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# Optimal Monetary Policy in the Presence of Food Price Subsidies

William Ginn<sup>a</sup> and Marc Pourroy<sup>b</sup>

## Abstract:

Food price subsidies are a prevalent means by which fiscal authorities may counteract food price volatility in middle-income countries (MIC). We develop a DSGE model for a MIC that captures this key channel of a policy induced price smoothing mechanism that is different to, yet in parallel with, the classic Calvo price stickiness approach, which can have consequential effects for monetary policy. We then use the model to address how the joint fiscal and monetary policy responds to an increase in inflation driven by a food price shock can affect welfare. We show that, in the presence of credit constrained households and households with a significant share of food expenditures, a coordinated reaction of fiscal and monetary policies via subsidized price targeting can improve aggregate welfare. Subsidies smooth prices and consumption, especially for credit constrained households, which can consequently result in an interest rate reaction less intensely with subsidized price targeting compared with headline price targeting.<sup>1</sup>

**Key Words:** Monetary Policy, Fiscal Policy, Food subsidies, DSGE Model

**JEL Codes:** E52, E62, O23, E31, E32

## Highlights:

- *We study the role of fiscal and monetary authorities in stabilizing food price shocks in middle-income economies*
- *Both fiscal and monetary policy can have redistributive impacts*
- *Coordinated fiscal and monetary reactions to food price shocks can improve aggregate welfare*
- *Subsidies smooth consumer prices and reduce the need for monetary policy action*

<sup>a</sup> William Ginn, Friedrich Alexander Universität Erlangen-Nürnberg, Germany. [William.Ginn@OxfordBusinessAlumni.org](mailto:William.Ginn@OxfordBusinessAlumni.org)

<sup>b</sup> Marc Pourroy, CRIEF Université de Poitiers. [Marc.Pourroy@univ-poitiers.fr](mailto:Marc.Pourroy@univ-poitiers.fr)

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# 1 Introduction

Dramatic surges in international food commodity prices relative to the last couple decades, widely acknowledged as a global food price crisis, have posed major challenges for policy makers. The impact has been more pronounced in middle-income countries (MIC), considering food consumption represents a large share of household expenditures, renewing interest in how central banks react to food price shocks.

In response to the rising food prices, many governments had significant budget outlays to support food price subsidies to curb household inflation. Many countries had existing subsidy programs in place before the onset of the food price shocks to the extent that they are an entrenched social contract.

Only recently, there are a handful of papers to address the challenges that central banks face whether to target headline or core inflation based on a high share of food expenditures and financially constrained households in emerging markets (Anand *et al.* [2015], Catão and Chang [2015] and Pourroy *et al.* [2016]). Our research, focusing on MICs, adds an additional channel by incorporating the effects of price subsidies to cushion global food price shocks.

Our research investigates whether a central bank should react to core or headline inflation and furthermore does the degree of fiscal intervention affect this decision for a MIC with a presence of financial constrained households? This paper aspires to capture the main elements to analyzing policy makers' intentions when faced with exogenous food price shocks. We address the fiscal challenges and macroeconomic implications of a representative MIC to isolate the effects of exogenous food price shocks using a multi-sector New Keynesian DSGE model in a small open economy setting.

To our knowledge, there are a couple novelties in our paper. Firstly, we provide empirical evidence regarding food price subsidy characteristics (institutions, geography, income, expenditures). Based on the empirical findings, this is the first paper in the DSGE literature to address the impacts of subsidies relating to household optimization.<sup>2</sup> In doing so, we can capture the effects of distorted prices from the demand side in a general equilibrium model. We also add, unlike any of the papers incorporating a food sector, capital as an input technology for the non-food sector. Our three main results can be summarized as follows:

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<sup>2</sup> To our knowledge, the research by Ben Aissa and Rebei [2012] and Arseneau and Leduc [2013] are the only two papers in the DSGE literature which consider food subsidies. Ben Aissa and Rebei [2012] show firms optimize output in the presence of subsidies on the supply side. Similarly, Arseneau and Leduc [2013] develop a model which captures optimizing storage based on commodity price movements. Our paper is different to the literature considering it relates to household optimization with price subsidies which can alter the effective price of food that the household faces.

- In the presence of financial frictions and fiscal intervention, monetary policy reaction to food price shocks (subsidized headline inflation targeting) achieves the highest welfare;
- Optimal policy is defined with respect to the population set. We find large welfare distributional effects: Ricardians (non-Ricardians) are better off with a low (high) degree of fiscal intervention and the best monetary policy regime is to target core (headline) inflation; and
- There are welfare gains from fiscal and monetary policy coordination. If, on the one hand, monetary policy reacts to a food price shock, it helps stabilize production and therefore reduces the financing cost of food subsidies. On the other hand, when fiscal policy reacts to the food price shock it helps in stabilizing food demand and therefore avoid second round effects.

The remainder of the paper is organized as follows. Section 2 motivates the importance of food subsidies as stylized fact and review of the literature. Section 3 describes the model. In Section 4 the model experiments are presented. Section 5 introduces welfare results and robustness checks, while Section 6 concludes the paper.

## 2 Empirical Findings and Literature Review

We examine the relevant features of a representative MIC which allow us to understand the macroeconomic channels faced by policy makers. There have been two recent inflationary episodes attributed to food price shocks occurring in 2007 and 2011. Since the turn of the century to 2015, food prices have soared 83% (152%) in real (nominal) terms according to the Food and Agriculture Organization (FAO). Dawe *et al.* [2015] find that while domestic prices have generally followed in lock-step of world food price changes, they find the former tends to increase less as intensely as the latter which may depend on country- and commodity-specific factors (e.g., policies, exchange rates, infrastructure).

To cushion the effects of global food price shocks, the IMF [2008b] documents that twenty-eight countries significantly increased food subsidies to offset rising food prices with a median change of 0.2% of GDP, and circa 20% of those countries ended up spending in excess of 1% of GDP.<sup>3</sup>

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<sup>3</sup> The IMF [2008a] also reveals sharp increases in food subsidies in 2008 relative to 2007, coinciding with the same period of the world food price increase.

## 2.1 Empirical Findings

We develop a novel dataset to gain further insight on countries where food prices are controlled by a policy decision via food subsidies. Food price subsidies produce a gap between the actual selling price and a benchmark price (see e.g. Sdrlevich [2014], Koplow [2009] and Clements *et al.* [2013]). Therefore, if such a gap exists, food prices may be considered “policy driven”. We rely on publications by the FAO, IMF and World Bank<sup>4</sup> to identify countries with food price subsidies.

We find that out of the more than 165 countries in the world, food prices are controlled in 85 countries. We then investigated central banks. Among countries with food subsidies we find 31 central banks communicate an inflation target, which we ascribe an inflation targeting regime (see e.g. Hammond [2012] for a definition) or simply an inflation objective as a point target rate or a range target. If such an objective has been communicated, we considered the central bank to have an objective of price stability<sup>5</sup>.

To further understand the main attributes of countries with food price control policies, we grouped our data in three categories: general, food and agriculture. We then performed a Wilcoxon rank-sum test (also known as the Mann-Whitney two-sample statistic); two equality of median tests (Pearson chi-squared test and Fisher's test); and a two-sample Kolmogorov – Smirnov distribution test to identify variables where countries with food price control differ from countries with free food price. The empirical results are provided in the Appendix (Table 9) and summarized below.

**General:** we explore income features and institutional performance as it relates to food controls. Our empirical findings suggest that:

- food price control policies are popular in MICs, or similarly, in countries where the share of households living under poverty line is high: the average GINI per capita (Atlas

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<sup>4</sup> We assume a country has a food price control mechanism if it appears in the FAO FAPDA database (Food and Agriculture Policy Decision Analysis Tool, Consumer Oriented Policy Food Price Control), then considering complementary information from the World Bank [2008] or the IMF (IMF [2008a, 2008b]). We make no distinction among the different varieties of food goods under consideration.

<sup>5</sup> Food prices are controlled through fiscal interventions via food subsidies in the following 85 countries, where we additionally identify 31 of them having an explicit inflation stability objective denoted by '\*': Algeria; Argentina\*; Azerbaijan\*; Bahrain; Bangladesh\*; Belarus\*; Benin; Bhutan; Bolivia; Bosnia and Herzegovina; Brazil\*; Burkina Faso; Burundi; Cameroon; Central African Republic; Chad; China\*; Congo, Dem. Rep.; Congo, Rep.; Costa Rica\*; Djibouti; Dominican Republic\*; Ecuador; Egypt, Arab Rep.; Eritrea; Ethiopia; Fiji; Gabon; Guatemala\*; Guinea-Bissau; Honduras; India\*; Indonesia\*; Iran, Islamic Rep.; Iraq; Jamaica\*; Jordan; Kazakhstan\*; Kenya\*; Kosovo; Kuwait; Kyrgyz Republic\*; Lao PDR; Lebanon; Liberia; Macedonia, FYR; Malaysia; Mali\*; Mauritania; Mauritius; Mexico\*; Moldova\*; Mongolia\*; Montenegro; Morocco; Mozambique\*; Niger; Nigeria\*; Oman; Pakistan\*; Panama; Paraguay\*; Philippines\*; Russia\*; Saudi Arabia; Senegal; Solomon Islands; Sri Lanka\*; Swaziland; Syrian Arab Republic; Taiwan; Tajikistan; Tanzania; Thailand\*; Timor-Leste; Tunisia; Turkmenistan; Ukraine\*; Uruguay\*; Uzbekistan; Venezuela, RB; Vietnam\*; Yemen, Rep.; Zambia\*; Zimbabwe.

method) is \$5,045 while the median is \$3,770<sup>6</sup> (GDP per Capita and Poverty, represented on Figure 1, have similar distributions);

- institutional performances are generally assumed to be correlated with income, i.e. one would perhaps expect food subsidies to take place in a low institutional context. Interestingly, we find no evidence that institutional quality in countries with food price controls are different from that of countries with free food prices; and
- households in countries with food price controls are characterized by weak, if any, access to financial services.

**Agriculture:** food price subsidies may be considered a solution to cope with high agriculture prices caused by a low supply with regards to consumption needs. We find that:

- countries where food prices are controlled generally have lower agricultural capacities than countries with free food prices, particularly in terms of yield per hectare or fertilizer consumption;
- agriculture production has increased faster over the last decade in countries with food subsidies; and
- food price controls are present in countries with a large share of the economy dedicated to agriculture, in terms of employment or value added, both of which were expected as food price control are a widespread practice in MICs.

**Food:** we find that food subsidies may be considered to counteracting high or volatile food prices:

- food subsidies are on average associated with a large share of consumer spending on food, our sample average being 41.5% (see Table 2);
- there is no evidence that food supply is less stable in countries with food subsidies and we obtained mixed results about food availability. Similarly, undernourishment is not statistically higher in countries with food subsidies;
- food access, as measured by the FAO (food security indicators) with infrastructures measurements, is statistically lower in countries where food prices are controlled. This may be interpreted as a limitation to market functioning, justifying other price setting mechanisms; and
- we find no statistical evidence that countries with food subsidies are on average larger net food importer than other countries.

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<sup>6</sup> We use the World Bank classification such that low-income economies are defined as those with a GNI per capita (Atlas method) below \$1,005; lower middle-income economies are those with a GNI per capita between \$1,006 and \$3,955; upper middle-income economies are those with a GNI per capita between \$3,956 and \$12,235; high-income countries are those with a GNI per capita above \$12,236.

Insert About Here

Figure 1: Food Policy - GDP per Capita and Poverty.

## 2.2 Food subsidies

Food subsidies may take the form of either universal or targeted subsidies. By reducing the food price a household would pay relative to the non-subsidized food price, mandated government subsidies are designed to achieve several social, economic and political goals. For example, Kramer [1990] cites several objectives, to ensure adequate nutrition, food consumption and food security for its citizens as well to transfer income to the poor (p. 2). Food subsidies usually target certain population groups and comprise specific food items.

For governments, food subsidies may be a matter of survival. Arezki and Bruckner [2011] have shown that “during times of international food price increases political institutions in Low Income Countries significantly deteriorated” (p. 11). Food price hikes create hunger which calls for political action. Barrett and Bellemare [2011] point out that food price spikes (as opposed to prices volatility) are correlated to civil unrest. Governments must be “seen to be doing something” (Poulton *et al.* [2006]). Lastly, Gouel [2014] discusses in a literature review that government stabilization policies may be considered as a second-best intervention in an absence of insurance and futures markets.

Fiscal intervention via subsidies is not without shortcomings. There is an existing body of research, while ad hoc, to suggest intended subsidies do not always reach its intended beneficiary (commonly known as targeting leakage) and can be associated with excess costs.<sup>7</sup> Food subsidies are usually targeted to cost effectively transfer benefits to vulnerable members of society and reduce or stabilize fiscal outlays for supporting subsidies (Kramer [1990]). Subsidy programs typically are associated with administrative costs e.g. collecting information on households thereby reducing the subsidy benefit to the household (Coady *et al.* [2004]). The purpose of surveying households is to improve targeting performance. According to Coady *et al.* [2004], “scarce government resources have encouraged efforts to concentrate resources on ‘target groups’ of poor households or individuals” (p. 1). Targeting leakage is an outcome of an inclusion error, whereby those that are not intended to receive a subsidy enjoy some of the direct benefits. This can be problematic considering the scarcity of fiscal resources.

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<sup>7</sup> Jha and Ramaswami [2004] find that the private sector in India is more efficient than the public sector in terms of lower costs in trading, marketing costs and storage costs.

## 2.3 Monetary Policy

While many central banks have pursued inflation targeting policies, it has been less clear-cut as to whether central banks should target core or headline inflation. The recent food inflationary episodes have provoked reconsideration whether inflation indexation should be anchored on core or headline prices. Wynne [1999] argues that core inflation is an appropriate measure of inflation since volatile components (e.g., energy and food) may be non-monetary in nature. Walsh [2011] finds that food inflation in many developing economies is higher than non-food inflation even in the long-run, thus excluding food inflation from policy target can lead to a biased perception of the underlying dynamic.

In a seminal paper for the theoretical analysis of relative price shocks, Aoki [2001] shows targeting core inflation is optimal by means of achieving headline price stability, since fully-flexible prices are posited as mean-reverting.

Anand *et al.* [2015] develop a New Keynesian closed economy DSGE model aimed at understanding optimal monetary policy when faced by increases in food prices relating to a productivity shock. The authors argue that targeting core inflation is no longer welfare maximizing in the presence of incomplete markets characterized with credit-constrained consumers. As financial limitations are a key feature of MICs, we follow Anand *et al.* [2015] by assuming population is divided between Ricardian and non-Ricardian types.

Catão and Chang [2015] develop a DSGE model including a food sector in a small open economy setting facing an exogenous price shock. They show that targeting headline inflation can be welfare improving with volatile food price shocks. While they assumed food price shocks are explained by the world price, they model an economy that does not produce food goods.

Pourroy *et al.* [2016] develop a small, open economy with tradable and non-tradable food and non-food composite goods. They find that while non-tradable food consumption is negligible in developed economies, it is not the case in developing countries where the share of food consumption is higher. Thus, the authors argue, central banks in developing countries should target headline inflation. We follow Pourroy *et al.* [2016] such that we assume that world food price shocks are transferred to the domestic economy through domestic food production, which is confirmed in empirical papers such as Holtemöller and Mallick [2016] and Bekkers *et al.* [2017]). We extend Pourroy *et al.* [2016] model by considering a fraction of the population is credit constrained as in Anand *et al.* [2015].

None of the above papers consider price subsidies. Ben Aissa and Rebei [2012] investigate the impact of a price subsidy for monetary policy in a closed New Keynesian economy model. They conclude that inflation targeting may not be the optimal policy. Their model is not specific to food goods (which have a low elasticity of substitution) and they consider a producer subsidy while we focus on fiscal policy aimed at stabilizing consumer food prices.

### 3 The Model

The model incorporates a two agent New Keynesian (TANK) model, which draws on the work of Gali *et al.* [2004], as opposed to a representative agent New Keynesian (RANK)<sup>8</sup> model as coined by Kaplan *et al.* [2018]. There is a continuum of households of measure unity. A share  $1 - \lambda$  represent the neo-classical Ricardian household ( $\tau$ ), who is able to smooth consumption via trading in asset (i.e., capital, bond) markets. The rest of the households  $\lambda$  are labeled non-Ricardian ( $\pi$ ), who do not have access to trade in asset markets. To simplify notation for the household, let  $i \in (\tau, \pi)$ . The Ricardian household works in the manufacturing (sticky price) sector. Following Anand *et al.* [2015], non-Ricardian type is credit constrained and works in the food (flexible price) sector. We augment the model to include an open food sector following Catão and Chang [2015] and Pourroy *et al.* [2016]. Labor is assumed to be immobile between food and non-food sectors, however food labor is mobile between tradable and non-tradable food. Our treatment by household and production type can be rationalized since the agricultural sector is associated with rural regions, where a sizable proportion of income is directly or indirectly linked with agriculture. According to the U.N., “[t]hree quarters of the world's poor live in rural areas of developing countries and depend mainly on agriculture and related activities for their livelihood” (U.N. [2003]).

#### 3.1 Households

Household member  $i$  is assumed to have the same consumption preferences for both food ( $C_{i,t}^F$ ) and manufacturing ( $C_{i,t}^M$ ) goods, combined in a CES basket:

$$C_{i,t} = \left[ \varphi^{\frac{1}{\theta}} (C_{i,t}^F)^{\frac{\theta-1}{\theta}} + (1 - \varphi)^{\frac{1}{\theta}} (C_{i,t}^M)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \quad (1)$$

where  $\varphi$  denotes the share of food consumption and  $\theta$  represents the intertemporal elasticity of substitution between food and manufacturing goods. The CES basket implies the following consumption price index (CPI) per unit of consumption:

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<sup>8</sup> A burgeoning literature (Bilbiie [2017] and Kaplan *et al.* [2018] among others) shows that taking into account household heterogeneity allows for a better understanding of monetary policy indirect effects (endogenous amplification on output), as opposed to RANK models, that tend to over-estimate monetary policy direct effect (intertemporal substitution). Kaplan *et al.* [2018] have developed a Heterogeneous Agent New Keynesian (HANK) model where household heterogeneity includes a portion of poor households who behave in a hand-to-mouth fashion, combined with a wealthy hand-to-mouth manner. Thus, in the HANK model the direct effects of changes in the interest rate on demand is not as important than its indirect effect (different assets with different yields, borrowing constraint not always binding, etc.). Finally, Debortoli and Gali [2017] show that TANK models can be viewed as a “tractable framework that captures well the predictions of HANK models”.

$$P_t = [\varphi(P_t^F)^{1-\theta} + (1-\varphi)(P_t^M)^{1-\theta}]^{\frac{1}{1-\theta}} \quad (2)$$

$P_t^F$  and  $P_t^M$  denote the price of food and non-food goods, respectively. We assume the global food price ( $P_t^{F*}$ ) sold domestically are based on the prevailing exchange rate:  $P_t^F = e_t P_t^{F*}$ . Equation (2) does not necessarily reflect fiscal intervention to shield households from food price shocks. Many countries implemented measures to mitigate the effects of rising food prices. Similar to Ben Aissa and Rebei [2012], we introduce a simple way of capturing the effects of fiscal intervention via subsidizing food prices in the event of higher food price shocks as follows:

$$\vec{P}_{i,t}^F = \kappa_i \vec{P}_{i,t-1}^F + (1-\kappa_i) P_t^F \quad (3)$$

The food price denoted  $\vec{P}_{i,t}^F$  represents an adjusted price subsidy depending on the intensity of  $\kappa_i$ . In the event of fiscal intervention, equation (3) represents a policy-induced form of price stickiness determined by the parameter  $\kappa_i$ , which represents the degree of government intervention ( $0 \leq \kappa_i \leq 1$ ) by household type. As  $\kappa_i$  approaches zero (unity) translates to household  $i$  effectively paying the non-distorted (subsidized) price. Any fiscal intervention results in an increase in debt and taxes (discussed below). Therefore, household  $i$  faces the following price index:

$$\vec{P}_{i,t} = \left[ \varphi (\vec{P}_{i,t}^F)^{1-\theta} + (1-\varphi) (P_t^M)^{1-\theta} \right]^{\frac{1}{1-\theta}} \quad (4)$$

Each household  $i$  has perfect foresight on the underlying price changes they face at the time they occur, thus chooses the consumption bundle that minimizes expenditure. The first order conditions for food and non-food are summarized:

$$C_{i,t}^M = (1-\varphi) \left( \frac{P_{i,t}^M}{\vec{P}_{i,t}} \right)^{-\theta} C_{i,t} \quad C_{i,t}^F = \varphi \left( \frac{\vec{P}_{i,t}^F}{\vec{P}_{i,t}} \right)^{-\theta} C_{i,t} \quad (5)$$

### 3.1.1 Ricardian Household

Ricardian households represent optimizing agents, both inter-temporally and intra-temporally. Ricardian households supply labor to the manufacturing sector, consume and take investment portfolio decisions. These households derive utility from consumption ( $C_{r,t}$ ) and labor effort ( $N_{r,t}$ ).

$$U_{r,t} = \mathbb{E}_t \left\{ \sum_{t=0}^{\infty} \beta^t \left( \frac{1}{1-\rho} C_{r,t}^{1-\rho} - \psi \frac{(N_{r,t})^{1+\chi}}{1+\chi} \right) \right\} \quad (6)$$

where  $\beta^t$  represents the subjective discount factor ( $0 < \beta^t < 1$ );  $\chi$  is the intra-temporal elasticity of substitution of labor supply ( $\chi > 0$ ); and  $\psi$  denotes the disutility of labor supply ( $\psi > 0$ ).

Physical and financial assets are solely owned by the Ricardian household. Financial assets include domestic ( $B_{r,t}$ ) and foreign ( $B_{r,t}^*$ ) bond holdings, which pays a return of  $(1 + i_{t-1})$  and

$e_t(1 + i_{t-1}^*)$ , respectively. Consumption, wages, capital rents and profits are endogenously taxed at a time-varying rate  $\tau_t$ . As in Anand *et al.* [2015], we allow for two types of wages:  $W_{n,t}$  and  $W_{r,t}$  for food and manufacturing wages, respectively. Labor is not mobile; only Ricardians are associated with the manufacturing sector while non-Ricardians relate to the food sector. The representative Ricardian agent faces the following intertemporal budget constraint:

$$\begin{aligned}
(1 + \tau_t)C_{r,t} + I_t + \frac{B_{r,t}}{\bar{P}_{r,t}} + \frac{e_t B_{r,t}^*}{\bar{P}_{r,t}} \\
= \frac{(1 + i_{t-1})B_{r,t-1}}{\bar{P}_{r,t}} + \frac{e_t(1 + i_{t-1}^*)\theta(\mathcal{B}_t)B_{r,t-1}^*}{\bar{P}_{r,t}} \\
+ \frac{(1 - \tau_t)W_{r,t}N_{r,t}}{\bar{P}_{r,t}} + ((1 - \tau_t)r_t u_t + \delta\tau_t - a[u_t])k_{t-1} \\
+ (1 - \tau_t)\Pi_t
\end{aligned} \tag{7}$$

where  $\theta(\mathcal{B}_t)$  is a country risk premium;  $u_t$  is capital utilization with a physical cost of capital  $a[u_t]$ ; and profit is denoted  $\Pi_t$ . The manufacturing sector is capital intensive where the capital stock includes capital and investment is denoted by  $k_t$  and  $I_t$ , respectively. Capital is subject to a depreciation rate ( $\delta$ ). Note that  $\delta\tau_t$  is a depreciation allowance rebated back from capital income taxes (see Stähler and Thomas [2012]). We follow Christiano *et al.* [2005] in modeling investment adjustment costs and capital utilization costs. The capital stock constraint evolves as follows:

$$k_t = (1 - \delta)k_{t-1} + \left[1 - \Psi\left(\frac{I_t}{I_{t-1}}\right)\right]I_t \tag{8}$$

where  $\delta \in (0,1)$  and investment adjustment costs are denoted by  $\Psi(I_t/I_{t-1})$ . Similarly, variable capital utilization cost is:

$$a[u_t] = \epsilon_1(u_t - 1) + \frac{\epsilon_2}{2}(u_t - 1)^2 \tag{9}$$

The representative Ricardian household maximizes utility as in equation (6) subject to its resource constraint (7) and capital constraint (10) with respect to  $C_{r,t}$ ,  $B_{r,t}$ ,  $B_{r,t}^*$ ,  $k_t$ ,  $I_t$ ,  $u_t$  and  $N_{r,t}$ .

The term  $\theta(\mathcal{B}_t)$  is a country risk premium that depends on the net asset liquid position. We follow Schmidt-Grohé and Uribe [2003] and assume the interest rate is a function of the world interest rate ( $i_t^w$ ) with a country risk premium  $\theta(\mathcal{B}_t)$ , where the latter depends on the net foreign asset position:  $\theta(\mathcal{B}_t) = e^{-\zeta(e_t B_{r,t}^*/\bar{P}_t)}$  where  $\zeta > 0$ . The parameter  $\zeta$  is scalar denoting a country risk premium elasticity on the net foreign asset position.

### 3.1.2 Non-Ricardian Household

The non-Ricardian household thus has the following utility function:

$$U_{n,t} = \frac{1}{1 - \rho} C_{n,t}^{1-\rho} - \psi \frac{(N_{n,t})^{1+\chi}}{1 + \chi} \tag{10}$$

The budget constraint for this representative non-Ricardian agent evolves where these agents only consume their current income as follows:

$$(1 + \tau_t)C_{n,t} = (1 - \tau_t) \frac{W_{n,t}}{\bar{P}_{n,t}} N_{n,t} \quad (11)$$

## 3.2 Firms

There are two types of production firms in the domestic economy: a food sector and manufacturing sector. The firm production in the manufacturing sector is based on labor and capital, whereas the food sector is solely based on labor technology.

### 3.2.1 Food Firms

Food firms ( $Y_t^F$ ) allocate labor resources from the non-Ricardian household ( $N_{n,t}$ ) using a constant return to scale technology:  $Y_t^F = A_t^F N_{n,t}$ , where  $A_t^F$  represents productivity which follows an AR(1) stochastic process.

$$Y_t^F = A_t^F N_{n,t} \quad (12)$$

### 3.2.2 Non-Food Firms

The non-tradable manufacturing technology is based on capital and labor.

$$Y_t^M = A_t^M (u_t k_{t-1})^\alpha (N_{r,t})^{1-\alpha} \quad (13)$$

where  $0 < \alpha < 1$  is the share of capital.  $A_t^M$  represents food sector productivity that follows an AR(1) stochastic process. Manufacturing labor is supplied by the Ricardian household. The manufacturing sector solves pricing via a two-stage process. The first stage consists of minimizing cost based on perfectly competitive factor markets which is generalized as follows:

$$\min_{N_{r,t}, \hat{k}_{t-1}} W_{r,t} N_{r,t} + r_t \hat{k}_{t-1} + mc_t \left[ Y_t^M - A_t^M (\hat{k}_{t-1})^\alpha (N_{r,t})^{1-\alpha} \right] \quad (14)$$

Note that we have made a change of variable for capital to simplify notation:  $u_t k_{t-1} = \hat{k}_{t-1}$ . Cost minimization yields the following marginal products for the optimal choice of labor and capital:

$$N_{r,t} = (1 - \alpha) \cdot mc_t \frac{Y_t^M}{W_{r,t}} \quad (15)$$

$$\hat{k}_{t-1} = \alpha \cdot mc_t \frac{Y_t^M}{r_t} \quad (16)$$

Where  $mc_t^M$  represents marginal costs for the manufacturing sector producer. The previous two equations yield the relative factor demands and nominal marginal cost function:

$$\frac{\hat{k}_{t-1}}{N_{r,t}} = \frac{\alpha}{(1-\alpha)} \frac{W_{r,t}}{r_t} \quad (17)$$

$$mc_t = \frac{1}{(1-\alpha)^{1-\alpha}} \frac{1}{\alpha^\alpha} \frac{(W_{r,t})^{1-\alpha} (r_t)^\alpha}{A_t^M} \quad (18)$$

In the second stage, we incorporate stickiness a la Calvo [1983] such that each manufacturing firm faces an exogenous probability  $\phi > 0$  of not being able to re-optimize its price and hence retain the price charged from the previous period. This can be expressed as follows:

$$\max_{P_{j,t}^M} \mathbb{E}_t \sum_{s=0}^{\infty} \phi^s \Xi_{t+s} \left\{ \left( \frac{P_{j,t}^M}{P_{t+s}^M} - mc_{t+s} \right) Y_{j,t+s}^M \right\} \quad (19)$$

subject to sector specific demand:

$$Y_{j,t}^M = \left( \frac{P_{j,t}^M}{P_t^M} \right)^{-\epsilon} Y_t^M \quad (20)$$

We set the pricing kernel equal to the Ricardian owners' valuation  $\Xi_{t+s} = \Lambda_{t+s}/\Lambda_t$ , i.e. the marginal utility of consumption. Inserting the demand into the maximization process above simplifies optimization from a constrained maximization to an unconstrained one:

$$\max_{P_{j,t}^M} \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \phi^s \Xi_{t+s} \left\{ \left( \frac{P_{j,t}^M}{P_{t+s}^M} \left( \frac{P_{j,t}^M}{P_t^M} \right)^{-\epsilon} - \left( \frac{P_{j,t}^M}{P_t^M} \right)^{-\epsilon} mc_{t+s} \right) Y_t^M \right\} \quad (21)$$

Note that  $P_{j,t}^M$  is decided in period  $t$  and not  $t+1$  since manufacturing firms choose the optimal price in the current time which will occur in the next period. The first order conditions with respect to  $P_{j,t}^M$  yields the well know optimal price setting equation as follows:

$$\frac{\tilde{p}_t^M}{P_t^M} = \frac{\epsilon}{\epsilon - 1} \frac{\mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \phi^s \Xi_{t+s} Y_{t+s}^M mc_{t+s} \left( \frac{P_{t+s}^M}{P_t^M} \right)^\epsilon}{\mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \phi^s \Xi_{t+s} Y_{t+s}^M mc_{t+s} \left( \frac{P_{t+s}^M}{P_t^M} \right)^{\epsilon-1}} \quad (22)$$

Note that if prices are completely flexible (i.e.,  $\phi = 0$ ), equation (22) simplifies to  $\frac{\tilde{p}_t^M}{P_t^M} = \frac{\epsilon}{\epsilon-1} mc_t$ . We work with the condition of symmetric prices where  $\tilde{p}_t^M = P_t^M$ , implying marginal cost would be equivalent to the inverse mark-up, i.e.  $mc_t = \frac{\epsilon-1}{\epsilon}$ . We find it convenient to express (22) recursively, which simplifies to  $\epsilon \cdot f_{1,t} = (\epsilon - 1) \cdot f_{2,t}$  where:

$$f_{1,t} = \Xi_t Y_t^M mc_t + \beta^s \phi^s \mathbb{E}_t \left( \frac{P_{t+1}^M}{P_t^M} \right)^{\epsilon+1} f_{1,t+1} \quad (23)$$

$$f_{2,t} = \Xi_t Y_t^M + \beta^s \phi^s \mathbb{E}_t \left( \frac{P_{t+1}^M}{P_t^M} \right)^\epsilon f_{2,t+1} \quad (24)$$

We can express manufacturing prices evolving as a weighted average of the fraction of manufacturing firms which optimized its price and those that did not optimize prices:

$$P_t^M = \left[ (1 - \phi)(\tilde{P}_t^M)^{1-\epsilon} + \phi(P_{t-1}^M)^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}} \quad (25)$$

We define manufacturing price inflation ( $\pi_t^M$ ) by dividing (25) by  $P_{t-1}^M$ :

$$\pi_t^M = \left[ (1 - \phi) \left( \frac{\tilde{P}_t^M}{P_{t-1}^M} \right)^{1-\epsilon} + \phi \right]^{\frac{1}{1-\epsilon}} \quad (26)$$

### 3.3 Fiscal Policy

The government's inter-temporal budget constraint is funded via both domestic ( $B_t^G$ ) and foreign ( $e_t B_t^{G*}$ ) debt and tax revenues to finance a stream of food price subsidies ( $\vec{S}_t$ ).  $\vec{S}_t$  is defined by household's food price spread (depending on the intensity and segmentation of  $\kappa_i$ ) and consumption units for household  $i$ , i.e.  $(P_t^F - \bar{P}_{i,t}^F)C_{i,t}^F$ .

$$\vec{S}_t = (P_t^F - \bar{P}_{n,t}^F)C_{n,t}^F + (P_t^F - \bar{P}_{r,t}^F)C_{r,t}^F \quad (27)$$

$$\begin{aligned} B_t^G + e_t B_t^{G*} - (1 + i_{t-1})B_{t-1}^G - e_t(1 + i_{t-1}^*)\theta \left( \frac{e_t B_t^*}{P_t Y_t} \right) B_{t-1}^{G*} \\ = \vec{S}_t - \tau_t (C_{n,t} + C_{r,t} + W_{n,t}N_{n,t} + W_{r,t}N_{r,t} + r_t u_t k_{t-1} + \Pi_t) \end{aligned} \quad (28)$$

There are three instruments in (28) domestic and foreign debt; and time varying taxes. We simplify the model by assuming government debt is denominated in domestic currency.

For purposes of ensuring stability, a Ponzi scheme is ruled out, i.e. both the consumer budget constraint and a debt ceiling will always bind. The share of the government's budget financed via debt relies on the leverage parameter  $\phi_Z$ . As  $\phi_Z$  approaches zero, the fiscal response will be financed by debt. However,  $\phi_Z > 0$  ensures solvency related to time-varying marginal tax rates on labor wages, capital rents and profits. In this setup, the tax instrument responds positively to deviations in the debt-to-output ratio ( $B_t^G/P_t Y_t$ ) relatively the steady state level (where  $B_t^G = 0$ ).<sup>9</sup>

$$\tau_t = \bar{\tau} + \rho(\tau_{t-1} - \bar{\tau}) + (1 - \rho)\phi_Z \left( \frac{B_t^G}{P_t Y_t} \right) \quad (29)$$

<sup>9</sup> Similar to Stähler and Thomas [2012], we incorporate government revenues that adjust to changing leverage, thereby ensuring stability.

### 3.4 Foreign Economy

We set the balance of payment ( $TB_t$ ) equation as simply the value of exports less the difference on the foreign asset position including the net interest provision.

$$e_t B_{r,t}^* = e_t (1 + i_{t-1}^*) B_{r,t-1}^* + TB_t \quad (30)$$

$$TB_t = P_t^F (Y_t^F - C_t^F) \quad (31)$$

Equation (30) represents the aggregate net liquid position on foreign bond holdings.<sup>10</sup> Equation (31) shows that the trade balance depends on the variation of the domestic value of food traded abroad based on domestic absorption.

### 3.5 Monetary Policy

The central bank follows a Taylor-like Rule (Taylor [1993]) to set changes in short-term interest rates in response to deviations from the inflation target and output gap:

$$\left( \frac{1 + i_t}{1 + \bar{i}} \right) = \left( \frac{1 + i_{t-1}}{1 + \bar{i}} \right)^{\alpha_i} \left[ \left( \frac{Y_t}{\bar{Y}} \right)^{\alpha_Y} \left( \frac{\pi_t^X}{\bar{\pi}} \right)^{\alpha_X} \right]^{(1-\alpha_i)} \quad (32)$$

The central bank conducts interest rate smoothing as  $0 < \alpha_i \leq 1$ . The policy weights with respect to deviations away from output gap and the inflation target are assigned by  $\alpha_Y$  and  $\alpha_X$ , respectively, where  $X \in (M, S, H)$  representing a policy reaction on stabilizing:

- **Core inflation**, defined as sticky price inflation:  $\pi_t^M = \frac{P_t^M}{P_{t-1}^M}$ ;
- **Headline inflation**, defined as overall price level inflation:  $\pi_t^H = \frac{P_t}{P_{t-1}}$ ;
- **Subsidized headline inflation** defined as:  $\pi_t^S = \frac{\bar{P}_t}{\bar{P}_{t-1}}$ , where  $\bar{P}_t$  is defined in equation (4);  
and
- **Optimal inflation**: as in Anand *et al.* [2015], the optimal inflation rate is defined as the weighted value ( $\varpi$ ) of core and non-subsidized headline inflation that maximize welfare  $\pi_{i,t}^* = \varpi_i \pi_{i,t}^M + (1 - \varpi_i) \pi_{i,t}^H$ , where  $0 \leq \varpi_i \leq 1$

The steady state non-subsidized inflation ( $\bar{\pi}$ ) rate is identical to that of the distorted inflation steady state.

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<sup>10</sup> See Medina and Soto [2007].

## 4 Model Experiments

We conduct three “crisis” experiments regarding different fiscal intervention models based on a disturbance of the food price level. The first experiment describes a scenario in the absence of fiscal subsidies, i.e. the Baseline model (Model I).<sup>11</sup> We consider a targeted approach where fiscal authorities subsidize food price shocks only for the non-Ricardian household type (Model II). Lastly, we conduct an experiment where households receive a universal subsidy (Model III). Despite the subsidy targeting literature, the latter scenario appears to be quite prevalent than a more targeted scenario.<sup>12</sup>

### 4.1 Aggregation

GDP is equal to consumption, investment (including capital adjustment costs) and the trade balance:

$$P_t Y_t = P_t^F C_t^F + P_t^M C_t^M + Q_t I_t + a[u_t]k_t + TB_t \quad (33)$$

which is equivalent to:

$$\vec{P}_t Y_t = \vec{P}_t^F C_t^F + P_t^M C_t^M + \vec{S}_t + Q_t I_t + a[u_t]k_t + TB_t \quad (34)$$

### 4.2 Calibration

The model parameters are summarized in Table 1. We assume the share of credit constrained household ( $\lambda$ ) is equal to 40% (Anand *et al.* [2015]).<sup>13</sup> The subjective discount factor ( $\beta$ ) is set to 0.99. Consistent with Aguiar and Gopinath [2007], we set  $\rho$  to 2. The inverse Frisch parameter is set  $\chi = 3$ , a standard value used in the DSGE literature.

The Calvo price signal ( $\phi_M$ ) in the manufacturing sector is assumed to be 0.66 (Anand *et al.* [2015]).<sup>14</sup> We assume a quarterly depreciation rate of 0.03, i.e. an annual depreciation of 12%.

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<sup>11</sup> This implies all agents face the same price level, i.e. there is no price distortion ( $\pi_t = \pi_{t,i}$ ).

<sup>12</sup> The IMF [2008a] argues that subsidies were poorly designed. According to McDermott [1992] food subsidy targeting programs are typically not well established for two reasons. Firstly, better targeting can reduce support for the subsidy, thereby reducing the beneficiaries. Secondly, there is a “tradeoff between better targeting and the increased risk of civil unrest or demands for wage increases” (p. 8).

<sup>13</sup> The average value for financial access in our sample is 50%. However,  $\lambda$  represents households with binding financial constraints, which is intuitively lower than the financial access sample (Table 2).

<sup>14</sup> This implies one-third of manufacturing firms will reset prices each quarter.

We set investment the adjustment cost parameter  $\psi=1.3$ .<sup>15</sup> The capital ratio in the manufacturing sector is set to 0.33. The capital utilization function  $a[u_t]$  satisfies  $a[1] = 0$ . Capital utilization is normalized to unity in the steady state, hence we set  $\epsilon_1 = \frac{1}{\beta} - (1 - \delta)$ .  $\epsilon_2$  is calibrated to 0.015.

We set the substitution between food and manufacturing goods to  $\theta = 0.7$  based on a sample of countries (see Table 2).<sup>16</sup> The share of food in consumption is set to  $\varphi = 0.4$  based on the same sample of countries. In the baseline model, we assume no fiscal intervention (i.e.  $\kappa_r, \kappa_n = 0$ ).<sup>17</sup> When fiscal policies are used to counteract food price shocks,  $\kappa_i$  is set to 0.33. This assumption reflects an increase of government spending close to 1% in case of a typical food price shock (IMF [2008b]) under a universal subsidy policy. Therefore, a targeted policy (Model II) is obtained with the combination of  $\kappa_r=0$  and  $\kappa_n=0.33$  while a universal policy (Model III) is obtained with  $\kappa_r=\kappa_n=0.33$ .

We draw on Schmitt-Grohé and Uribe [2003] by incorporating a bond adjustment cost;  $\zeta=0.001$ . We follow Gali *et al.* [2004] by setting monetary policy coefficient on the output gap ( $\alpha_y$ ) equal to 0.5. The policy reaction on the inflation targeting regimes ( $\alpha_x$ ) is equal to 2 and assume monetary policy inertia ( $\alpha_i=0.7$ ).<sup>18</sup> As our focus is to characterize policy actions in response to the food price crisis, we prefer to incorporate a measure of aggregate productivity, rather than a sector-specific one as in Anand *et al.* [2015] and Pourroy *et al.* [2016]. Our rationale for favoring an aggregate productivity shock is that, while there were a combination of factors that lead up to the spike in food prices in 2007, abnormal weather patterns was not necessarily the main causal factor.<sup>19</sup> The technology disturbance obeys an AR(1) process and can be generalized as follows:  $\ln A_t = \rho^A \ln A_{t-1} + \varepsilon_t$ , where  $\varepsilon_t \sim \mathcal{N}(0, \sigma_A)$ . We set the AR(1) coefficient on the persistence on aggregate productivity ( $\rho^A$ ) to 0.8. The AR(1) coefficient for the

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<sup>15</sup> Investment adjustment costs are supported empirically, see e.g. Peiris and Saxegard [2007] for the case of Mozambique or Aguiar and Gopinath [2007] for Mexico.

<sup>16</sup> Anand *et al.* [2015] set the elasticity of substitution of food to 0.6 based on an average sample of low, middle and high-income countries. We use a higher food elasticity of substitution (0.7) considering our research overlaps with MICs which tend to be more elastic considering a larger share of expenditures on food (see e.g., Green *et al.* [2013]).

<sup>17</sup> This is consistent on the RBC foundation where the role of food policies plays little role in explaining short-term frictions over the business cycle.

<sup>18</sup> The monetary policy parameter (i.e.,  $\alpha_y$ ,  $\alpha_x$  and  $\alpha_i$ ) values were also used in Anand *et al.* [2015].

<sup>19</sup> The literature attributes the food price crisis not necessarily to one main cause, but rather a confluence of factors in the lead up to the onset of the global food price increases in 2007 (Timmer [2008], Mittal [2009] and Wiggins *et al.* [2010]), which cite higher energy costs (e.g., oil, fertilizers); diversion of maize to produce biofuels; macroeconomic factors (e.g., U.S. dollar devaluation, speculation); and lower stock levels. The lower stock levels are engendered by a combination of adverse weather conditions (some of which occurred in the recent years prior (Wiggins *et al.* [2010]) and structural changes (Trostell [2008] argues there were incentives to reduce inventory levels relating to “just-in-time” inventory management and a shift toward liberalized trade policies). Timmer [2008] also cites high living standards in a number of growing economies led to increased demand of food goods. Wiggins *et al.* [2010] notes that once prices started to increase in 2007, there were amplifying reactions that accelerated the price increases such as export restrictions, country-imposed increase in import taxes on food goods and restocking by countries.

world interest rate ( $\rho^{i^*}$ ) is set to 0.46 (see Deveraux *et al.* [2006]). We incorporate a global food price:  $\rho^{P^{F^*}}$  is set to 0.5 to allow persistence (conditional on the shock occurring) to represent a food price crisis experiment (see Pourroy *et al.* [2016]).

Insert About Here  
 Table 1: Parameter Selection

Insert About Here  
 Table 2: Food Expenditure; Income and Slutsky  
 Food Elasticity

### 4.3 Baseline Model (Crisis Scenario: No Intervention)

To illustrate how the model behaves, we consider a food price crisis experiment where there is no intervention (Model I). The impulse response functions (IRF) are presented in Figure 2 which compare monetary policy targeting core and headline inflation. The IRFs display a transitory one standard deviation shock and are provided in percentage deviations.

An increase in the world price of food creates inflationary pressure in the domestic economy on impact. While the central bank raises the policy rate in response to inflation for both headline and core inflation targeting regimes, the reaction of the policy rate is stronger under a headline inflation targeting regime.

To simulate higher food prices recently experienced in global markets, an orthogonal shock hits the world price of food goods in foreign currency. It is translated partially to the domestic food price (there is an exchange rate appreciation).

An increase in the price of food creates upwards pressure for non-Ricardian wages.<sup>20</sup> Based on this income effect and that non-Ricardians do not smooth consumption, labor effort (and hence food production) for non-Ricardians declines. As non-Ricardians' consumption increases and labor declines, their utility and welfare increase.

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<sup>20</sup> This relates to the real wage is equivalent to productivity, i.e.  $W_t^F = A_t^F P_t^F$ . If productivity is assumed to be constant, an exogenous increase in the world food price coupled with a strong pass-through, can put upward pressure on non-Ricardian wages.

The picture turns out to be quite different for Ricardian households such that their Ricardian consumption falls. An increase in food prices can modify the consumption basket: food consumption declines, while manufacturing consumption tends to be relatively higher than at steady state (even while considering a low elasticity of substitution).

The Ricardian labor supply increases to offer goods relatively more expensive than at steady state, while labor demand rises due to the higher demand for manufacturing goods from non-Ricardian households. With an increase in number of hours worked and a decline in consumption, Ricardian utility and welfare falls at the time of the world food price shock.

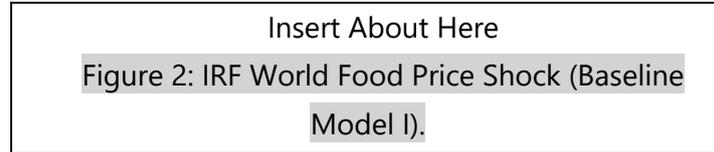
The increase of the world food price has somewhat comparable properties to a positive productivity shock for our open economy setting: for a given amount of labor in the food sector, there is an increase in firm turnover. As the domestic wage in the food sector increases less than the price of food goods on the world market, domestic food producers observe a competitive advantage such that the small open economy becomes a net-food exporter at the time of the shock.

One may have expected the Ricardian households to borrow money from abroad at the time of the shock to smooth consumption over time. However, the picture is different. As labor and wages in the manufacturing sector increase at the time of the shock (due to non-Ricardian higher consumption), manufacturing producer incomes increase as well. However, because domestic consumption is more expensive and investment demand is lower, Ricardian households would prefer to increase their savings abroad. Ricardian households become net positive holders of foreign bonds. This compensates the positive trade balance (associated with positive food exports). The inflationary shock pushes capital away from our small open economy: manufacturing investment falls while foreign bonds holdings increase.

As non-Ricardian demand (in particular for manufacturing goods) increases at the time of the shock, as well as food exports, the output gap is positive. Under core (headline) inflation targeting the central bank reacts to output gap and core (headline) inflation. While the central bank raises the policy rate in response to inflation for both headline and core inflation targeting regimes, the reaction of the policy rate is stronger under a headline inflation targeting regime.

The central bank reaction consists of increasing the nominal interest rate, which has a stronger impact on Ricardian consumers than on hand-to-mouth households. Under headline inflation targeting, the substitution of food and non-food goods by Ricardian households is reduced, as the incentive to consume is replaced by an incentive to save. This impacts total consumption, which is larger under core inflation targeting than under headline targeting. This also affects total production through the investment channel. Because under headline targeting manufacturing consumption is larger than under core inflation targeting, production and manufacturing capital utilization rate are lower. Then rental cost of capital increase more under

core targeting than under headline targeting. Consequently, both investment and capital decline less under headline targeting. Thus, headline inflation targeting is a more effective policy choice in terms of stabilizing output.



#### 4.4 Fiscal Policy Intervention (Crisis Experiment with Price Subsidies)

We extend the baseline model (Model I) to incorporate two additional experiments: fiscal intervention targeting only financially constrained households (Model II:  $\kappa_r = 0$ ;  $\kappa_n = 0.33$ ) and universal fiscal intervention (Model III:  $\kappa_r = 0.33$ ;  $\kappa_n = 0.33$ ). The IRFs are displayed in Figure 3 for headline inflation targeting and Figure 6 for core inflation targeting. Fiscal intervention to stabilize prices may create a market distortion between the market food price ( $P_t^F$ ) and the price faced by consumers ( $\bar{P}_{i,t}^F$ ).<sup>21</sup> At the time of an orthogonal food price shock, the shock translates into an immediate increase of the domestic food price of 5.6% without fiscal intervention (Model I), 4.7% with a target fiscal policy (Model II) and 3.2% with a global subsidy (Model III).

One of the implications of fiscal policy in lowering prices faced by the household results in, as expected, higher food consumption. For Ricardian households, food subsidies reduce the substitution effects from food to manufacturing consumption. For non-Ricardian households, subsidies may slacken the expenditure side of their budget constraint. As they are “hand-to-mouth” in nature, they reduce the income side of their budget constraint. In the presence of fiscal intervention, non-Ricardians observe an income effect; their wages increase and their labor supply falls.<sup>22</sup>

The reduction in investment, which is only specific to the manufacturing (sticky price) sector, is lessened as the intensity of fiscal intervention increases in the presence of food price shocks. This suggests (similar to consumption) that food price subsidies can crowd in private investment engendered by the effects of increasing aggregate demand.

<sup>21</sup> The mechanics for household prices works as follows: for Model I,  $P_t^F = \bar{P}_{i,t}^F$ ; for Model II,  $P_t^F = \bar{P}_{c,t}^F$  and  $P_t^F \geq \bar{P}_{n,t}^F$ ; and Model III  $P_t^F \geq \bar{P}_{i,t}^F$ .

<sup>22</sup> To provide further inference, the food sector wage is a linear function of the exogenous food price. Furthermore, as labor is the only technology factor, a reduction of non-Ricardian labor can reduce food production.

In addition to shielding households from volatile world food price shocks, food price subsidies may diminish Ricardian saving, which consequentially have diminishing effects on the trade balance. Net bond savings (private and government) slightly decrease the higher the intensity of fiscal intervention. On the one side, private bonds are reduced, on the other side government bonds, which are strictly held by the Ricardian household, increase to pay for the food subsidy.

Food production is either consumed or exported (in the steady state the trade balance is nil). There is a decrease in domestic absorption and increase in tradeable food production, which in turn leads to an increase in the trade balance in Model I. Hence, independent of fiscal intervention, the economy has a sizable food production and at the time of the shock while food consumption is reduced, the excess production is subsequently exported. Under Model II, food production is lower (because of the income effect that reduces food households' labor) while food consumption is supported by subsidies. Under Model III, subsidies are universal; food consumption (in particular food good consumption for the Ricardian household) is higher relative to Model II, while food production remains approximately the same as in Model II.

As expected, the highest level of subsidies ( $\vec{S}$ ) occurs under Model III (subsidies are nil under Model I). To finance subsidy spending, fiscal authorities increase taxes ( $\tau_t$ ) and increase public debt ( $B_t^G$ ). In our model, the exchange rate is derived via the interest rate parity condition. A shock to the foreign world denominated food price ( $P^{F*}$ ) translates to an increase in the consumer price index faced by households: the headline price increase by 2.3% in the absence of a subsidy, but only by 1.6% with a uniform subsidy (Model III) under a headline inflation targeting regime.

When monetary policy reacts to the food price shock, it helps to stabilize production and therefore reduces the financing cost of food subsidies. The tax rate and public debt are lower under headline targeting because of the large monetary policy reaction to the food price shock relative to core inflation targeting.<sup>23</sup> This is mainly due to a more stable aggregate demand if the central bank follows a headline inflation targeting rule. Thus, headline inflation targeting is a more effective policy choice in terms of stabilizing output.<sup>24</sup>

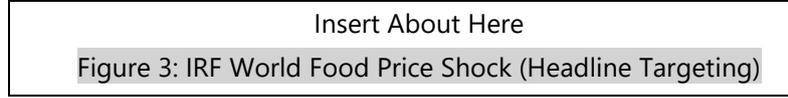
The policy rate affects the Ricardian household's intertemporal optimization via the Euler equation. A higher interest rate reduces present consumption (and increases savings for future consumption) and less intensely under Model III. Hence subsidies can crowd in consumption for Ricardians, but consumption is further reduced in future periods as taxes start to increase (to pay for the subsidy). At the time of the shock, Ricardian consumption decreases less intensely as the interest rate reaction is based on core inflation targeting. Consequently, savings

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<sup>23</sup> This is because non-food production is also more stable; a larger production means larger profit, wage etc. to be taxed and therefore fiscal debt burden is lower.

<sup>24</sup> While Anand *et al.* [2015] do not include investment in their model (they focus on domestic productivity shocks), our findings strongly overlap with theirs: headline inflation is a better policy in terms of stabilizing output.

related variables react in the opposite direction: the level of domestic bonds held by Ricardian households is larger under headline targeting than core inflation targeting.



## 5 Welfare Analysis

Welfare is calculated as gains in consumption units relative to core inflation based on three disturbances: a shock to aggregate technology, the world interest rate and the world food price. We conduct a conditional welfare analysis of the different policy options using a second order approximation of the household welfare. Following Faia and Monacelli [2007], we define welfare for household type  $i$  as follows:

$$W_{i,t} = \mathbb{E}_t \left\{ \sum_{n=0}^{\infty} \beta^n U_i(C_{i,t+n}, N_{i,t+n}) \right\} \Big|_{x_0=x} \quad (35)$$

We can write the welfare equation above in recursive form as follows:

$$W_{i,t} = U_i(C_{i,t}, N_{i,t}) + \beta W_{i,t+1} \quad (36)$$

This allows us to calculate aggregate welfare which is defined as the sum of household  $i$  welfare weighted by the respective share of each household:

$$W_t = (1 - \lambda)W_{t,t} + \lambda W_{n,t} \quad (37)$$

We compare welfare for the baseline model with no fiscal intervention (Model I) for each household,  $W_{i,t}$ , with the two models based on fiscal intervention (Models II and III) for four monetary policy regimes.<sup>25</sup> The monetary policy regimes considered include headline inflation, distorted headline inflation, core inflation and optimal inflation.

We present the results of the welfare evaluation for both aggregate and heterogeneous welfare based on the fiscal and monetary policy stance. All models have the same steady state. As we are analyzing an isolated food price shock that occurs for a MIC economy, we define welfare gains as the cumulative consumption units needed to make welfare under core inflation targeting equivalent to that of alternative policy choices.

### 5.1 Aggregate welfare evaluation

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<sup>25</sup> We take as given the Taylor rule including interest rate smoothing and a reaction to the output gap.

Core inflation targeting is taken as a basis to compare alternative welfare policy rules, which include headline and distorted headline inflation. We consider distorted headline inflation as a *leaning against the wind* targeting rule. We also compute the optimal inflation which is an outcome of maximizing welfare by changing  $\varpi$ .

We rank different fiscal and monetary policies in terms of welfare. In the welfare tables, we include a “local” and “global” ranking. The former is defined by ranking the different monetary policies given a certain fiscal policy. That is, based on the fiscal intervention policy, we assess which monetary policy regime achieves the highest level of welfare. In addition to local welfare, we also incorporate relative welfare in Table 3 as a measure of global welfare ranking for all three models compared to a core inflation index.

Headline inflation has a higher local rank in Model I than core inflation for aggregate welfare.<sup>26</sup> This is consistent with Model II and Model III, however distorted headline inflation achieves a higher welfare ranking than headline inflation. The global ranking suggests that welfare is increasing in the level of fiscal intensity; hence Model III is preferred to other model alternatives.

Our findings for aggregate welfare are twofold. Firstly, our results, consistent for all three welfare models, suggest that aggregate welfare is improving given fiscal policy activism and when monetary policy targets distorted headline inflation (followed by headline inflation relative to core inflation). Thus, the results suggest a central bank should react to food price volatility. Secondly, incorporating optimal monetary policy (determined by  $\varpi$ ) is decreasing the higher intensity of fiscal policy activism. This is an important, yet intuitive, result: fiscal policy intervention that shields households, particularly non-asset holders, from food price shocks reduces the volatile effects of headline prices in the optimal inflation target.

Insert About Here Table 3: Aggregate Welfare
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## 5.2 Distributional Welfare Evaluation

To better understand the consequences of fiscal and monetary policies have on aggregate welfare, we analyze the heterogeneous distributional effects these policies have on the two

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<sup>26</sup> Note that headline inflation targeting and distorted inflation targeting welfare are identical since  $\kappa_i = 0$ .

household types. From the perspective of non-Ricardians, presented in Table 4, welfare is strictly increasing in the value of fiscal intervention ( $\kappa_{\pi}$ ). The mechanism behind this is the following: non-Ricardians are unable to smooth consumption, unlike the Ricardian household, however the government can do so for non-Ricardians households by borrowing vis-à-vis a food price subsidy. Welfare for non-Ricardians is also strictly increasing when monetary policy targets distorted headline inflation relative to core inflation.

Our results in Table 5 suggest a somewhat polar case for the Ricardian household type. From the perspective of the Ricardian household, the best fiscal policy is to minimize the degree of fiscal intervention and the best monetary policy regime is to target core inflation. In the event of moderate (intense) fiscal intervention proxied by Model II (Model III) welfare is improving when monetary policy targets core inflation.

The optimal inflation targeting weight ( $\varpi$ ) is decreasing in the level of fiscal intensity for both household types. Considering this interdependency, the results suggest consideration needs to be made on fiscal (intensity and scope) and monetary policy responses.

Insert About Here  
Table 4: Non-Ricardian Welfare

Insert About Here  
Table 5: Ricardian Welfare

### 5.3 Robustness checks

We conduct several sensitivity experiments to check the robustness of our results for Models I, II and III (which correspond to Tables 6, 7 and 8). Overall, the model suggests that optimal inflation targeting (that includes both core and headline inflation) is always welfare improving

in aggregate (relative to core inflation). Further, targeting headline inflation is welfare improving in aggregate, with the exception when the share of non-Ricardians reaches a certain threshold.<sup>27</sup> The model is mainly affected by the following parameters:

- welfare is decreasing (increasing) as the **share of food expenditure** ( $\phi$ ) is higher for Ricardians (non-Ricardians). Our results lend support to recent evidence that higher food prices can transfer welfare from urban to rural households (de Janvry and Sadoulet [2009], Aksoy and Isik-Dikmelik [2008]);
- the optimal inflation target places more weight on core prices as prices become stickier (i.e., as  $\phi$  increases), which is consistent with Anand *et al.* [2015] and Mankiw and Reis [2002];
- the higher the **leverage response** ( $\phi_Z$ ) corresponds with a higher the tax rate. The results in Tables 7 and 8 (recall there is no debt in Model I) display no significant change when considering alternative calibrations. This may be explained by Ricardian equivalence in a context where Non-Ricardian households are not directly impacted by subsidy financing;
- aggregate welfare is decreasing as the **elasticity of food** ( $\theta$ ) becomes more elastic for Model I and II. This is due to a compensating effect: Ricardians (non-Ricardians) are worse-off (better-off) with higher food prices since they are net-food buyers (sellers). Model III shows that aggregate welfare may increase if there is a universal subsidy; and
- the optimal inflation target places more weight on core prices as the share of non-Ricardian households increase, which is consistent with Anand *et al.* [2015].

We also experimented with the share of capital and capital utilization costs. The sensitivity suggests that the optimal inflation target places more weight on core prices as the economy is more capital intensive and utilization costs increase.

<p>Insert About Here</p> <p>Table 6: Welfare Gain - Model</p>
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<p>Insert About Here</p> <p>Table 7: Welfare Gain - Model II</p>
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<p>Insert About Here</p> <p>Table 8: Welfare Gain - Model III</p>
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<sup>27</sup> The threshold is around 0.5 for Models I and II (see Table 6 and 7) and is around 0.6 for Model III (Table 8). Therefore, in high income countries where the share of credit constrained households is low, the policy recommendation would not necessarily imply a monetary or fiscal reaction to a food price shock.

## 6 Conclusion

We provide empirical evidence that food price subsidies are typically associated with a higher share of food expenditures; are present in countries with weak access to financial services; and are popular in MICs. Our main contribution is the development of a DSGE model to account for this evidence and to show how fiscal and monetary policy interventions should be designed to shield households from food price volatility. The DSGE model incorporates two sectors intersecting with a HANK model incorporating sticky prices (à la Calvo and policy induced subsidy pricing) and incomplete financial markets. The novelty of our approach is we consider fiscal intervention through the effect of consumer subsidies. This is a key, realistic feature of MICs considering the prevalence of food price subsidies which are a central component of the pass-through from world food prices to domestic inflation. In explicitly modeling food price subsidies we show such a policy can create a wedge between distorted prices faced by household and non-subsidized prices. This allows us to capture key factors to analyze fiscal and monetary policy simultaneous responses to food price volatility.

Our research overlaps with a small, burgeoning literature providing evidence overturning the conduct of monetary policy focusing strictly on core inflation in an environment of financial frictions for a MIC. We find that targeting *distortive* headline inflation achieves the highest welfare. While this is a *leaning against the wind* approach to monetary policy, we consider this as finding a middle-ground, particularly for Ricardians (who can smooth consumption over time), in the event of fiscal intervention. This implies that targeting distorted inflation results in an interest rate response below headline inflation target, but higher than core inflation targeting.

There are distributional effects based on the policy reaction. We find the relative importance of headline inflation decreases the higher the intensity of fiscal intervention. This is an important, yet intuitive, result: non-Ricardians are sensitive to changes in food prices considering a substantial share of expenditures is attributed to food and their limited financial access to smooth consumption. The government can thus borrow for non-Ricardians, thereby decreasing non-Ricardians' vulnerability to food price shocks.

Lastly, we argue coordinated fiscal and monetary policies may be desirable considering the optimal joint policy reactions are interdependent. This is an important property considering an inefficient reaction due to uncoordinated monetary/fiscal policy may potentially diminish some of the benefits. Therefore, we consider that central bank independence in MICs with food prices subsidies should not be achieved without consideration of the cost of a lack of monetary and fiscal policy coordination. The optimal institutional design remains an open question for future research.

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## 9 Tables

**Table 1: Parameter Selection**

<b><u>Population Type</u></b>			
Non-Ricardian; Food Labor Supply	$\lambda$	0.4	
<b><u>Utility</u></b>			
Discount factor	$\beta$	0.99	
Inverse of intertemporal elasticity of subst.	$\rho$	2	
Inverse elasticity of labor supply	$\chi$	3	
Share of food in consumption	$\varphi$	0.4	
Elasticity of substitution: food and non-food	$\theta$	0.7	
<b><u>Industrial Sector</u></b>			
Capital share	$\alpha$	0.33	
Investment adj. cost	$\psi$	1.3	
Capacity-utilization	$\epsilon_1$	0.04	
Capacity-utilization	$\epsilon_2$	0.015	
Depreciation	$\delta$	0.03	
Domestic Calvo signal	$\phi$	0.66	
Monopoly power	$\eta$	6	
<b><u>Adjustment Costs</u></b>			
Bond adjustment costs	$\zeta$	0.001	
<b><u>Fiscal Policy</u></b>			
<i>Baseline</i> Model I: i.e., no subsidy	$\kappa_r, \kappa_n$	0	0
<i>Targeted</i> Model II: i.e., non-Ricardian subsidy	$\kappa_r, \kappa_n$	0	0.33
<i>Universal</i> Model III: i.e. blanket subsidy	$\kappa_r, \kappa_n$	0.33	0.33
Tax rate parameter	$\bar{\tau}$	0	
Leverage response (ensures solvency)	$\phi_Z$	0.15	
Tax rate smoothing	$\rho$	0	
<b><u>Monetary Policy</u></b>			
Interest Rate Smoothing	$\alpha_i$	0.7	
Response on output gap	$\alpha_Y$	0.5	
Response on policy rate	$\alpha_X$	2	
<b><u>Shocks</u></b>			
Aggregate productivity	$\rho^A$	0.80	
Aggregate persistence	$\sigma^A$	0.02	

**Table 2: Food Expenditure; Income and Slutsky Food Elasticity; and Financial Access**

	<b>Food Ex- penditure</b>	<b>Financial Access</b>	<b>Income Elasticity</b>	<b>Price Elasticity</b>	<b>Classifica- tion</b>
Argentina	20.3	50.0	67.0	-0.60	UMIC
Azerbaijan	45.0	29.0	74.6	-0.69	UMIC
Bangladesh	55.1	31.0	79.5	-0.76	LMIC
Belarus	40.5	72.0	68.3	-0.62	UMIC
Brazil	23.0	68.0	70.4	-0.64	UMIC
China	36.2	79.0	77.5	-0.73	UMIC
Costa Rica	19.9	65.0	N/A	N/A	UMIC
Dominican Rep.	23.2	54.0	N/A	N/A	UMIC
Guatemala	36.4	41.0	N/A	N/A	LMIC
India	44.6	53.0	78.2	-0.74	LMIC
Indonesia	48.6	36.0	75.7	-70.5	LMIC
Jamaica	32.3	78.0	N/A	N/A	UMIC
Kazakhstan	58.7	54.0	67.6	-60.9	UMIC
Kenya	55.4	75.0	79.1	-75.2	LMIC
Kyrgyz Rep.	58.9	18.0	75.7	-70.5	LMIC
Mali	51.8	20.0	81.3	-78.5	LIC
Mexico	22.7	39.0	64.6	-57.7	UMIC
Moldova	39.2	18.0	73.1	-67.3	LMIC
Mongolia	45.1	92.0	78.1	-73.7	LMIC
Mozambique	52.5	N/A	82.2	-80.2	LIC
Nigeria	56.8	44.0	79.0	-75.0	LMIC
Pakistan	50.0	13.0	76.0	-70.9	LMIC
Paraguay	N/A	N/A	73.8	-68.1	UMIC
Philippines	47.1	31.0	75.6	-70.4	LMIC
Russia	36.0	67.0	67.2	-60.5	HIC
Sri Lanka	47.6	83.0	75.0	-69.6	LMIC
Thailand	39.6	78.0	72.3	-66.3	UMIC
Uruguay	18.2	46.0	67.9	-61.3	HIC
Vietnam	53.2	31.0	78.1	-73.8	LMIC
Zambia	49.4	36.0	80.5	-77.3	LMIC
<b>Mean</b>	<b>41.5</b>	<b>50.0</b>	<b>74.6</b>	<b>-51.2</b>	
<b>Median</b>	<b>45.0</b>	<b>48.0</b>	<b>75.7</b>	<b>-67.7</b>	

Sources: USDA and World Bank (Global Food Index Database and Global Consumption Database).

Note: classification is based on GINI per capita. The sampled classification includes high-income (HIC), lower-middle (LMIC) and upper-middle income countries (UMIC) based on World Bank criteria.

**Table 3: Aggregate Welfare**

		Headline Inflation	Distorted Headline	Core Inflation	Global Rank	Optimal Inflation	Optimal Weight $\omega$
<b>Model I</b> ( $\kappa_r=\kappa_n=0$ )	Local Welfare	0.008		0.000	3	0.014	0.41
	Relat. Welfare	0.008		0.000		0.014	
	Local Rank	1		2			
<b>Model II</b> ( $\kappa_r=0, \kappa_n=0.5$ )	Local Welfare	0.008	0.010	0.000	2	0.014	0.39
	Relat. Welfare	0.010	0.012	0.002		0.016	
	Local Rank	2	1	3			
<b>Model III</b> ( $\kappa_r=\kappa_n=0.5$ )	Local Welfare	0.012	0.016	0.000	1	0.017	0.34
	Relat. Welfare	0.015	0.019	0.003		0.019	
	Local Rank	2	1	3			

**Table 4: Non-Ricardian Welfare**

		Headline Inflation	Distorted Headline	Core Inflation	Global Rank	Optimal Inflation	Optimal Weight $\omega$
<b>Model I</b> ( $\kappa_r=\kappa_n=0$ )	Local Welfare	0.049		0.000	3	0.052	0.19
	Relat. Welfare	0.049		0.000		0.052	
	Local Rank	1		2			
<b>Model II</b> ( $\kappa_r=0, \kappa_n=0.5$ )	Local Welfare	0.050	0.053	0.000	2	0.050	0.02
	Relat. Welfare	0.136	0.139	0.086		0.136	
	Local Rank	2	1	3			
<b>Model III</b> ( $\kappa_r=\kappa_n=0.5$ )	Local Welfare	0.054	0.063	0.000	1	0.054	0.00
	Relat. Welfare	0.183	0.191	0.128		0.183	
	Local Rank	2	1	3			

**Table 5: Ricardian Welfare**

		Headline Inflation	Distorted Headline	Core Inflation	Global Rank	Optimal Inflation	Optimal Weight $\omega$
<b>Model I</b> ( $\kappa_r=\kappa_n=0$ )	Local Welfare	-0.019		0.000	1	0.000	1.00
	Relat. Welfare	-0.019		0.000		0.000	
	Local Rank	2		1			
<b>Model II</b> ( $\kappa_r=0, \kappa_n=0.5$ )	Local Welfare	-0.019	-0.019	0.000	2	0.001	0.81
	Relat. Welfare	-0.073	-0.073	-0.054		-0.053	
	Local Rank	3	2	1			
<b>Model III</b> ( $\kappa_r=\kappa_n=0.5$ )	Local Welfare	-0.016	-0.015	0.000	3	0.003	0.71
	Relat. Welfare	-0.097	-0.096	-0.081		-0.078	
	Local Rank	3	2	1			

**Table 6: Welfare Gain - Model I**

	Total Welfare				Ricardian Welfare				Non-Ricardian Welfare			
	Headline IT	Dist. IT	Optimal IT	Optimal weight $\omega$	Headline IT	Dist. IT	Optimal IT	Optimal weight $\omega$	Headline IT	Dist. IT	Optimal IT	Optimal weight $\omega$
<b>A. Food Expenditure Share (baseline = 0.4)</b>												
0.2	0.009	0.009	0.016	0.395	-0.010	-0.010	0.004	0.645	0.084	0.084	0.084	0.019
0.3	0.009	0.009	0.015	0.395	-0.016	-0.016	0.001	0.822	0.066	0.066	0.067	0.100
0.4	0.008	0.008	0.014	0.405	-0.019	-0.019	0.000	1.000	0.049	0.049	0.052	0.193
0.5	0.006	0.006	0.013	0.432	-0.019	-0.019	0.000	1.000	0.030	0.030	0.038	0.304
<b>B. Calvo (baseline = 0.66)</b>												
0.55	0.005	0.005	0.010	0.395	-0.025	-0.025	0.000	1.000	0.052	0.052	0.052	0.000
0.66	0.008	0.008	0.014	0.405	-0.019	-0.019	0.000	1.000	0.049	0.049	0.052	0.193
0.75	0.006	0.006	0.017	0.442	-0.014	-0.014	0.001	0.835	0.036	0.036	0.047	0.326
0.8	0.003	0.003	0.016	0.470	-0.010	-0.010	0.002	0.720	0.023	0.023	0.040	0.393
<b>C. Response on Debt (baseline = 0.15)</b>												
0.15	0.008	0.008	0.014	0.405	-0.019	-0.019	0.000	1.000	0.049	0.049	0.052	0.193
1	0.008	0.008	0.014	0.405	-0.019	-0.019	0.000	1.000	0.049	0.049	0.052	0.193
5	0.008	0.008	0.014	0.405	-0.019	-0.019	0.000	1.000	0.049	0.049	0.052	0.193
10	0.008	0.008	0.014	0.405	-0.019	-0.019	0.000	1.000	0.049	0.049	0.052	0.193
<b>D. Elasticity for Food (baseline = 0.7)</b>												
0.5	0.024	0.024	0.029	0.305	-0.029	-0.029	0.000	1.000	0.102	0.102	0.122	0.286
0.6	0.014	0.014	0.020	0.350	-0.019	-0.019	0.000	1.000	0.064	0.064	0.071	0.240
0.7	0.008	0.008	0.014	0.405	-0.019	-0.019	0.000	1.000	0.049	0.049	0.052	0.193
0.8	0.003	0.003	0.011	0.464	-0.022	-0.022	0.000	0.972	0.040	0.040	0.041	0.145
<b>E. Share of Non-Ricardian (baseline = 0.4)</b>												
0.3	0.014	0.014	0.015	0.205	-0.008	-0.008	0.000	0.968	0.048	0.048	0.048	0.000
0.4	0.008	0.008	0.014	0.405	-0.019	-0.019	0.000	1.000	0.049	0.049	0.052	0.193
0.5	-0.003	-0.003	0.013	0.527	-0.035	-0.035	0.000	1.000	0.045	0.045	0.056	0.304
0.6	-0.018	-0.018	0.012	0.615	-0.057	-0.057	0.000	1.000	0.041	0.041	0.061	0.367
<b>F. Capital Ratio (baseline = 0.33)</b>												
0.2	0.003	0.003	0.010	0.458	-0.023	-0.023	0.000	1.000	0.042	0.042	0.045	0.188
0.3	0.008	0.008	0.014	0.395	-0.020	-0.020	0.000	1.000	0.050	0.050	0.052	0.166
0.33	0.008	0.008	0.014	0.405	-0.019	-0.019	0.000	1.000	0.049	0.049	0.052	0.193
0.4	0.012	0.012	0.018	0.353	-0.016	-0.016	0.000	0.998	0.055	0.055	0.057	0.161
<b>G. Utilization (baseline = 0.015)</b>												
0.00	0.019	0.019	0.021	0.216	-0.015	-0.015	0.000	0.999	0.070	0.070	0.070	0.000
0.010	0.012	0.012	0.016	0.347	-0.018	-0.018	0.000	1.000	0.056	0.056	0.057	0.122
0.015	0.008	0.008	0.014	0.405	-0.019	-0.019	0.000	1.000	0.049	0.049	0.052	0.193
0.020	0.008	0.008	0.014	0.405	-0.019	-0.019	0.000	1.000	0.049	0.049	0.052	0.193

**Table 7: Welfare Gain - Model II**

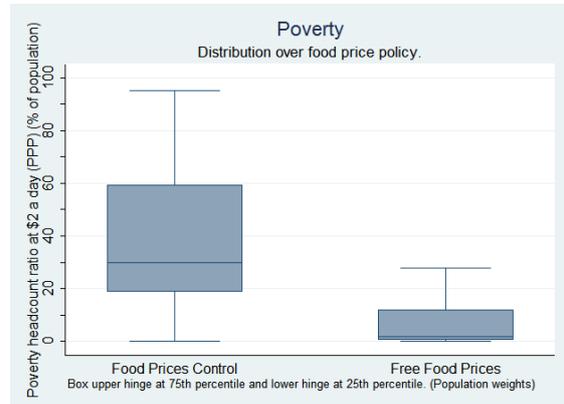
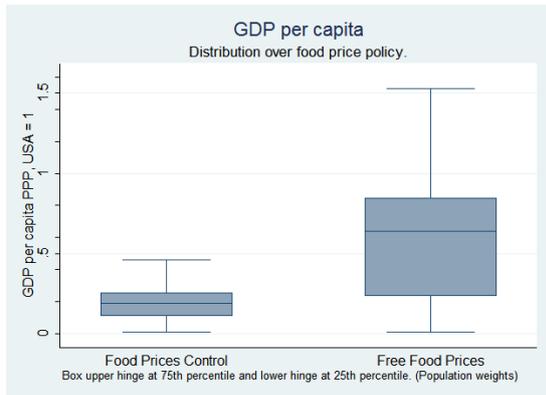
	Total Welfare				Ricardian Welfare				Non-Ricardian Welfare			
	Headline IT	Dist. IT	Optimal IT	Optimal weight $\omega$	Headline IT	Dist. IT	Optimal IT	Optimal weight $\omega$	Headline IT	Dist. IT	Optimal IT	Optimal weight $\omega$
<b>A. Food Expenditure Share (baseline = 0.4)</b>												
0.2	0.010	0.010	0.016	0.392	-0.009	-0.009	0.006	0.615	0.084	0.085	0.084	0.000
0.3	0.009	0.010	0.016	0.388	-0.015	-0.015	0.003	0.719	0.066	0.068	0.066	0.000
0.4	0.008	0.010	0.014	0.391	-0.019	-0.019	0.001	0.809	0.050	0.053	0.050	0.015
0.5	0.007	0.010	0.013	0.406	-0.020	-0.020	0.001	0.859	0.034	0.039	0.034	0.123
<b>B. Calvo (baseline = 0.66)</b>												
0.55	0.006	0.007	0.009	0.378	-0.025	-0.026	0.000	1.000	0.053	0.055	0.053	0.000
0.66	0.008	0.010	0.014	0.391	-0.019	-0.019	0.001	0.809	0.050	0.053	0.050	0.015
0.75	0.007	0.009	0.017	0.432	-0.014	-0.013	0.004	0.680	0.038	0.042	0.042	0.234
0.8	0.004	0.006	0.016	0.462	-0.011	-0.009	0.006	0.631	0.025	0.030	0.034	0.328
<b>C. Response on Debt (baseline = 0.15)</b>												
0.15	0.008	0.010	0.014	0.391	-0.019	-0.019	0.001	0.809	0.050	0.053	0.050	0.015
1	0.008	0.010	0.014	0.391	-0.019	-0.019	0.001	0.809	0.050	0.053	0.050	0.010
5	0.008	0.010	0.014	0.392	-0.019	-0.019	0.001	0.810	0.050	0.053	0.050	0.009
10	0.008	0.010	0.014	0.392	-0.019	-0.019	0.001	0.810	0.050	0.053	0.050	0.009
<b>D. Elasticity for Food (baseline = 0.7)</b>												
0.5	0.026	0.027	0.030	0.265	-0.033	-0.032	0.000	1.000	0.114	0.116	0.119	0.169
0.6	0.015	0.017	0.020	0.328	-0.020	-0.020	0.000	1.000	0.068	0.071	0.069	0.102
0.7	0.008	0.010	0.014	0.391	-0.019	-0.019	0.001	0.809	0.050	0.053	0.050	0.015
0.8	0.003	0.005	0.010	0.456	-0.021	-0.021	0.002	0.791	0.040	0.043	0.040	0.000
<b>E. Share of Non-Ricardian (baseline = 0.4)</b>												
0.3	0.015	0.016	0.015	0.168	-0.008	-0.008	0.001	0.729	0.049	0.051	0.049	0.000
0.4	0.008	0.010	0.014	0.391	-0.019	-0.019	0.001	0.809	0.050	0.053	0.050	0.015
0.5	-0.002	0.000	0.014	0.521	-0.035	-0.034	0.001	0.855	0.047	0.051	0.049	0.184
0.6	-0.016	-0.013	0.013	0.607	-0.055	-0.055	0.001	0.889	0.042	0.048	0.050	0.277
<b>F. Capital Ratio (baseline = 0.33)</b>												
0.2	0.003	0.005	0.010	0.447	-0.024	-0.024	0.000	0.943	0.045	0.048	0.045	0.000
0.3	0.009	0.010	0.014	0.381	-0.020	-0.019	0.001	0.831	0.051	0.054	0.051	0.000
0.33	0.008	0.010	0.014	0.391	-0.019	-0.019	0.001	0.809	0.050	0.053	0.050	0.015
0.4	0.013	0.014	0.018	0.337	-0.015	-0.015	0.002	0.732	0.055	0.058	0.055	0.000
<b>G. Utilization (baseline = 0.015)</b>												
0.00	0.020	0.022	0.021	0.167	-0.012	-0.012	0.002	0.736	0.068	0.073	0.068	0.000
0.010	0.012	0.014	0.016	0.329	-0.017	-0.017	0.001	0.787	0.056	0.059	0.056	0.000
0.015	0.008	0.010	0.014	0.391	-0.019	-0.019	0.001	0.809	0.050	0.053	0.050	0.015
0.020	0.008	0.010	0.014	0.391	-0.019	-0.019	0.001	0.809	0.050	0.053	0.050	0.015

**Table 8: Welfare Gain - Model III**

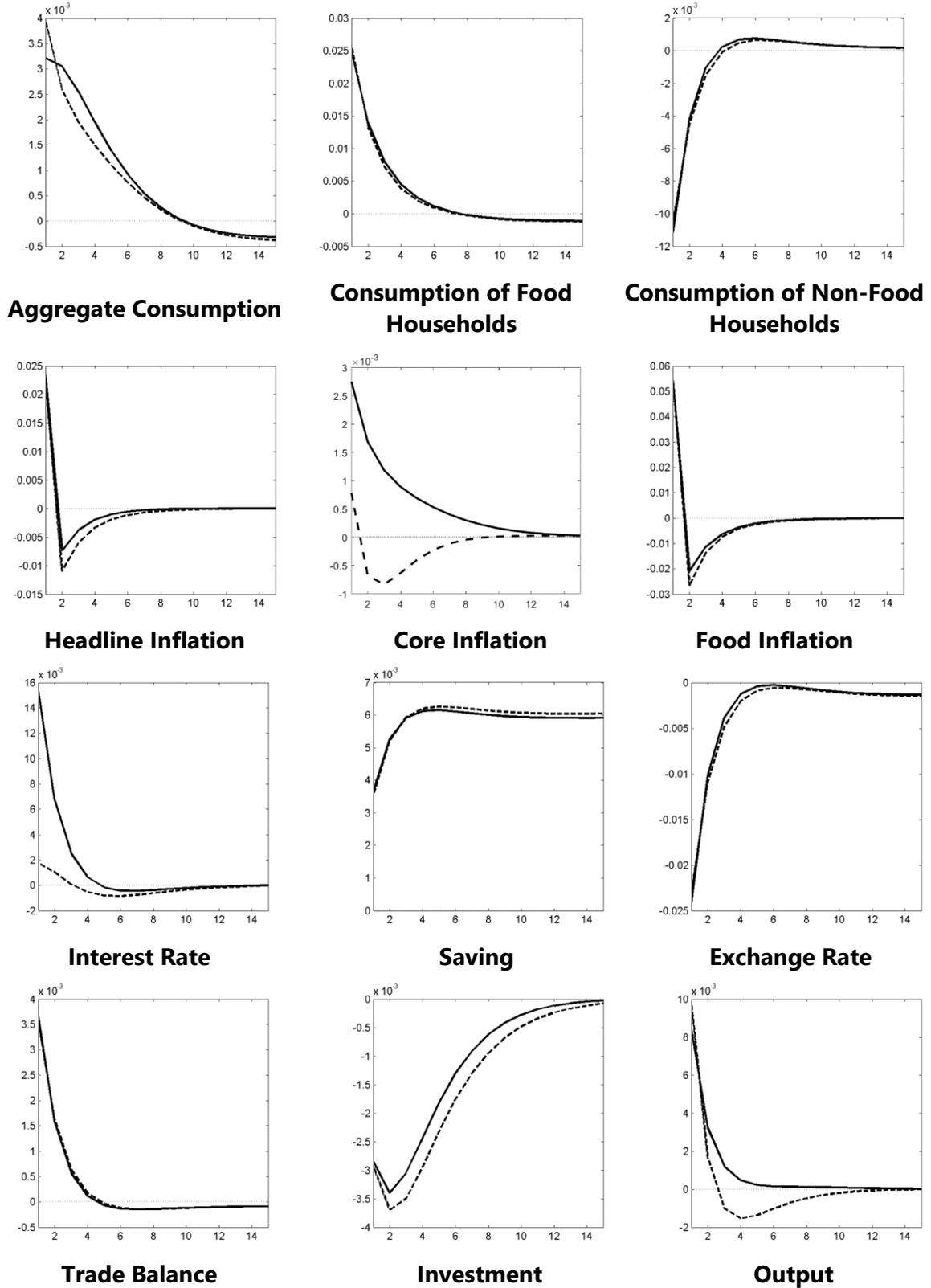
	Total Welfare				Ricardian Welfare				Non-Ricardian Welfare			
	Headline IT	Dist. IT	Optimal IT	Optimal weight $\omega$	Headline IT	Dist. IT	Optimal IT	Optimal weight $\omega$	Headline IT	Dist. IT	Optimal IT	Optimal weight $\omega$
<b>A. Food Expenditure Share (baseline = 0.4)</b>												
0.2	0.013	0.013	0.019	0.358	-0.006	-0.007	0.008	0.570	0.088	0.093	0.088	0.000
0.3	0.013	0.015	0.018	0.347	-0.012	-0.012	0.005	0.651	0.071	0.077	0.071	0.000
0.4	0.012	0.016	0.017	0.343	-0.016	-0.015	0.003	0.713	0.054	0.063	0.054	0.000
0.5	0.011	0.016	0.015	0.349	-0.017	-0.016	0.003	0.739	0.038	0.049	0.038	0.000
<b>B. Calvo (baseline = 0.66)</b>												
0.55	0.009	0.010	0.011	0.316	-0.023	-0.024	0.000	0.896	0.056	0.062	0.056	0.000
0.66	0.012	0.016	0.017	0.343	-0.016	-0.015	0.003	0.713	0.054	0.063	0.054	0.000
0.75	0.011	0.017	0.019	0.389	-0.010	-0.008	0.007	0.611	0.044	0.054	0.045	0.130
0.8	0.008	0.015	0.018	0.422	-0.007	-0.004	0.009	0.576	0.032	0.043	0.036	0.245
<b>C. Response on Debt (baseline = 0.15)</b>												
0.15	0.012	0.016	0.017	0.343	-0.016	-0.015	0.003	0.713	0.054	0.063	0.054	0.000
1	0.012	0.016	0.017	0.341	-0.016	-0.015	0.003	0.713	0.054	0.062	0.054	0.000
5	0.012	0.015	0.016	0.343	-0.016	-0.016	0.003	0.716	0.054	0.062	0.054	0.000
10	0.012	0.015	0.016	0.344	-0.016	-0.016	0.003	0.717	0.054	0.062	0.054	0.000
<b>D. Elasticity for Food (baseline = 0.7)</b>												
0.5	0.032	0.034	0.034	0.205	-0.030	-0.030	0.000	1.000	0.125	0.130	0.126	0.064
0.6	0.020	0.023	0.023	0.275	-0.017	-0.017	0.001	0.811	0.074	0.082	0.074	0.000
0.7	0.012	0.016	0.017	0.343	-0.016	-0.015	0.003	0.713	0.054	0.063	0.054	0.000
0.8	0.006	0.010	0.012	0.411	-0.018	-0.017	0.003	0.718	0.043	0.052	0.043	0.000
<b>E. Share of Non-Ricardian (baseline = 0.4)</b>												
0.3	0.017	0.020	0.017	0.093	-0.005	-0.004	0.003	0.613	0.050	0.057	0.050	0.000
0.4	0.012	0.016	0.017	0.343	-0.016	-0.015	0.003	0.713	0.054	0.063	0.054	0.000
0.5	0.003	0.007	0.016	0.483	-0.031	-0.031	0.003	0.788	0.054	0.064	0.054	0.105
0.6	-0.011	-0.005	0.016	0.574	-0.052	-0.051	0.001	0.866	0.051	0.065	0.057	0.251
<b>F. Capital Ratio (baseline = 0.33)</b>												
0.2	0.006	0.010	0.011	0.408	-0.022	-0.021	0.001	0.840	0.048	0.057	0.048	0.000
0.3	0.012	0.016	0.016	0.332	-0.017	-0.016	0.003	0.735	0.055	0.064	0.055	0.000
0.33	0.012	0.016	0.017	0.343	-0.016	-0.015	0.003	0.713	0.054	0.063	0.054	0.000
0.4	0.017	0.021	0.021	0.283	-0.011	-0.011	0.005	0.641	0.060	0.068	0.060	0.000
<b>G. Utilization (baseline = 0.015)</b>												
0.00	0.023	0.028	0.023	0.051	-0.010	-0.008	0.004	0.668	0.072	0.082	0.072	0.000
0.010	0.016	0.019	0.018	0.276	-0.014	-0.013	0.003	0.696	0.060	0.068	0.060	0.000
0.015	0.012	0.016	0.017	0.343	-0.016	-0.015	0.003	0.713	0.054	0.063	0.054	0.000
0.020	0.012	0.016	0.017	0.343	-0.016	-0.015	0.003	0.713	0.054	0.063	0.054	0.000

# 10 Figures

### Figure 1: Food Policy - GDP per Capita and Poverty

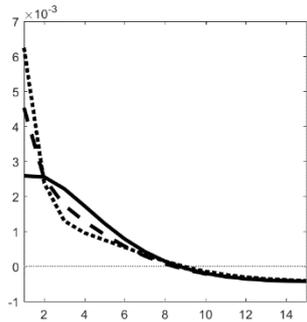


**Figure 2: IRF World Food Price Shock (Baseline Model I)**

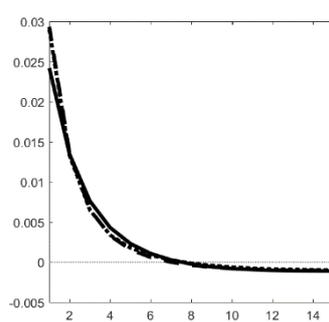


**Legend: — headline inflation targeting; -- core inflation targeting**

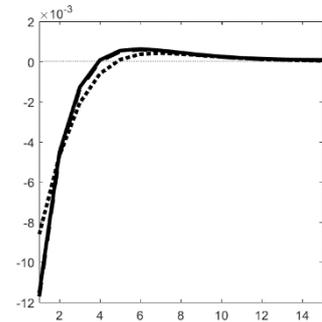
**Figure 3: IRF World Food Price Shock (Headline Targeting)**



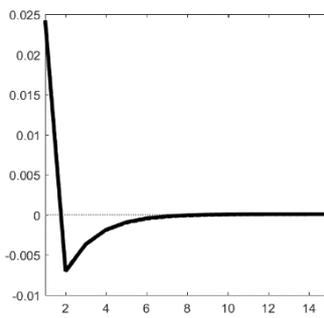
**Aggregate Consumption**



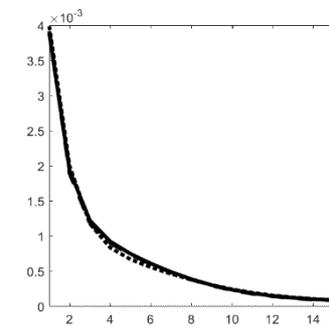
**Consumption of Food Households**



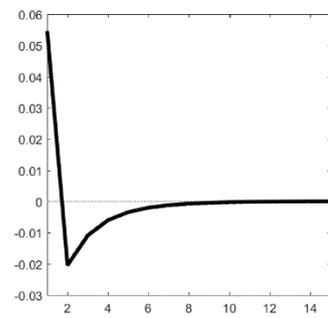
**Consumption of Non-Food Households**



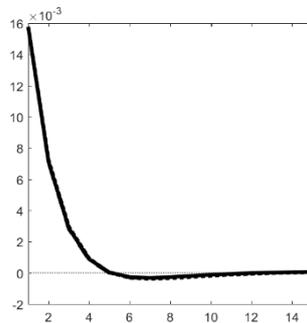
**Headline Inflation**



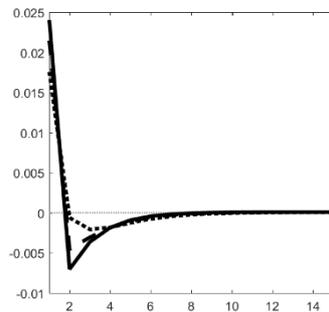
**Core Inflation**



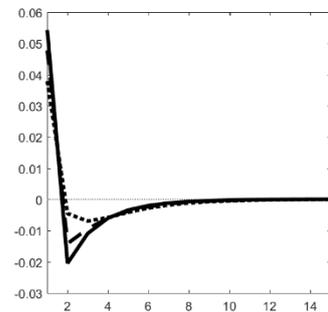
**Food Inflation**



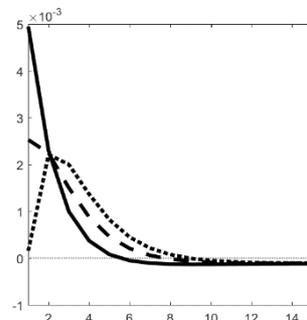
**Interest Rate**



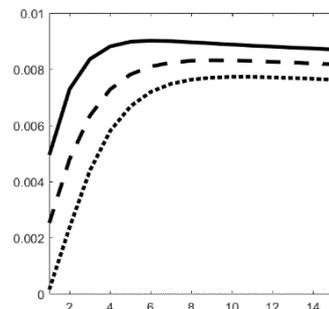
**Distorted Headline Inflation**



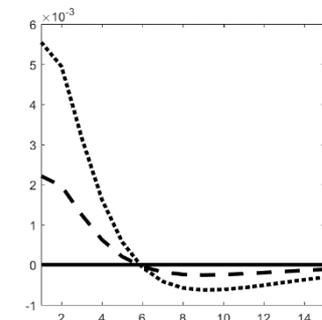
**Subsidized Food Inflation**



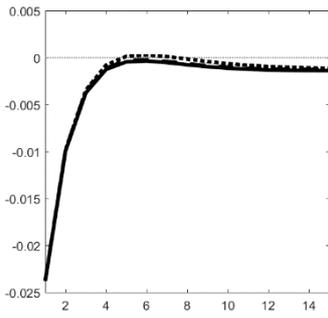
**Trade Balance**



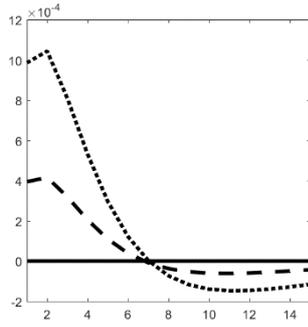
**Saving**



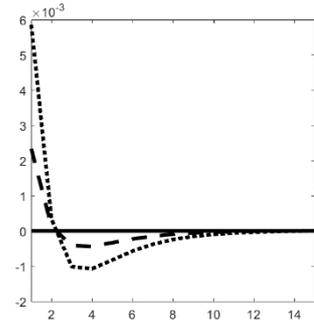
**Government Debt**



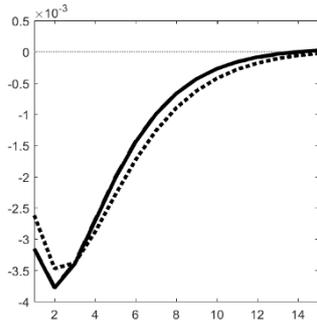
**Exchange Rate**



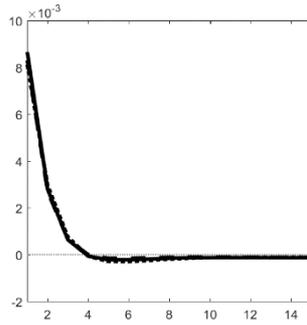
**Marginal Tax Rate (%)**



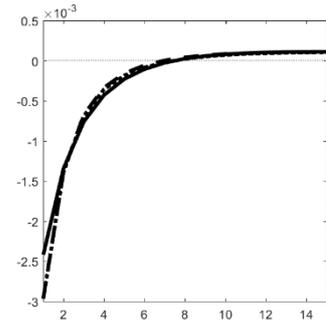
**Subsidy (in % GDP)**



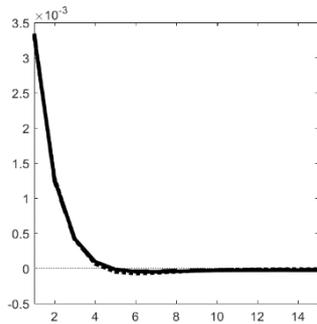
**Investment**



**Output**



**Food Labor**



**Manufacturing Labor**

**Legend: — Model I; - - Model II; •• Model III**



$$\frac{\partial \mathcal{L}_{r,t}^U}{\partial B_{r,t}^*}: \Lambda_{r,t} = \beta \mathbb{E}_t \left[ \frac{\Lambda_{r,t+1} (1 + i_{t+1}^*) \theta(\mathcal{B}_t) \frac{e_{t+1}}{e_t}}{\bar{\pi}_{t,t+1}} \right] \quad (41)$$

$$\begin{aligned} \frac{\partial \mathcal{L}_{r,t}^U}{\partial I_t}: q_t \left( 1 - \Psi \left( \frac{I_t}{I_{t-1}} \right) - \Psi' \left( \frac{I_t}{I_{t-1}} \right) I_t \right) + \beta \mathbb{E}_t \left\{ \frac{\Lambda_{r,t+1}}{\Lambda_{r,t}} \left[ q_{t+1} \frac{I_{t-1}^2}{I_t} \Psi' \left( \frac{I_t}{I_{t-1}} \right) \right] \right\} \\ = 1 \end{aligned} \quad (42)$$

$$\begin{aligned} \frac{\partial \mathcal{L}_{r,t}^U}{\partial k_t}: q_t = \beta \mathbb{E}_t \left\{ \frac{\Lambda_{r,t+1}}{\Lambda_{r,t}} \left[ (1 - \tau_t) r_t + \delta \tau_t - a(u_t) \right. \right. \\ \left. \left. + (1 - \delta) q_{t+1} \right] \right\} \end{aligned} \quad (43)$$

$$\frac{\partial \mathcal{L}_{r,t}^U}{\partial u_t}: (1 - \tau_t) r_t = a'(u_t) \quad (44)$$

$$\frac{\partial \mathcal{L}_{r,t}^U}{\partial N_{r,t}}: \psi(N_{r,t})^\chi = \Lambda_{r,t} (1 - \tau_t) W_{r,t} \frac{W_{r,t}}{\bar{P}_{r,t}} \quad (45)$$

Equation (39) represents the marginal utility of consumption. Equations (39) and (45) together represent the inter-temporal optimization relating labor supply decisions with the marginal rate of consumption and real net wage.

Equations (40) and (41) represents the Euler equations for domestic and foreign bonds which, in equilibrium, characterizes the standard uncovered interest rate parity (UIP) condition. Note the marginal utility of income and inter-temporal equations are a function of the distorted price as implied by utility maximization. This implies that fiscal intervention affects inflation faced by the Ricardian household type defined by  $\bar{\pi}_{i,t} = \bar{P}_{i,t} / \bar{P}_{i,t-1}$ .

### Non-Ricardian Household

Utility maximization yields the intra-temporal labor supply optimality conditions:

$$\frac{\partial \mathcal{L}_{n,t}^U}{\partial C_{n,t}}: \Lambda_{n,t} = \frac{C_{n,t}^{-\rho}}{(1 + \tau_t)} \quad (46)$$

$$\frac{\partial \mathcal{L}_{n,t}^U}{\partial N_{n,t}}: \psi(N_{n,t})^\chi = \frac{\Lambda_{n,t} (1 - \tau_t) W_{n,t}}{\bar{P}_{n,t}} \quad (47)$$

### Food Firms

Food firms minimize the expected costs subject to the production technology:

$$\min_{N_{n,t}} W_{n,t} N_{n,t} + mc_t^F (Y_t^F - A_t^F N_{n,t}) \quad (48)$$

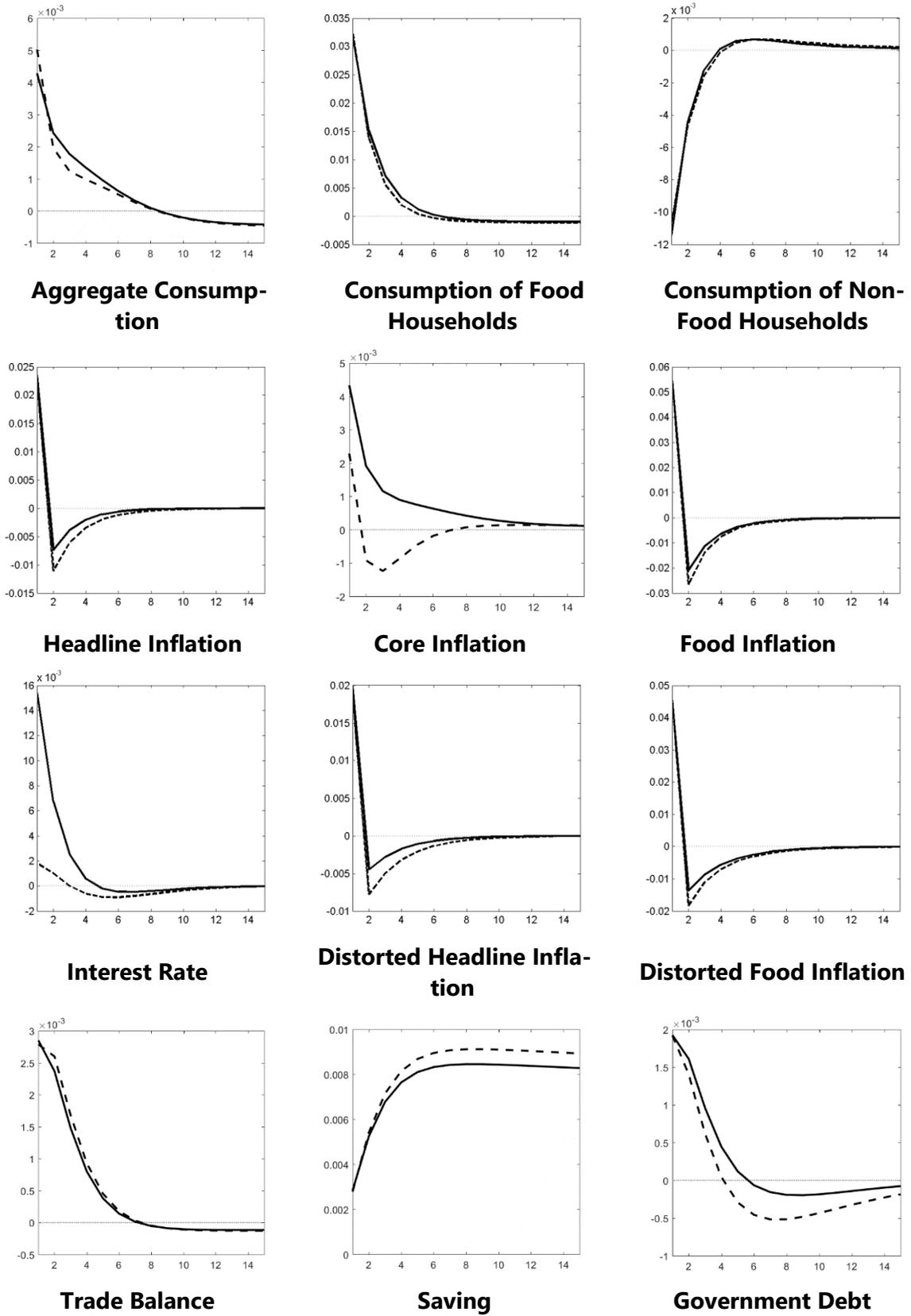
where  $mc_t^F$  can be interpreted as the marginal cost for the respective firm. Assuming an interior solution, the first order condition yields:

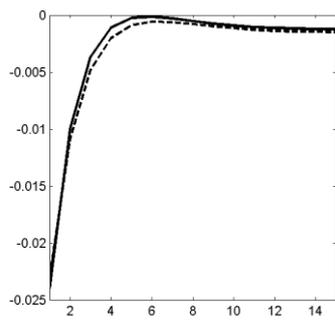
$$mc_t^F = \frac{W_{n,t}}{A_t^F} \quad (49)$$

## 11.2 Additional Impulse Response Functions

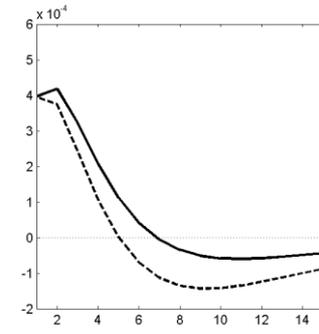
As a complement to the IRF presented in Figure 2 that focused on Model I, this section presents the IRF which compare core inflation targeting and headline inflation targeting under Model II and III. The IRFs display a transitory one standard deviation shock in the presence of fiscal intervention: targeted subsidies (Model II) correspond with Figure 4 and universal subsidies (Model III) correspond with Figure 5.

**Figure 4: IRF World Food Price Shock (Model II)**

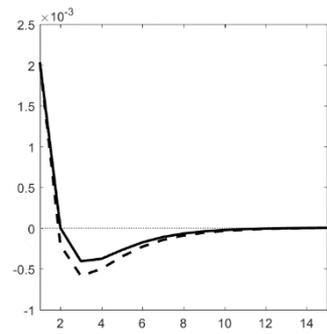




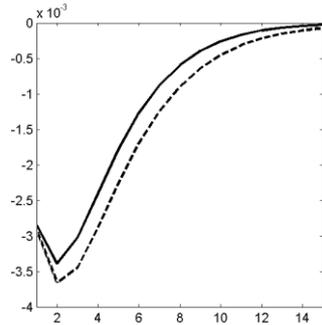
**Exchange Rate**



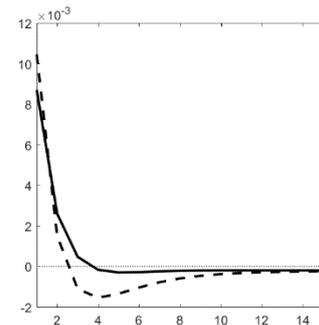
**Marginal Tax Rate (%)**



**Subsidy (in % GDP)**



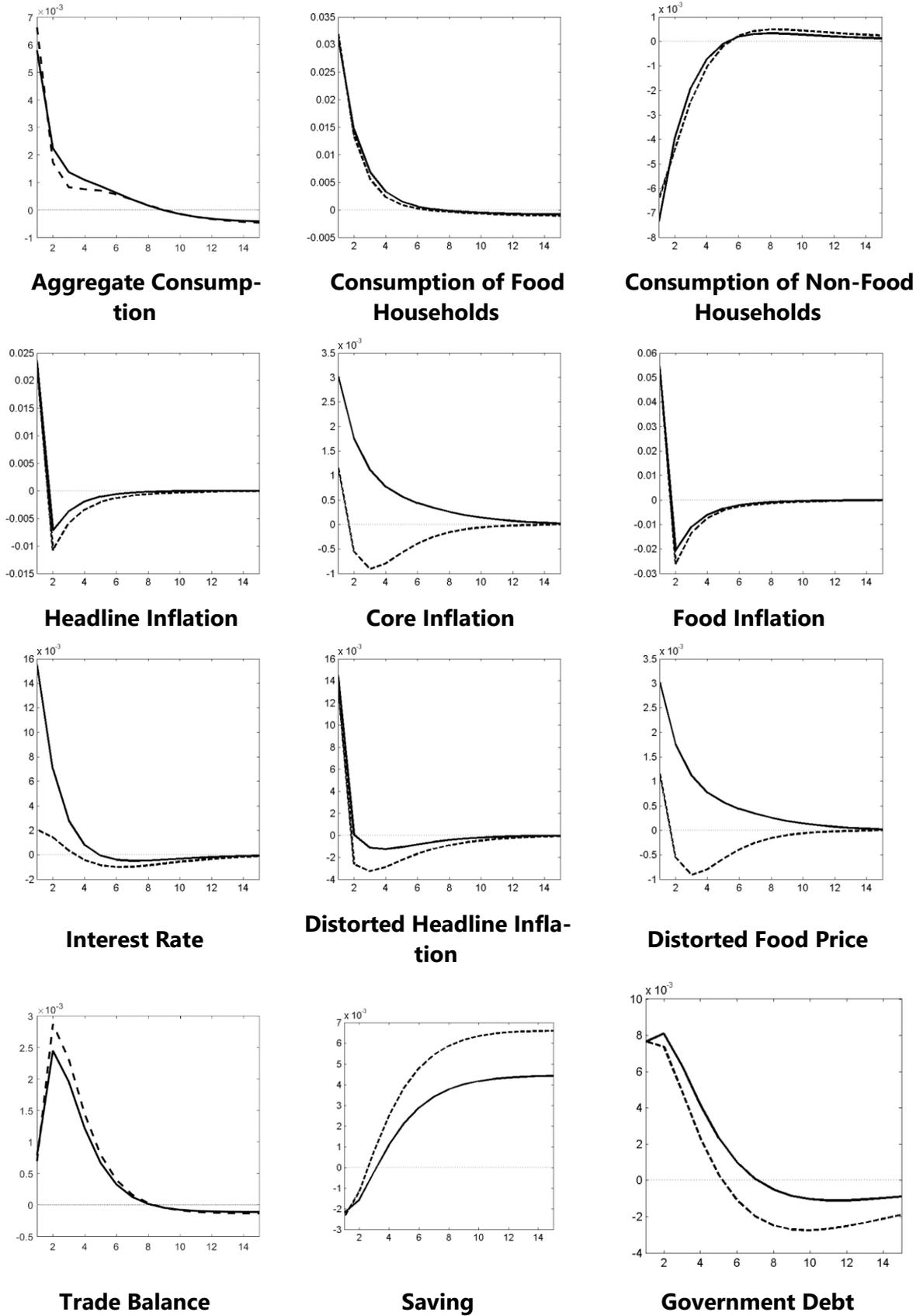
**Investment**

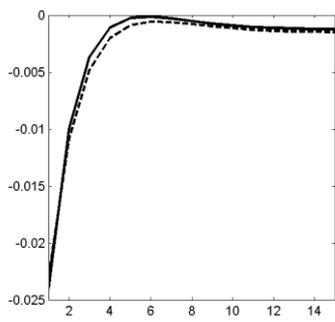


**Output**

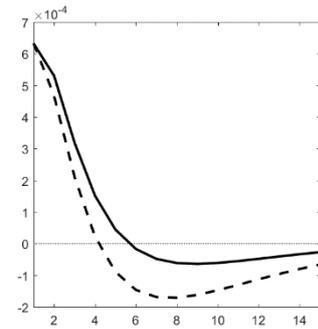
**Legend: — headline inflation targeting; -- core inflation targeting**

**Figure 5: IRF World Food Price Shock (Model III)**

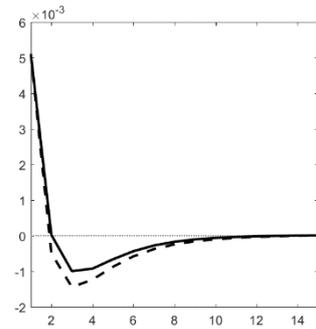




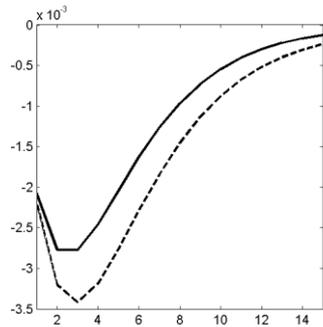
**Exchange Rate**



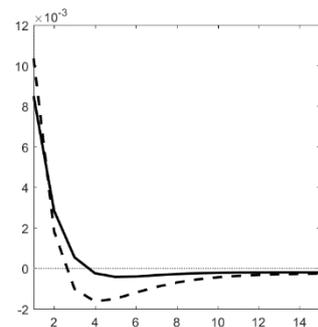
**Marginal Tax Rate (%)**



**Subsidy (in % GDP)**



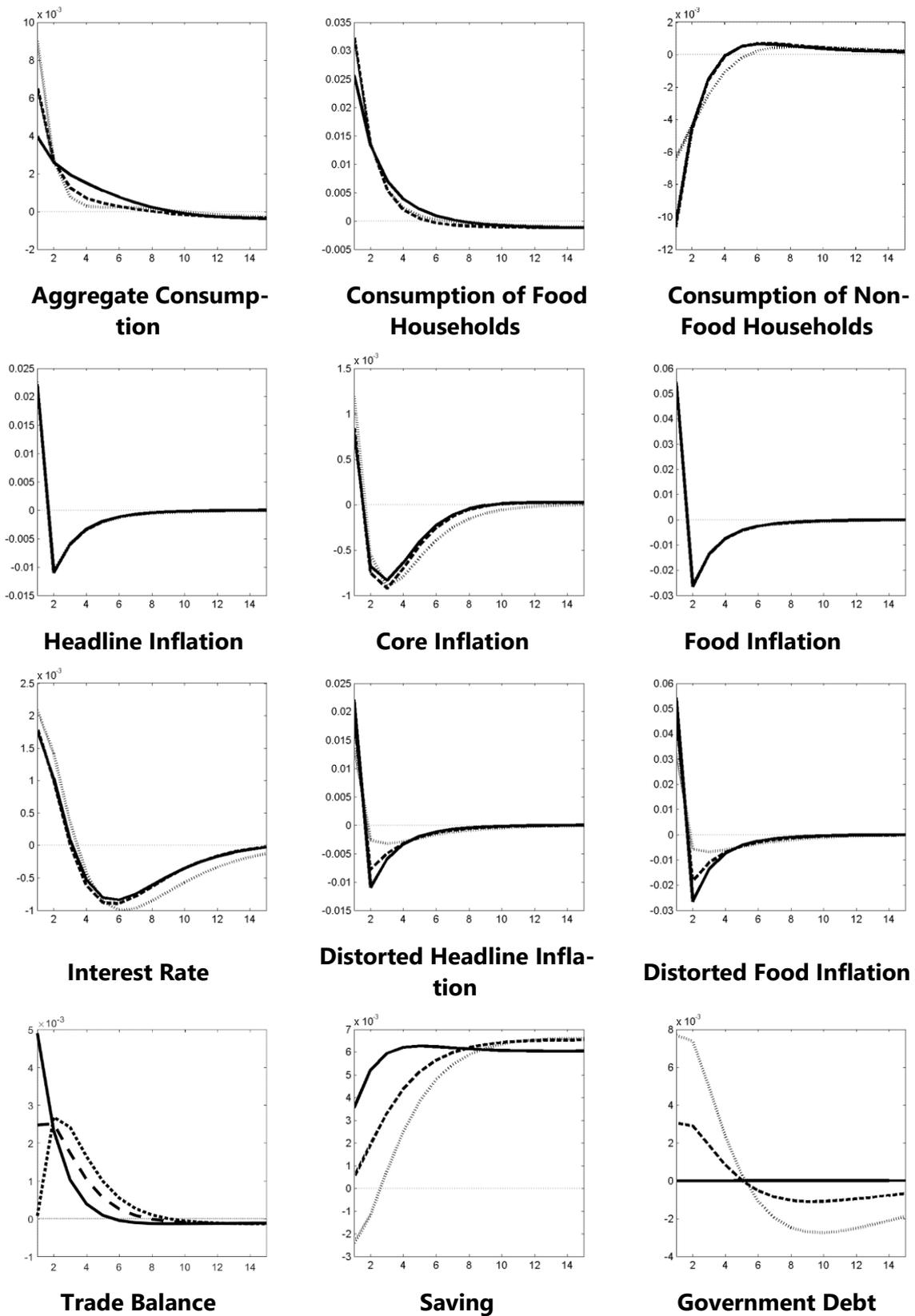
**Investment**

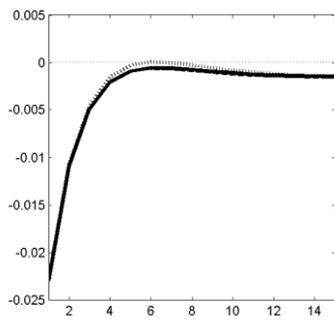


**Output**

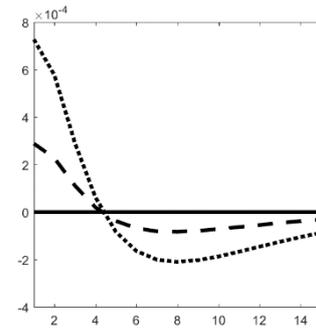
**Legend: — headline inflation targeting; -- core inflation targeting**

**Figure 6: IRF World Food Price Shock (Core Targeting)**

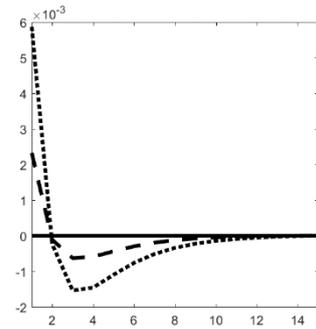




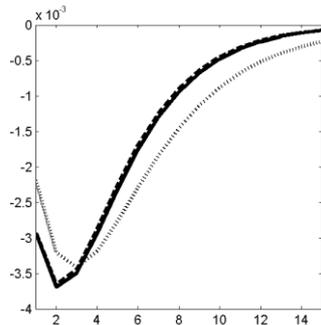
**Exchange Rate**



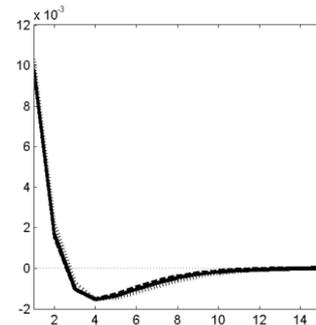
**Marginal Tax Rate (%)**



**Subsidy (in % GDP)**



**Investment**



**Output**

**Legend: — Model I; -- Model II; •• Model III**

### 11.3 Data

The following section described the data used for the stylized facts.

**Table 9: Stylized Facts**

Category	Definition	Wilcoxon rank-sum test		Equality of medians			Kolmogorov-Smirnov test		Median	Number of obs.		Source	
		Stat	P value	Stat	Pearson P value	Fisher P value	Combined Stat	P value	Comparison	Food control	Free price		
<b>Section I. - Agriculture</b>													
I.1	Agricult. capacities	Fertilizer consumption (kilograms per hectare of arable land)	-1.598	0.110	5.031	0.025	0.031	0.255	0.014	free > controled	72	73	WB WDI
I.2	Agricult. capacities	Agricultural land (% of land area)	0.226	0.821	1.376	0.241	0.274	0.113	0.615	free > controled	84	79	WB WDI
I.3	Agricult. capacities	Arable land (hectares per person)	-0.731	0.465	0.054	0.816	0.876	0.121	0.536	free > controled	84	79	WB WDI
I.4	Agricult. capacities	Agricultural irrigated land (% of total agricultural land)	1.793	0.073	3.305	0.069	0.106	0.277	0.037	controled > free	43	57	WB WDI
I.5	Agricult. capacities	Cereal yield (kg per hectare)	-3.305	0.001	7.698	0.006	0.007	0.321	0.000	free > controled	82	77	WB WDI
I.6	Agricult. Prod. gains	Crop production (2004-2006 = 100)	3.718	0.000	13.070	0.000	0.001	0.306	0.001	controled > free	83	79	WB WDI
I.7	Agricult. Prod. gains	Food production (2004-2006 = 100)	4.545	0.000	18.011	0.000	0.000	0.378	0.000	controled > free	83	79	WB WDI
I.8	Agricult. in GDP	Agriculture, value added (% of GDP)	4.367	0.000	17.633	0.000	0.000	0.446	0.000	controled > free	82	72	WB WDI
I.9	Agricult. in GDP	Total natural resources rents (% of GDP)	4.511	0.000	6.774	0.009	0.012	0.346	0.000	controled > free	82	79	WB WDI
I.10	Agricult. in GDP	Employment in agriculture, female (% of female employment)	3.511	0.000	17.198	0.000	0.000	0.433	0.000	controled > free	67	67	WB WDI
I.11	Agricult. in GDP	Employment in agriculture, male (% of male employment)	3.885	0.000	15.791	0.000	0.000	0.433	0.000	controled > free	67	67	WB WDI
I.12	Agricult. in GDP	Employment in agriculture (% of total employment)	3.919	0.000	13.718	0.000	0.000	0.436	0.000	controled > free	68	67	WB WDI
<b>Section II. - Food</b>													
II.1	Agricult. in GDP	Food, beverages and tobacco (% value add in manufact.)	3.708	0.000	12.711	0.000	0.001	0.394	0.000	controled > free	50	52	WB WDI
II.2	Food access	Access to improved water sources	-4.119	0.000	9.258	0.002	0.004	0.393	0.000	free > controled	79	77	FAO FSI
II.3	Food access	Access to improved sanitation facilities	-3.042	0.002	4.272	0.039	0.056	0.374	0.000	free > controled	80	78	FAO FSI
II.4	Food access	Percent of paved roads over total roads	-1.467	0.142	2.046	0.153	0.196	0.313	0.093	free > controled	30	29	FAO FSI
II.5	Food access	Road density	-4.487	0.000	11.816	0.001	0.001	0.479	0.000	free > controled	47	51	FAO FSI
II.6	Food access	Rail lines density	-5.342	0.000	20.414	0.000	0.000	0.576	0.000	free > controled	40	43	FAO FSI
II.7	Food Availability	Average dietary energy supply adequacy	-2.008	0.045	1.297	0.255	0.323	0.216	0.053	free > controled	77	71	FAO FSI
II.8	Food Availability	Per capita food net prod. value (const. 2004-06 internat. dollars)	-2.399	0.016	7.111	0.008	0.010	0.250	0.013	free > controled	79	74	FAO FSI
II.9	Food Availability	Average protein supply	-3.403	0.001	3.276	0.070	0.100	0.334	0.000	free > controled	77	71	FAO FSI
II.10	Food Availability	Average supply of protein of animal origin	-4.016	0.000	14.161	0.000	0.000	0.360	0.000	free > controled	77	71	FAO FSI
II.11	Food cons. cost	Domestic food price index	5.076	0.000	22.453	0.000	0.000	0.542	0.000	controled > free	46	58	FAO FSI
II.12	Food cons. cost	food Share of consumer expenditures	6.273	0.000	33.980	0.000	0.000	0.678	0.000	controled > free	41	45	USDA
II.13	Food export	Food exports, %GDP	-2.089	0.037	2.462	0.117	0.139	0.234	0.027	free > controled	72	75	WB WDI
II.14	Food export	Net food exports, current US dollars	0.182	0.855	0.327	0.567	0.624	0.094	0.850	controled > free	73	76	WB WDI
II.15	Food export	Net food exports, %GDP	-0.511	0.609	0.007	0.936	1.000	0.129	0.514	free > controled	72	75	WB WDI
II.16	Food export	Agricultural raw materials exports (% of merchandise exports)	-0.323	0.746	0.107	0.744	0.870	0.153	0.298	controled > free	74	76	WB WDI
II.17	Food export	Food exports (% of merchandise exports)	1.256	0.209	2.667	0.102	0.141	0.223	0.038	controled > free	74	76	WB WDI
II.18	Food import	Food imports, %GDP	-3.428	0.001	12.091	0.001	0.001	0.355	0.000	free > controled	71	75	WB WDI
II.19	Food import	Food imports (% of merchandise imports)	3.087	0.002	8.216	0.004	0.005	0.290	0.003	controled > free	73	76	WB WDI

Category	Definition	Wilcoxon rank-sum test		Equality of medians			Kolmogorov-Smirnov test		Median	Number of obs.		Source	
		Stat	P value	Stat	Pearson P value	Fisher P value	Combined Stat	P value	Comparison	Food control	Free price		
II.20	Food supply stab.	Cereal import dependency ratio	1.611	0.107	0.936	0.333	0.420	0.194	0.093	controled > free	80	74	FAO FSI
II.21	Food supply stab.	Percent of arable land equipped for irrigation	1.056	0.291	1.104	0.293	0.336	0.116	0.614	controled > free	82	73	FAO FSI
II.22	Food supply stab.	Domestic food price volatility	0.955	0.340	0.853	0.356	0.440	0.172	0.350	controled > free	50	58	FAO FSI
II.23	Food supply stab.	Per capita food production variability	-1.195	0.232	1.227	0.268	0.342	0.130	0.452	free > controled	83	77	FAO FSI
II.24	Food supply stab.	Per capita food supply variability	0.601	0.548	1.016	0.313	0.401	0.168	0.234	controled > free	74	68	FAO FSI
II.25	Undernourishment	Depth of the food deficit	-0.589	0.556	0.947	0.331	0.404	0.180	0.389	free > controled	70	34	FAO FSI
II.26	Undernourishment	Prevalence of food inadequacy	-0.614	0.540	0.699	0.403	0.531	0.208	0.230	free > controled	70	34	FAO FSI
II.27	undernourishment	Prevalence of wasting, weight for height (% children < 5)	0.692	0.489	0.265	0.607	0.698	0.133	0.678	controled > free	74	41	WB WDI
II.28	Undernourishment	Prevalence of undernourishment (% of population)	-0.924	0.356	0.699	0.403	0.531	0.181	0.386	free > controled	70	34	WB WDI
II.29	undernourishment	Depth of the food deficit (kilocalories per person per day)	-0.765	0.444	1.219	0.270	0.305	0.200	0.271	free > controled	70	35	WB WDI
II.30	undernourishment	Vitamin A supplement. coverage rate (% children ages 6-59 months)	1.020	0.308	1.882	0.170	0.226	0.184	0.539	controled > free	49	26	WB WDI
<b>Section III. - General</b>													
III.1	Financial access	Account at a financial institution (% age 15+)	-4.808	0.000	12.462	0.000	0.001	0.438	0.000	free > controled	75	67	FINDEX
III.2	Financial access	Credit card (% age 15+)	-4.912	0.000	20.601	0.000	0.000	0.464	0.000	free > controled	75	67	FINDEX
III.3	Financial access	Used an account at finan. Inst. to receive govern. transfers (% age 15+)	-4.702	0.000	12.462	0.000	0.001	0.447	0.000	free > controled	75	67	FINDEX
III.4	Financial access	Used an account at finan. Inst. to receive remittances (% age 15+)	-3.995	0.000	8.167	0.004	0.007	0.342	0.000	free > controled	75	67	FINDEX
III.5	Financial access	Saved at a financial institution (% age 15+)	-4.334	0.000	12.462	0.000	0.001	0.351	0.000	free > controled	75	67	FINDEX
III.6	Financial access	Saved at a financial institution, rural (% age 15+)	-4.340	0.000	14.803	0.000	0.000	0.349	0.000	free > controled	73	64	FINDEX
III.7	Financial access	Borrowed from a financial institution (% age 15+)	-2.176	0.030	2.289	0.130	0.178	0.246	0.022	free > controled	75	67	FINDEX
III.8	Financial access	Borrowed from a store by buying on credit (% age 15+)	-2.544	0.011	6.358	0.012	0.018	0.235	0.033	free > controled	75	67	FINDEX
III.9	Financial access	Borrowed from a private informal lender (% age 15+)	3.717	0.000	10.201	0.001	0.002	0.314	0.001	controled > free	75	67	FINDEX
III.10	General	Population density (people per sq. km of land area)	-1.926	0.054	4.467	0.035	0.042	0.244	0.013	free > controled	84	79	WB WDI
III.11	General	Population in urban agglomerations of more than 1 million	1.528	0.126	0.036	0.849	1.000	0.190	0.233	controled > free	57	53	WB WDI
III.12	General	GDP, PPP (current international \$)	-1.231	0.218	2.239	0.135	0.157	0.151	0.279	free > controled	82	79	WB WDI
III.13	General	Export volume index (2000 = 100)	-0.186	0.852	0.025	0.874	1.000	0.073	0.964	controled > free	81	79	WB WDI
III.14	General	Merchandise exports (current US\$)	-2.689	0.007	7.140	0.008	0.012	0.273	0.004	free > controled	83	79	WB WDI
III.15	Incomes	Access to electricity, rural (% of rural population)	-2.590	0.010	4.783	0.029	0.042	0.278	0.003	free > controled	84	80	WB WDI
III.16	incomes	GDP per capita (in purchasing power equivalent)	-4.147	0.000	13.231	0.000	0.000	0.440	0.000	free > controled	79	74	FAO FSI
III.17	incomes	GNI per capita, Atlas method (current US\$)	-4.626	0.000	15.953	0.000	0.000	0.435	0.000	free > controled	84	79	WB WDI
III.18	incomes	Income share held by second 20%	-2.295	0.022	7.556	0.006	0.010	0.302	0.003	free > controled	72	64	WB WDI
III.19	incomes	Income share held by third 20%	-3.011	0.003	9.563	0.002	0.003	0.354	0.000	free > controled	72	64	WB WDI
III.20	incomes	Income share held by lowest 10%	0.209	0.834	0.118	0.731	0.864	0.134	0.512	free > controled	72	64	WB WDI

Category	Definition	Wilcoxon rank-sum test		Equality of medians			Kolmogorov-Smirnov test		Median	Number of obs.		Source	
		Stat	P value	Stat	Pearson P value	Fisher P value	Combined Stat	P value	Comparison	Food control	Free price		
III.21	incomes	Poverty headcount ratio at \$3.10 a day (2011 PPP; % population)	3.304	0.001	6.213	0.013	0.016	0.375	0.000	controled > free	74	63	WB WDI
III.22	incomes	GINI index (World Bank estimate)	1.899	0.058	7.556	0.006	0.010	0.257	0.018	controled > free	72	64	WB WDI
III.23	incomes	Poverty gap at national poverty lines (%)	-1.892	0.059	1.365	0.243	0.350	0.238	0.202	free > controled	57	27	WB WDI
III.24	Institut. quality	CPIA business regulatory environment rating (1=low to 6=high)	0.210	0.834	0.668	0.414	0.469	0.107	0.975	free > controled	44	28	WB WDI
III.25	Institut. quality	CPIA economic management cluster average (1=low to 6=high)	0.806	0.420	0.087	0.768	0.812	0.179	0.568	controled > free	44	28	WB WDI
III.26	Institut. quality	CPIA fiscal policy rating (1=low to 6=high)	0.920	0.358	0.236	0.627	0.740	0.185	0.519	controled > free	44	28	WB WDI
III.27	Institut. quality	CPIA gender equality rating (1=low to 6=high)	-0.284	0.776	0.421	0.516	0.614	0.075	1.000	free > controled	44	28	WB WDI
III.28	Institut. quality	CPIA quality of public administration rating (1=low to 6=high)	0.796	0.426	0.505	0.477	0.569	0.088	0.995	free > controled	44	28	WB WDI
III.29	Institut. quality	CPIA social protection rating (1=low to 6=high)	0.729	0.466	0.273	0.601	0.623	0.189	0.520	free > controled	43	27	WB WDI
III.30	Institut. quality	CPIA policies for social inclusion/equity cluster aver. (1=low, 6=high)	0.755	0.450	0.810	0.368	0.463	0.159	0.715	controled > free	43	28	WB WDI
III.31	Monetary policy	Central bank independence	-3.900	0.000	16.204	0.000	0.000	0.321	0.001	free > controled	70	69	CEPII IPD
III.32	Monetary policy	Dummy variable equals 1 if central bank has price stability object.	-2.259	0.024				0.176	0.131	free > controled	85	80	Authors
III.33	Monetary policy	Shambaugh Peg exchange rate regimes classification	0.978	0.328				0.081	0.949	free > controled	70	77	NBER
III.34	Monetary policy	Shambaugh Softpeg exchange rate regimes classification	-1.245	0.213	1.561	0.211	0.243	0.087	0.911	free > controled	70	77	NBER
III.35	People involvem.	Participation of the population	-2.533	0.011	6.204	0.013	0.016	0.263	0.014	free > controled	70	69	CEPII IPD
III.36	People involvem.	Civil liberties	-4.552	0.000	14.670	0.000	0.000	0.339	0.000	free > controled	70	69	CEPII IPD
III.37	People involvem.	Freedom of information	-3.670	0.000	8.810	0.003	0.004	0.307	0.002	free > controled	70	69	CEPII IPD
III.38	People involvem.	Political opposition	1.735	0.083	2.350	0.125	0.173	0.145	0.465	controled > free	69	69	CEPII IPD
III.39	People involvem.	Freedom to establish organisations	-3.971	0.000	8.818	0.003	0.004	0.306	0.002	free > controled	70	69	CEPII IPD
III.40	People involvem.	Spaces for reflection on the major national issues	-2.877	0.004	4.496	0.034	0.042	0.204	0.097	free > controled	70	69	CEPII IPD
III.41	People involvem.	Society's capacity to mobilise	-3.396	0.001	13.942	0.000	0.000	0.308	0.002	free > controled	70	69	CEPII IPD
III.42	People involvem.	Territorial coverage of public services	-3.891	0.000	13.319	0.000	0.000	0.394	0.000	free > controled	70	69	CEPII IPD
III.43	People involvem.	Institutional solidarity	-4.071	0.000	8.807	0.003	0.004	0.435	0.000	free > controled	70	69	CEPII IPD
III.44	People involvem.	Trade union freedoms	-2.945	0.003	10.128	0.001	0.002	0.308	0.002	free > controled	70	69	CEPII IPD
III.45	People involvem.	Effectiveness of social dialogue	-3.647	0.000	13.173	0.000	0.000	0.293	0.004	free > controled	70	69	CEPII IPD
III.46	Public ownership	Significance of public companies to the economy	3.408	0.001	15.967	0.000	0.000	0.339	0.000	controled > free	70	69	CEPII IPD
III.47	Public ownership	Significance of the public sector in the delivery of	1.076	0.282	0.368	0.544	0.610	0.105	0.787	controled > free	70	69	CEPII IPD
III.48	Public ownership	All prices control policy	6.211	0.000	27.830	0.000	0.000	0.440	0.000	controled > free	70	69	CEPII IPD
III.49	Public ownership	Scale of public ownership	2.916	0.004	8.828	0.003	0.004	0.252	0.019	controled > free	70	69	CEPII IPD
III.50	Public ownership	Weight of State-owned banks	2.090	0.037	4.780	0.029	0.037	0.181	0.167	controled > free	70	69	CEPII IPD
III.51	Social Protection	Coverage of social protection and labor programs (% of population)	-1.694	0.090	2.178	0.140	0.206	0.257	0.081	free > controled	63	35	WB WDI
III.52	Social Protection	Coverage of unemployment benefits and ALMP (% of population)	-1.426	0.154	1.893	0.169	0.271	0.234	0.380	free > controled	31	23	WB WDI
III.53	Social Protection	Benefit incidence of social safety net programs to poorest quintile (% of population)	-0.838	0.402	0.586	0.444	0.501	0.134	0.814	free > controled	52	31	WB WDI
III.54	Social Protection	Coverage of social safety net programs (% of population)	-1.073	0.283	1.167	0.280	0.388	0.184	0.401	free > controled	61	33	WB WDI
III.55	Social Protection	Adequacy of social insurance programs (% of total welfare of beneficia	-0.110	0.912	0.285	0.593	0.654	0.097	0.978	free > controled	55	30	WB WDI
III.56	Social Protection	Coverage of social insurance programs (% of population)	-0.590	0.555	0.000	1.000	1.000	0.303	0.034	free > controled	58	32	WB WDI

Note: the null hypothesis of each test is that both distributions (countries with controlled or market prices) is the same. The p-values in gray indicate where the null has been rejected based on a 5% cut-off.