 20% of expenditure distribution in India.

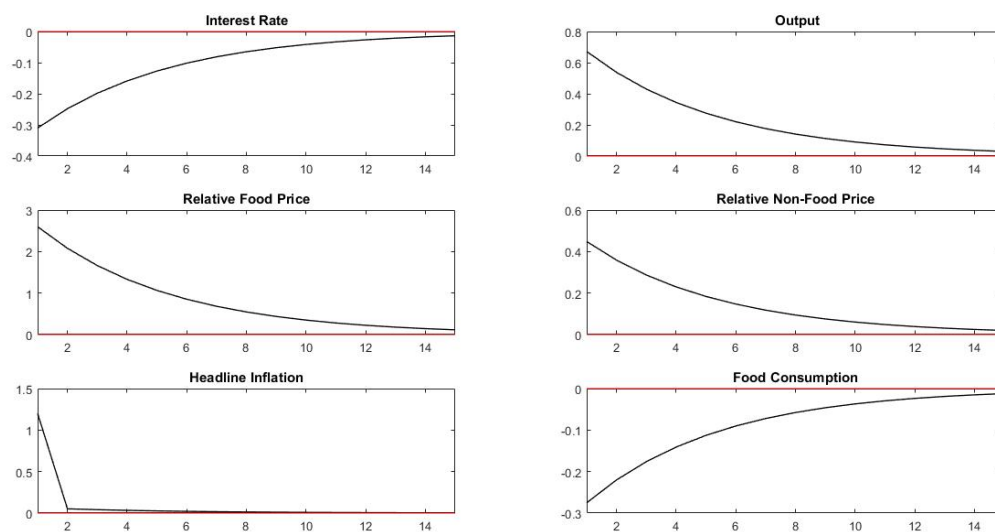


Figure 4.10: Impulse Responses to Expansionary Monetary Policy Shock, Developed Economy (Sensitivity Analysis).

Notes: Impulse response functions over 16 quarters to a 30 basis point decline in interest rate. The developed economy features households who belong to the top 20% of expenditure distribution in India.

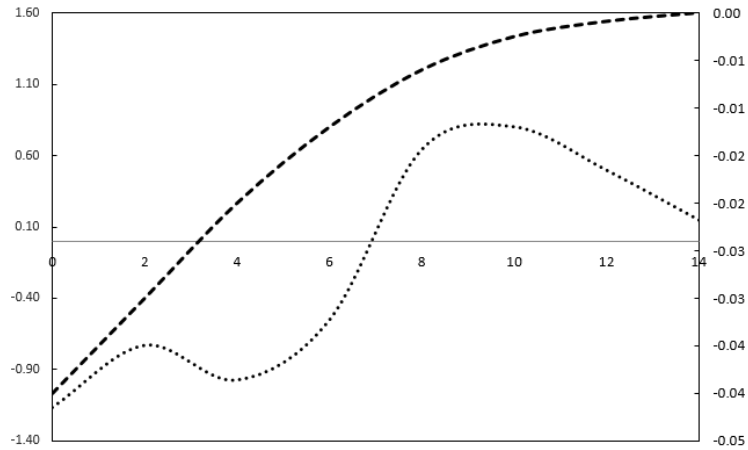


Figure 4.11: Food consumption Response, Bottom Quintile, India, FAVAR vs. DSGE

Notes: Food consumption response of households who lie in the bottom 20% of expenditure distribution (bottom quintile or 20<sup>th</sup> percentile) to a 30 basis point decline in interest rates in India from FAVAR and DSGE analysis. The impulse response from FAVAR analysis is given by the dotted line whereas that from DSGE analysis is given by the dashed line. The former is plotted against the primary axis or the left-hand axis, while the latter is plotted against the secondary axis or the right hand axis.

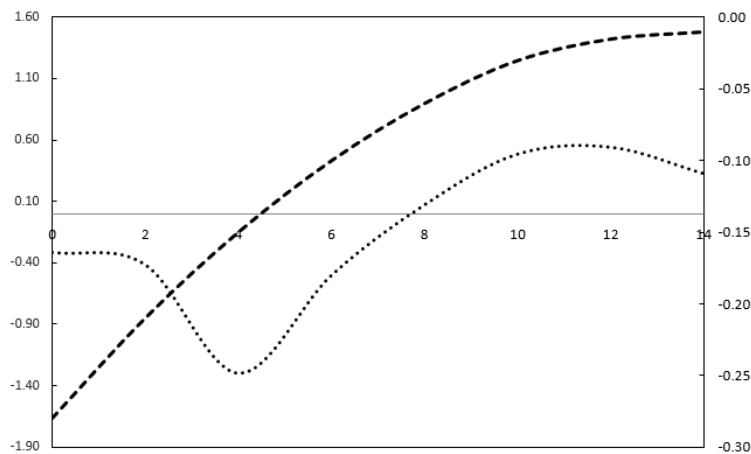


Figure 4.12: Food consumption Response, Top Quintile, India, FAVAR vs. DSGE

Notes: Food consumption response of households who lie in the top 20% of expenditure distribution (top quintile or 80<sup>th</sup> percentile) to a 30 basis point decline in interest rates in India from FAVAR and DSGE analysis. The impulse response from FAVAR analysis is given by the dotted line whereas that from DSGE analysis is given by the dashed line. The former is plotted against the primary axis or the left-hand axis, while the latter is plotted against the secondary axis or the right hand axis.

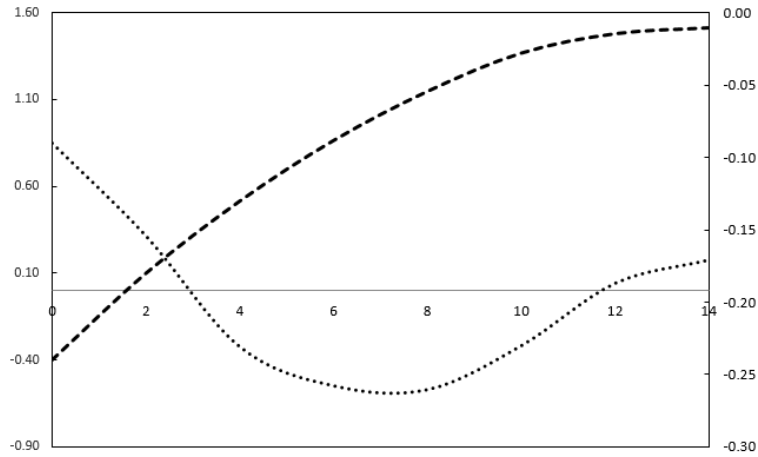


Figure 4.13: Food Consumption Inequality Response, India, FAVAR vs. DSGE

Notes: Impulse response for food consumption inequality to a 30 basis point decline in interest rate in India from FAVAR and DSGE analysis. Food consumption inequality is measured as the difference between the top quintile (80<sup>th</sup> percentile) and bottom quintile (20<sup>th</sup> percentile) of the log levels in the food consumption distribution. The impulse response from FAVAR analysis is given by the dotted line whereas that from DSGE analysis is given by the dashed line. The former is plotted against the primary axis or the left-hand axis, while the latter is plotted against the secondary axis or the right hand axis.

## CHAPTER 5

### CONCLUSION

My dissertation is devoted to studying the distributional effects of monetary policy on household food consumption in emerging market economies, and the channel through which these distributional effects occur. The main contribution of my dissertation is finding evidence of the presence a “*food price channel*” of monetary policy in emerging market economies. Three essays investigate the empirical relationship between monetary policy, relative food prices and the distribution of food consumption in emerging market economies to understand the relative importance of the “*food price channel*” in these growing economies.

Chapter 2 of the dissertation, titled “The Food Price Channel: Effects of Monetary Policy on the Poor in India” studies the impact of monetary policy on *relative* food prices and the distribution of food consumption in India. Using household survey data from 1996-2013, I estimate the dynamic effects of monetary policy shocks on the *relative* prices of food and the distribution of food consumption in rural and urban India from a factor augmented vector auto regression model (FAVAR) (Bernanke, Boivin, and Elias, 2005 and Stock and Watson, 2011), and identify monetary policy shocks using the sign restriction approach of Uhlig (2005). FAVAR results show that expansionary monetary policy shocks *positively* impact the *relative* prices of food, and *negatively* impact the distribution of food consumption in India. Further, the *negative* impact on food consumption varies systematically across the expenditure distribution in rural and urban India: food consumption at the lower end of the distribution falls far more than that at the upper end. Expansionary monetary policy shocks via the increase in *relative* food prices reduce the *subsistence* food consumption of poor

households and increase poverty and inequality in India. Chapter 2 provides evidence of the impact of a “*food price channel*” of monetary policy on the distribution of food consumption as well as poverty and inequality in India.

Chapter 3 titled “Monetary Policy and Distribution of Food Consumption in China: The Role of Food Prices” explores the “*food price channel*” of monetary policy in another large emerging market economy, China. Using data from the household surveys conducted by China’s National Bureau of Statistics, I estimate the dynamic effects of monetary policy shocks on the *relative* price of food and the distribution of food consumption in rural and urban China from a vector auto regression (VAR) model, and identify monetary policy shocks using the sign restriction approach of Uhlig (2005). Consistent with my results for India, results for China also show that the *relative* price of food responds *positively*, and the distribution of food consumption responds *negatively* to expansionary monetary policy shocks, however contrary to India, food consumption at the lower end of the distribution in China falls much less than that at the upper end in response to monetary expansion. Expansionary monetary shocks in China are found to be associated with lower levels of food consumption inequality. Overall, results of chapter 3 also provide evidence of the impact of the “*food price channel*” of monetary policy on the distribution of food consumption and inequality in China.

Interestingly, in India while expansionary monetary shocks via the “*food price channel*” increase food consumption inequality, in China expansionary monetary shocks via the same channel reduce inequality. This observed difference in the results between India and China could be attributed to the marked heterogeneity in the characteristics of poor households across the two countries. Relative to China, poor households in India are characterized by a higher share of food in total budget, dependence on cash purchases of food, financial constraints, and informal employment; all these make them more vulnerable to fluctuations

in relative food prices. Consequently expansionary monetary policy shocks, which increase the relative price of food, have stronger adverse effects on the Indian poor.

Aside from these factors, other differences in household characteristics (with regard to socioeconomic and demographic factors, such as age and education, rural-urban migration, income, wealth, employment status, tax and housing status, patterns of food consumption) between the two economies could also potentially have implications for their response to changes in monetary policy. Many mechanisms through which monetary policy affects households in different ways may be at play, and it is a daunting task to disentangle and identify these effects empirically (Yannick and Ekobena, 2014). In conclusion, results for India and China suggest that in emerging market economies the impact of “*food price channel*” of monetary policy on inequality is a priori ambiguous, and rather specific to the household characteristics, institutions and histories of each economy.

Chapter 4 titled “The Food Price Channel in India Revisited” reinvestigates the impact of the “*food price channel*” of monetary policy on the distribution of food consumption in India using a dynamic stochastic general equilibrium (DSGE) model. The DSGE analysis is based on a two sector new-Keynesian model with flexible food and sticky non-food prices, and heterogeneous agents who differ in their proximity to subsistence food threshold. Results from the DSGE analysis point to expansionary monetary shocks having heterogeneous *negative* effects on food consumption which reduce food consumption at the lower end of the distribution much less than that at the upper end. Lower the income class, lower the sensitivity to policy shocks. Because proximity to subsistence reduces the income and price elasticities of demand in the food sector, and also reduces the inter-temporal elasticity of substitution (increases the risk aversion), poor households are far more demand inelastic with respect to food price compared to the rich. Consequently their food consumption does not show much variation in response to policy shocks. So, following monetary expansion, poor

households witness a much smaller decline in food consumption compared to rich households.

Consistent with my FAVAR analysis in chapter 2, the DSGE analysis in chapter 4 also provides evidence in favor of the impact of the “*food price channel*” of monetary policy on the distribution of food consumption in India. However contrary to the FAVAR analysis, the DSGE exercise points towards monetary expansion reducing the observed inequality across households in food consumption via the “*food price channel*” (instead of increasing). Understanding why the theoretical and empirical framework in the second and fourth chapter produce different results could be complex, however in understanding this, careful consideration needs to be given to how well the theoretical model is able to replicate the real economy. While the empirical framework (FAVAR) uses actual real time data which reflects many heterogeneous features of households like differential wages, labor market segmentation, and financial inclusion, the theoretical exercise (DSGE) relies only on *proximity to subsistence* and abstracts away from many of the other aforementioned heterogeneous household characteristics. Incorporating some of the other heterogeneous features of households in the DSGE model like financial inclusion and labor market segmentation could be helpful in making the two models more comparable, however this is beyond the scope of the current study and forms an avenue for future research.

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