# Core vs. Headline Inflation Targeting in Models with Incomplete Markets

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**Abstract**

In models with complete markets, targeting core inflation enables monetary policy to maximize welfare by replicating the flexible price equilibrium. We develop a two-sector new-Keynesian model to evaluate different inflation targeting rules in economies with financial frictions. We conclude that, in the presence of financial frictions, a welfare-maximizing central bank should adopt flexible headline inflation targeting—a target for headline CPI inflation with some weight on the output gap. These results are particularly relevant for emerging markets, where the share of food expenditures in total consumption expenditures is high and a large proportion of households are credit constrained.

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## 1. Introduction

The global financial crisis has reinvigorated the debate about the appropriate objectives for monetary policy. A consensus appears to be developing that the inflation targeting (IT) framework has delivered price stability and should be retained but that central banks should use prudential regulation and other policy tools to counteract asset price bubbles (see, e.g., Eichengreen et al., 2011). Whether or not IT is the chosen framework, central banks around the world view low and stable inflation as a primary, if not dominant, objective of monetary policy.

What is the right price index that should be the focus of the inflation objective? This is a central operational issue in implementing not just IT but any version of monetary policy. In this paper, we focus on the task of analytically determining the appropriate price index for markets with financial frictions in general and emerging markets in particular.[1]

In the existing literature, the choice of price index has been guided by the idea that inflation is a monetary phenomenon. It has been suggested that core inflation (excluding food, energy and other volatile components from headline CPI) is the most appropriate measure of inflation (Wynne, 1999). The logic is that fluctuations in food and energy prices represent supply shocks and are non-monetary in nature. Since these shocks are transitory and volatile and do not reflect changes in the underlying rate of inflation, they should not be a part of the inflation targeting price index (Mishkin, 2007, 2008).

Previous authors have used models with price and/or wage stickiness to show that targeting core inflation maximizes welfare. Existing models have looked at complete market settings where price stickiness is the only source of distortions (besides monopoly power). Infrequent price adjustments cause mark-ups to fluctuate and also distort relative prices. In order to restore the flexible price equilibrium, central banks should try to minimize these fluctuations by targeting sticky prices (Goodfriend and King, 1997, 2001). Using a variant of a New Keynesian model, Aoki (2001) has shown that under complete markets targeting inflation in the sticky price sector leads to welfare maximization and macroeconomic

[1] We set aside other issues relevant to designing optimal inflation targeting regimes—such as the choice of a point target versus a band (Orphanides and Wieland, 2000), the horizon over which inflation should be targeted (Batini and Nelson, 2000), the appropriate level of the target (Williams, 2009), and the implications of uncertainty about the perceived target (Aoki and Kimura, 2007).

stability. Targeting core inflation is equivalent to stabilizing the aggregate output gap as output and inflation move in the same direction under complete markets.

These results from the prior literature rely on the assumption that markets are complete (allowing households to fully insure against idiosyncratic risks). The central bank then only needs to tackle the distortions created by price stickiness. However, there is compelling evidence that a substantial fraction of agents even in advanced economies are unable to smooth their consumption in a manner consistent with the permanent income hypothesis.[2] It has also been shown that the presence of credit-constrained consumers alters policymakers' welfare objectives and renders the Taylor rule as too weak a criterion for stability (Amato and Laubach, 2003; and Gali, Lopez-Salido and Valles, 2004).

Our main contribution in this paper is to develop a model to evaluate the welfare implications of targeting different price indices in an incomplete markets setting that is particularly relevant for emerging markets. We use this model to provide welfare comparisons of the practical choice that most central banks face—targeting core or headline inflation, along with some variants of those rules.[3]

Financial frictions that result in consumers being credit-constrained have not received much attention in models of inflation targeting. To examine the significance of such frictions, which are particularly relevant for emerging markets, we develop a model with heterogeneous agents where a fraction of consumers cannot smooth their consumption—that is, they simply consume their current labor income.[4] When markets are not complete and agents differ in their ability to smooth consumption, their welfare depends on the

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[2] Campbell and Mankiw (1989, 1990, 1991) estimate that in the U.S. nearly 50 percent of income accrues to consumers who do not smooth their consumption. Muscatelli, Tirelli and Trecroci (2004) find that 37 percent of U.S. consumers are rule-of-thumb consumers. For more evidence on the proportion of credit-constrained consumers in the U.S., see Jappelli (1990), Shea (1995), Parker (1999), Souleles (1999), Fuhrer (2000), and Fuhrer and Rudebusch (2004).
[3] Our objective is to evaluate policy rules with practically implementable price indexes. There is a related literature that attempts to compute optimal price indexes given a particular policy rule—see, e.g., Aoki (2001), Benigno (2004) and Eusepi, Hobijn and Tambalotti (2011).
[4] We introduce this friction in a manner similar to that of Gali, Lopez-Salido and Valles (2004). Aoki, Proudman and Vlieghe (2004) discuss the implications of credit market frictions related to collateral constraints for housing prices and monetary policy (also see Iacoviello, 2005). Blanchard and Gali (2010) evaluate monetary policy rules in the presence of labor market frictions, real wage rigidities and staggered price setting.

nature of idiosyncratic shocks. Thus, this model also allows us to analyze the welfare distribution under alternative inflation targeting rules.

When markets are complete, the income distribution following a sector-specific shock does not matter for the choice of consumption and, hence, welfare. However, under incomplete markets, household income, which is influenced by the nature of shocks and the price elasticity of the demand for goods, matters for consumption choices. We show that, through its impact on household income and expenditure, the price elasticity of the demand for food, which is low in emerging market economies, affects welfare outcomes from core and headline inflation targeting under incomplete markets. For instance, a negative productivity shock to a good with a low price elasticity of demand could increase the income of net sellers of that good and raise the expenditure of net buyers of that good.

Our model also incorporates other important features relevant to emerging markets. The share of food in total household expenditures is higher in emerging markets, constituting 40-50 percent of household expenditures compared to 10-15 percent in advanced economies. Low price and income elasticities of food expenditures as well as low income levels make the welfare of agents in emerging markets more sensitive to fluctuations in food prices. These features imply that agents factor in food price inflation while bargaining over wages, thus affecting broader inflation expectations. Thus, in emerging markets even inflation expectation targeting central banks must take into account food price inflation.[5]

Our key result is that in the presence of financial frictions targeting headline CPI inflation improves aggregate welfare relative to targeting core inflation (i.e., inflation in the sticky price sector). The intuition is as follows. Lack of access to financial markets makes the demand of credit-constrained consumers insensitive to fluctuations in interest rates. These consumers' demand depends only on real wages, establishing a link between aggregate demand and real wages. Thus, in the presence of financial frictions, the relative price of the good produced in the flexible price sector not only affects aggregate supply but, through its effects on real wages, also influences aggregate demand.

[5] Walsh (2011) documents the high pass-through from food price inflation to nonfood inflation in middle- and low-income countries.

This result differs from that obtained in the prior literature based on complete markets settings. For instance, in Aoki's (2001) model, relative prices of the flexible price sector only appear as a shift parameter of inflation in the sticky price sector. Under incomplete markets, by contrast, the central bank has to take account of price fluctuations in the flexible price sector in order to manage aggregate demand. Financial frictions break the comovement of inflation and output (as inflation and output may now move in opposite directions). Stabilizing core inflation no longer suffices to stabilize the output gap. Thus, in the presence of financial frictions, targeting headline inflation is a better policy choice.

To demonstrate the generality of our results, we nest models such as that of Aoki (2001) as special cases of our model. This allows us to demonstrate that the classical result about the optimality of core inflation targeting can be overturned by introducing financial frictions. Our work is related to that of Mankiw and Reis (2003) who show, in a different setting, that targeting a price index that gives substantial weight to the level of nominal wages helps improves the stability of economic activity. While additional features make our model more realistic, especially in the context of emerging market economies, we present various sensitivity tests that clearly show the quantitative relevance of each of these features. We do not attempt to define optimal policy rules but instead focus on evaluating welfare outcomes of different policy rules using alternative measures of inflation.

The paper is organized as follows. The next section contains some empirical facts to further motivate the analysis. In Section 3, we develop a two-sector, two-good model with heterogeneous agents that encapsulates the features discussed above. In Section 4 we discuss the main results and in Section 5 we conduct various sensitivity experiments to check the robustness of our baseline results and also present some extensions of the basic model. Section 6 concludes the paper.

## 2. Basic Stylized Facts

We first present some stylized facts that are relevant to monetary policy formulation in emerging markets, starting with the share of food in household consumption expenditures and measures of the elasticity of food expenditures. Engel's law states that as average household income increases the average share of food expenditure in total household expenditure declines. When this idea is extended to countries, we expect poor countries to have a high average share of food expenditure in total household expenditure. Figure 1 shows that countries with lower per capita income levels have a higher share of expenditure on food in total household expenditure.[6] In Table 1, we present recent data on shares of food expenditure in total expenditure for selected emerging and advanced economies.[7] As expected, expenditure on food constitutes a much larger share of total household expenditure in emerging markets relative to advanced economies.

Figure 2 plots the income elasticity of food against real per capita GDP for the year 1996. The average income elasticity of food is low, suggesting that food is a necessary good. In rich countries, the income elasticity of food is lower since expenditure on food is not a major share of household expenditures. We present the income elasticity of food for selected emerging markets and advanced economies in Table 2. The income elasticity of food in emerging markets is on average twice as large as that in advanced economies.

Figure 3 plots, for a large sample of countries, the Slutsky own price elasticity of food against the log real per capita GDP for the year 1996.[8] The price elasticity of food demand is nonlinear, decreasing at low income levels, and then increasing, with a range from -0.4 to -0.1. We also present data on this elasticity for selected countries in Table 2. The average price elasticity of food is -0.34, much lower in absolute terms than the typical assumption of a unitary price elasticity. As the share of expenditure on food is high in emerging markets, the price elasticity of food is higher in these economies but still lower than the value normally used in the literature. Low price and income elasticities of the demand for food have considerable significance for the choice of price index.

[6] We use data for 1996 for illustrative purposes since data for a large number of countries were available for that year.
[7] We looked at household surveys for each country in this table rather than the weight of food in each country's CPI index since those weights are changed only occasionally. These data typically cover expenditure on food consumed at home. Food away from home accounts for a much greater share of household food expenditures in advanced economies than in emerging markets. For instance, nearly half of food expenditures in the U.S. are accounted for by food away from home (Stewart et al., 2004). In China, food away from home accounts for about 20 percent of food expenditures of urban households (Gale and Kuang, 2007) and probably a much lower proportion for rural households. The price elasticity is likely to be higher and price rigidity is likely to be lower for food away from home relative to food prepared and consumed at home.
[8] The Slutsky own price elasticity is estimated by keeping real income constant. The price elasticity of food demand is non-linear, decreasing at low income levels, and then increasing, with a range from -0.4 to -0.1. The turning point (with elasticity equal to -0.4), when the Slutsky own-price elasticity starts rising (declining in absolute terms) with increasing per capita income, is roughly at a per capita income level that is about 25 percent that of the U.S. (Seale et al., 2003).

To examine the extent of credit constraints in emerging markets, in Table 3 we present data from the World Bank (Demirguc-Kunt and Klapper, 2012) on the percentage of the adult population with access to formal finance (the share of the population using formal financial services) in emerging markets. These data show that, on average, more than half of the population in emerging markets lacks access to the formal financial system. By contrast, in advanced economies, nearly all households have such access.

Next, we examine the characteristics of food and nonfood inflation using data from Walsh (2011). Both food and nonfood inflation are higher on average in emerging markets than in advanced economies (Table 4). In emerging markets, food inflation is more volatile than nonfood inflation, consistent with the notion of food prices being more flexible than prices of other goods. Innovations to food price inflation are also more volatile than innovations to nonfood inflation. This pattern holds for advanced economies as well, although the respective volatilities are lower than for emerging markets. These results are consistent with other evidence that headline inflation is more volatile than core inflation in both advanced and emerging market economies (Anand and Prasad, 2010). The two measures of inflation exhibit a high degree of persistence in both sets of economies and, contrary to conventional wisdom, food price shocks tend to be quite persistent in emerging markets.[9]

The main observations from this section are that, relative to households in advanced economies, those in emerging markets have a higher share of food expenditures in total consumption expenditures, a higher income elasticity and lower price elasticity of food expenditures, and significantly lower access to formal financial institutions. These features potentially have implications for households' responses to changes in monetary policy. In the next section, we develop a model that incorporates these features, allowing us to examine the quantitative significance of their implications for monetary policy. We also note that headline and core CPI inflation have very different degrees of persistence and volatility. In particular, deviations between these two measures can last for an extended period (contrary to the notion that shocks to the flexible price sector are transitory). This is relevant for evaluating the welfare implications of different inflation targeting rules.

[9] Walsh (2011) also finds that food price inflation is in fact more persistent than nonfood price inflation. This holds for both advanced and emerging market economies, although he finds that food price inflation is more persistent in emerging markets.

## 3. The Model

Our model builds upon a large literature that has developed and analyzed dynamic sticky price models (Clarida, Gali and Gertler, 1999; Woodford, 1996; Rotemberg and Woodford, 1997, 1999; Aoki, 2001). The model incorporates two features that are relevant to all economies but are particularly important for emerging markets--a fraction of consumers who are credit constrained and a subsistence level of food consumption. The model has two sectors and two goods—a flexible price good, food ($C_F$), whose prices adjust instantaneously, and a continuum of monopolistically produced sticky price goods, $c(z)$ indexed in $z \in (0,1)$ which we call nonfood and whose prices adjust sluggishly.[10] In the subsequent discussion, we interchangeably use the term food sector for the flexible price sector and the term nonfood sector for the sticky price sector.

### *3.1 Households*

The economy is populated by a continuum of 1 + λ infinitely lived households, where $\lambda > 0$, is the continuum of households in the flexible price sector (food sector). Each household owns a firm and produces one good. They provide labor to the firms in their respective sector (we assume that labor is immobile across sectors) and consume both the flexible price good (food) and all of the differentiated sticky price goods (nonfood).[11] The representative consumer, *i*, is indexed by *f* (flexible price sector) and *s* (sticky price sector). Household *i* maximizes the discounted stream of utility

$$E_0 \sum_{t=0}^{\infty} \beta^t [u(C_t^i, N_t^i)] \tag{1}$$

where $\beta \in (0,1)$ is the discount factor. The utility function takes the form:

$$u(C_t^i, N_t^i) = \frac{(C_t^i)^{1-\sigma}}{1-\sigma} - \phi_n \frac{(N_t^i)^{1+\psi}}{1+\psi} \tag{2}$$

[10] We model the sticky price sector by a continuum of monopolistic firms so that these firms have market power and they can set prices. This is done to introduce price stickiness in this sector.

[11] We have assumed the immobility of labor for simplicity and to capture the large inter-sectoral wage differentials in emerging markets. Gali, Lopez-Salido and Valles (2004) have demonstrated in their model that, even with free labor mobility, financial frictions lead to similar results as ours (aggregate demand going up even when the central bank raises the policy interest rate).

where $C_t^i$ is the composite consumption index of household *i* in period *t*, including the flexible price good and the continuum of the differentiated goods. It is defined as

$$C_t^i = \left[\gamma^{\frac{1}{\eta}}\left(C_{f,t}^i - C^*\right)^{1-\frac{1}{\eta}} + \left(1-\gamma\right)^{\frac{1}{\eta}}(C_{s,t}^i)^{1-\frac{1}{\eta}}\right]^{\frac{1}{1-\frac{1}{\eta}}} \tag{3}$$

where

$$C_{s,t}^i = \left[\int_0^1 c_t^i(z)^{\frac{\theta-1}{\theta}} dz\right]^{\theta/\theta-1} \tag{4}$$

The elasticity of substitution between the flexible price and sticky price goods is given by $\eta \in [0,\infty]$ and $\gamma \in [0,1]$ is the weight on food in the consumption index. The parameter θ >1 is the elasticity of substitution between any two differentiated goods, $N_t^i$ is aggregate labor supplied by household *i* in period *t* and $\sigma$ is the risk aversion factor (inverse of elasticity of inter temporal substitution). The parameter $\psi$ is the inverse of Frisch elasticity and $\phi_n$ is a scaling factor.

The utility function used here is of a generalized Klein-Rubin form. Since food is a necessity, households must consume a minimum amount $C^*$ of food for survival. We assume that all households always have enough income to buy the subsistence level of food. Even though the subsistence level food consumption does not bind, it alters the elasticity of substitution between food and nonfood and the marginal utility of food and nonfood consumption.

### *3.1.1 Flexible Price Sector (Food Sector) Households*

Households in the flexible price sector (food sector) do not have access to financial markets and they consume their wage income in each period.[12] So these households are

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[12] Data in Demirguc-Kunt and Klapper (2012) show that, in less developed economies, access to formal financial institutions is at least 10 percentage points lower in rural areas compared to urban areas. Basu et al. (2005) document that 80 percent of individuals in India's agricultural sector have no access to formal finance. To keep the model tractable, there is no storage technology.

akin to "rule of thumb" consumers. Each household in the sector owns one firm and produces food using a linear technology in labor, given by

$$y_{f,t} = A_{f,t} N_t^f \tag{5}$$

$A_{f,t}$ is a random productivity shock. Since we are interested in analyzing the effects of sector-specific shocks rather than household-level idiosyncratic shocks, we assume that all the households in the food sector face the same shock.

### *3.1.2 Sticky Price Sector (Nonfood Sector) Households*

Households in this sector can buy one-period nominal bonds to smooth their consumption. Each household owns a share of each firm in the sector and provides labor to each firm in the sector. Firms use a linear technology in labor given by

$$y_t(z) = A_{s,t} N_t^s(z) \tag{6}$$

where $y_t(z)$ is a sticky price good and $N_t^s(z)$ is the labor used in the firm producing good indexed by z ( where $z \in [0,1]$). $A_{s,t}$ is a random productivity shock. We assume that the shock is identical for all households in the nonfood sector.

## *3.2 Consumption Decision*

### *3.2.1 Food Sector Households (Credit Constrained Consumers)*

All households in this sector face an identical budget constraint every period (as their wage income is the same in every period). A representative household maximizes its lifetime utility given by equation (1) subject to the budget constraint

$$P_{f,t} C_{f,t}^f + P_{s,t} C_{s,t}^f = W_t^f N_t^f \tag{7}$$

where $P_{f,t}$ is the market price of food, $P_{s,t}$ is the price index of nonfood (defined below) and $W_t^f$ is the nominal wage in the food sector. The optimal allocation for a given level of spending between food and all the differentiated nonfood goods leads to a Dixit-Stiglitz demand relation. The total expenditure to attain a consumption index $C_t^f$ is given by $P_t C_t^f$ where $P_t$ is defined as

$$P_t = \left[\gamma (P_{f,t})^{1-\eta} + (1-\gamma)(P_{s,t})^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{8}$$

Demand for the flexible price good is given by

$$C_{f,t}^f = \gamma \left(\frac{P_{f,t}}{P_t}\right)^{-\eta} C_t^f + C^* \tag{9}$$

Demand for the sticky price good is given by

$$C_{s,t}^f = (1-\gamma)\left(\frac{P_{s,t}}{P_t}\right)^{-\eta} C_t^f \tag{10}$$

where $P_{s,t}$ is the Dixit-Stiglitz price index defined as

$$P_{s,t} = \left[\int_0^1 X_t(z)^{1-\theta} dz\right]^{\frac{1}{1-\theta}} \tag{11}$$

$X_t(z)$ is the price of differentiated good indexed on *z* at time *t*. Demand for each differentiated good is given by

$$c_t^f(z) = \left(\frac{X_t(z)}{P_{s,t}}\right)^{-\theta} C_{s,t}^f \tag{12}$$

### *3.2.2 Nonfood Sector Households (Unconstrained Consumers)*

Each household in this sector provides labor to each one of the firms in the sector and also holds one share in each firm. In this setup, as in Woodford (2003), each household faces the same budget constraint each period and hence chooses the same consumption stream.[13] A representative household maximizes the lifetime utility given by equation (1) subject to the following budget constraint

$$P_t C_t^s + B_t = \int_0^1 W_t^s(z) N_t^s(z) dz + \int_0^1 \Pi_t^s(z) dz + R_{t-1} B_{t-1} - P_{f,t} C^* \tag{13}$$

where $B_t$ represents the quantity of one-period nominal risk free discount bonds bought in period $t$ and maturing in period $t+1$ and $R_t$ is the gross nominal interest rate between period $t$ and $t+1$. $W_t^s(z)$ and $N_t^s(z)$ represent the nominal wage in firm $z$ and the amount of labor supplied to firm $z$ by the household, respectively. $\Pi_t^s(z)$ is the profit of firm $z$.

Demand for the flexible price good is given by

$$C_{f,t}^s = \gamma \left( \frac{P_{f,t}}{P_t} \right)^{-\eta} C_t^s + C^* \tag{14}$$

Demand for the sticky price good is given by

$$C_{s,t}^s = (1-\gamma) \left( \frac{P_{s,t}}{P_t} \right)^{-\eta} C_t^s \tag{15}$$

and the demand for each differentiated good is given by

$$c_t^s(z) = \left( \frac{X_t(z)}{P_{s,t}} \right)^{-\theta} C_{s,t}^s \tag{16}$$

[13] Alternatively, we could use the other set up in Woodford (2003) in which each household produces one of the differentiated products and there exists a complete range of securities for insuring fully against idiosyncratic risks. In that formulation as well, each household will choose the same consumption stream and therefore the analysis will be the same as in the present setting.

### *3.3 Firms*

#### *3.3.1 Firms in the Flexible Price Sector (Food Sector)*

Firms are assumed to be price takers. Given a market price $P_{f,t}$ they set prices such that

$$P_{f,t} = \frac{W_t^f}{A_{f,t}} \tag{17}$$

The market-clearing condition for food implies

$$Y_{f,t} = \lambda y_{f,t} = C_{f,t} = \gamma \left( \frac{P_{f,t}}{P_t} \right)^{-\eta} C_t + (1+\lambda) C^* \tag{18}$$

where we have defined $\lambda C_t^f + C_t^s = C_t = Y_t$ (19)

This is the total composite demand, which is equal to supply in equilibrium.

#### *3.3.2 Firms in the Sticky Price Sector*

We follow Calvo (1983) and Woodford (1996) in modeling price stickiness. A fraction $\alpha \in (0,1)$ of firms cannot change their price in each period. Firms are free to change the price at time *t*; they choose a price $X_t$ to maximize the following objective function:

$$\underset{X_t(z)}{Max}\, E_t \left[ \sum_{j=0}^{\infty} (\alpha\beta)^j Q_{t,t+j} \left[ X_t(z) y_{t,t+j}(z) - TC_{t,t+j}(y_{t,t+j}(z)) \right] \right] \tag{20}$$

where $Q_{t,t+j} = \beta^i \left( \frac{C_{t+j}^s}{C_t^s} \right)^{-\sigma} \frac{P_t}{P_{t+j}}$ is the stochastic discount factor and $y_{t,t+j}(z)$ is the output of firm in period *t+j* when it has set its price in period *t* that is given by

$$y_{t,t+j}(z) = \left( \frac{X_t(z)}{P_{s,t+j}} \right)^{-\theta} Y_{s,t+j} \tag{21}$$

The price index for the sticky price sector is as follows:

$$P_{s,t} = \left[\alpha (P_{s,t-1})^{1-\theta} + (1-\alpha) X_t^{1-\theta}(z)\right]^{\frac{1}{1-\theta}} \tag{22}$$

*3.4 Inflation and Relative Prices*

We define the relative prices as follows:

$\frac{P_{f,t}}{P_t} = x_{f,t}$, relative price of food, $\frac{P_{s,t}}{P_t} = x_{s,t}$, relative price of nonfood; and $\frac{X_t}{P_{s,t}} = x_t$, relative price charged by firms which are free to choose the price in time t. We define the gross headline inflation as $\Pi_t = \frac{P_t}{P_{t-1}}$, and gross inflation in the sticky price sector as $\Pi_{s,t} = \frac{P_{s,t}}{P_{s,t-1}}$.

*3.5 Steady State*

We characterize the steady state with constant prices (zero inflation) and no price stickiness in the economy.[14] This implies that $\Pi_t = 1$ and $\Pi_{s,t} = 1$ for all t. Under symmetric equilibrium, each firm faces the same demand and sets the same price. Thus, $X_t = P_{s,t}$ and $x_t = 1$. Therefore, $x_{s,t} = \frac{\theta}{\theta - 1} MC_t^r$. In the steady state, all firms set a price that is a constant markup over the real marginal cost. We assume that productivity is the same in both the sectors and normalize it to one.

*3.6 Monetary Policy Rule*

We assume that the monetary authority sets the short-term nominal interest rate ($R_t$) according to a simple Taylor (1993) type rule of the following form:

$$\log(R_t / \bar{R}) = \rho_i \log(R_{t-1} / \bar{R}) + \rho_\pi \log(\Pi_t / \bar{\Pi}) + \rho_y \log(Y_t / \bar{Y}) \tag{23}$$

[14] For more details about the equations in terms of stationary variables, see Appendix I in Anand and Prasad (2010). Note that our model has zero trend inflation. Ascari (2004) shows that, in the absence of full indexation, the Calvo staggered price model is not super-neutral when trend inflation is considered.

where $\bar{Y}, \bar{\Pi}$ and $\bar{R}$ are the steady state values of output, inflation and the nominal interest rate, respectively. The term $\rho_i$ represents the Central Banker's preference for interest rate smoothing. $\rho_\pi$ and $\rho_y$ are the weights on inflation and output gap assigned by the policy makers.[15] We characterize core inflation as the inflation in the sticky price sector, $\Pi_{s,t}$, and headline inflation as the overall inflation, $\Pi_t$, for our policy experiments.

We evaluate our model under the following monetary policy regimes:

*Strict Core Inflation Targeting*: The central bank's objectives are interest rate smoothing and stabilizing inflation in the sticky price sector.

$$\log(R_t / \bar{R}) = \rho_i \log(R_{t-1} / \bar{R}) + \rho_\pi \log(\Pi_{s,t} / \bar{\Pi}_s) \tag{24}$$

*Strict Headline Inflation Targeting*: The central bank's objectives are interest rate smoothing and stabilizing headline inflation.

$$\log(R_t / \bar{R}) = \rho_i \log(R_{t-1} / \bar{R}) + \rho_\pi \log(\Pi_t / \bar{\Pi}) \tag{25}$$

*Flexible Core Inflation Targeting*: The central bank cares about interest rate smoothing and in addition to stabilizing sticky price inflation also tries to stabilize output by assigning a weight to the output gap (deviation of output from trend).

$$\log(R_t / \bar{R}) = \rho_i \log(R_{t-1} / \bar{R}) + \rho_\pi \log(\Pi_{s,t} / \bar{\Pi}_s) + \rho_y \log(Y_t / \bar{Y}) \tag{26}$$

*Flexible Headline Inflation Targeting*: The central bank cares about interest rate smoothing and in addition to stabilizing headline inflation also tries to stabilize output.

$$\log(R_t / \bar{R}) = \rho_i \log(R_{t-1} / \bar{R}) + \rho_\pi \log(\Pi_t / \bar{\Pi}) + \rho_y \log(Y_t / \bar{Y}) \tag{27}$$

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[15] We include an interest rate smoothing parameter in our monetary policy rule as such behavior by central banks and the benefits thereof are well documented in the literature (see, e.g., Lowe and Ellis, 1997; Clarida et al., 1998l Sack and Wieland, 1999). Mohanty and Klau (2004) find that emerging market central banks also put substantial weight on interest rate smoothing.

*3.7 Exogenous Shock Process*

We assume that the productivity in the flexible price sector and sticky price sector follow AR(1) processes, with innovations drawn from i.i.d. normal distributions:

$$A_{f,t} = \rho_{af} A_{f,t-1} + \xi_t \quad , \xi_t \sim \text{i.i.d. } (0,\ \sigma_{af}) \tag{28}$$

$$A_{s,t} = \rho_{as} A_{s,t-1} + \upsilon_t \quad , \upsilon_t \sim \text{i.i.d. } (0,\ \sigma_{as}) \tag{29}$$

In the literature, exclusion of food prices from the price index has been justified on the ground that shocks to food (and energy) prices represent supply shocks. In order to compare our model with those in the prior literature and also to highlight the role of adverse supply shocks on the choice of price index, we focus on productivity shocks.

*3.8 Complete Markets Specification*

We follow the setting of Aoki (2001) to study the choice of price index under complete markets. In this setting all households can insure one another against idiosyncratic income risks completely. It implies that given the same initial wealth each household will choose an identical consumption sequence.[16] Thus, under this complete markets setting

$$C_t^f = C_t^s = \frac{C_t}{1+\lambda} = \frac{Y_t}{1+\lambda} \tag{30}$$

and aggregate demand is given by

$$\left(\frac{Y_t}{1+\lambda}\right)^{-\sigma} = \beta E_t\left[\left(\frac{Y_{t+1}}{1+\lambda}\right)^{-\sigma} \frac{R_t}{\Pi_{t+1}}\right] \tag{31}$$

The equilibrium path of the economy is determined by substituting relevant equations of the incomplete markets model with equations (30) and (31).

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[16] Insurance contracts are assumed to be written before households know which sector they are assigned to. The insurance contracts make the marginal utility of nominal income identical across the households at any time *t*.

### 3.9 Welfare Evaluations

We are interested in the choice of policy rule that yields the highest level of lifetime utility as a weighted sum of households' welfare, which can be written as $V_{total} = \lambda * V_t^f + V_t^s$. Formally, we compute $V_{total}$ associated with each policy rule and look for a policy rule that yields the highest value of $V_{total}$.

### 3.10 Solution Method

Following Kydland and Prescott (1982) and King, Plosser and Rebelo (1988), it became commonplace to characterize the solution of nonlinear models using approximation methods, with first-order approximation techniques being the norm. However, it is now widely accepted that first-order approximation techniques are ill-suited for the comparison of different policy environments using aggregate utility as a welfare criterion.[17] Accurate welfare comparisons across alternative policy environments require at least a second-order approximation of the equilibrium welfare function (Kim and Kim, 2003; Woodford, 2003).

We compute the second-order accurate consumer welfare measure with different monetary policy regimes as in Schmitt-Grohe and Uribe (2004).[18] To produce an accurate second-order approximation of the welfare function, we use a second-order approximation to the policy function. The policy function is approximated using the perturbation method by employing a scale parameter for the standard deviations of the exogenous shocks as an argument of the policy function and taking a second-order Taylor expansion with respect to the state variables as well as the scale parameter. We use an approximation algorithm developed by Schmitt-Grohe and Uribe (2004) with suitable modifications.

### 3.11 Measuring Welfare Gains

Strict core inflation targeting is regarded as the welfare maximizing policy rule in the literature. Therefore, we evaluate the welfare gains associated with a particular policy regime by comparing it to the strict core inflation targeting rule allocation. Let the strict core inflation targeting rule allocation be denoted by *r*, and an alternative policy regime be

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[17] Up to a first-order approximation, lifetime utility, $V_t$, is equal to its non-stochastic steady state value. Hence, given the same non-stochastic steady state, all policy rules yield the same amount of welfare up to a first-order approximation (Schmitt-Grohe and Uribe, 2007).
[18] For a justification of this approach and more details, see Anand and Prasad (2010).

denoted by $a$. We define the welfare associated with the core allocation conditional on the economy being at its non-stochastic steady state at time zero:

$$V_0^r = E_0 \sum_{t=0}^{\infty} \beta^t U(C_t^r, N_t^r) \tag{32}$$

where $C_t^r$ and $N_t^r$ are the consumption and hours of work under the strict core inflation targeting policy rule. Conditional welfare under the alternative regime a is given by

$$V_0^a = E_0 \sum_{t=0}^{\infty} \beta^t U(C_t^a, N_t^a) \tag{33}$$

In order to evaluate the welfare implications of a particular policy regime, we calculate the fraction of a household's consumption that would make it indifferent between regimes. Let $\omega$ be the welfare gain of adopting an alternative policy rule other than strict core inflation targeting. We define $\omega$ as a fraction of additional strict core inflation targeting regime's consumption process that would make a household as well off under regime a as under strict core inflation targeting regime. Then

$$V_0^a = E_0 \sum_{t=0}^{\infty} \beta^t U((1+\omega)C_t^r, N_t^r) \tag{34}$$

Under this specification, a positive value of $\omega$ means that welfare is higher under the alternative policy rule. Rearranging equation (35), the welfare gain $\omega$ is given by

$$\omega = \left[\frac{V_0^a + D_0^r}{V_0^r + D_0^r}\right]^{\frac{1}{1-\sigma}} - 1 \tag{35}$$

where $D_0^r = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \phi_n \frac{\left(N_t^r\right)^{+\psi}}{1+\psi} \right\}$ (36)

A value of $\omega$ *100 = 1, represents a one percentage point of permanent consumption gain under the alternative policy regime.

We study the choice of the optimal price index under two market settings–(i) complete markets (as in Rotemberg and Woodford, 1997; Aoki, 2001) and (ii) an incomplete markets structure characterized by the presence of 'rule of thumb' consumers (as in Gali, Lopez-Salido and Valles, 2004). We compute the welfare gains associated with the four monetary policy regimes defined by equations (24)-(27).[19]

### *3.12 Parameter Selection*

Parameter selection for the model is a challenging task. There is no consensus on the values of some parameters and those used in the literature are mostly based on micro data from advanced countries. We pick baseline parameters from the existing literature and then do extensive sensitivity analysis with respect to the choice of key parameters.

We choose $\beta$ =0.9902, which amounts to an annual real interest rate of 4 percent. We assume that $\lambda$ =2/3, implying that 40 percent of households in the economy are credit constrained, which is consistent with the data in Table 3. We use $\sigma$ =2 as the baseline value of the risk aversion parameter, (i.e., the intertemporal elasticity of substitution is 0.5). This is in the range of values usually assumed in DSGE models and is also the most common value used in the literature on emerging markets (Aguiar and Gopinath, 2007a; Schmitt-Grohe and Uribe, 2007; Devereux, Lane and Xu, 2004).[20]

Following Basu and Fernald (1994, 1995), Basu and Kimball (1997) and Basu (1996), we choose $\theta$ =10 (elasticity of substitution between the differentiated goods), implying a markup of 11 percent. We set the probability that a price does not adjust in a given period ( $\alpha$ ) at 0.66 (Ferrero, Gertler, Svensson, 2008; Rotemberg and Woodford, 1997). This implies that prices remain fixed for a mean duration of 3 quarters, consistent with the micro evidence for both advanced economies and emerging markets.[21]

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[19] For details, see Appendix II of Anand and Prasad (2010).

[20] Friend and Blume (1975) estimate a value of 2 for advanced economies. Other estimates for these countries are between 0 and 5 (e.g., Hansen and Singleton, 1983; Dunn and Singleton, 1986).

[21] Evidence from Brazil (Gouvea, 2007), Chile (Medina et al., 2007), Mexico (Gagnon, 2007) and South Africa (Creamer and Rankin, 2007) indicates that the frequency of price adjustment is much higher for food than for nonfood products and price adjustments are less frequent during periods of low to moderate inflation. Since our model has no trend inflation and we impose price stickiness only in the nonfood sector, our parameter choice is consistent with results of these studies.

The appropriate value of the Frisch elasticity ($\frac{1}{\psi}$) is both important and controversial. The range of values used in the literature goes from 0.25 to 1.[22] For our benchmark case we assume it to be 0.33 ($\psi$ =3). We choose the scaling parameter $\phi_n$ such that the average hours worked in the steady state is 0.38. The elasticity of substitution between food and nonfood goods, $\eta$, is another parameter for which we don't have a good approximation. As the demand for food is inelastic, we set $\eta = 0.6$ for the baseline case.[23]

An important feature of emerging markets is the high share of food expenditure in total household expenditures. Based on household surveys from emerging markets, the average expenditure on food is around 42 percent (see Table 1). We assume that on average half of the households' steady state food consumption is required for subsistence. To match these values in the baseline model we choose the subsistence level food consumption parameter $C^*$=0.0634 and the weight on food in the consumption index $\gamma$ equal to 0.2585 so that the steady state average household expenditure on food is 42 percent. For the monetary policy parameters, we follow Woodford (2003), Gali et al. (2004) and Mohanty and Klau (2004) and choose $\rho_i = 0.7$, $\rho_\pi = 2$ and $\rho_Y = 0.5$.

The major argument in favor of excluding food from the core price index is that the shocks in that sector are seasonal and transient. We set the value of the AR (1) coefficient of the food sector shock at 0.25 (implying that the shock has low persistence, which seems reasonable given the heavy dependence of agriculture on transitory weather conditions). Following the literature, we set the value of the AR(1) coefficient of the nonfood sector shock at 0.95 (Aguiar and Gopinath, 2007a; Schmitt-Grohe and Uribe, 2007). Volatility of productivity shocks in emerging markets is higher than in advanced countries (Pallage and Robe, 2003; Aguiar and Gopinath, 2007b). We choose the standard deviation of the food productivity shock, $\sigma_{af}$=0.03 and the standard deviation of the nonfood productivity shock, $\sigma_{as}$=0.02.[24] Table 5 shows a full set of baseline parameter values for the calibrations.

[22] Christiano, Eichenbaum and Evans (1996) estimate it to be 0.25 while Rotemberg and Woodford (1997) estimate it to be 0.40. Blundell and MaCurdy (1999) estimate the intertemporal elasticity of labor supply to be in the range of [0.5, 1].
[23] With the subsistence level of food consumption, this parameter choice implies a price elasticity of demand for food of about -0.3 in the steady state, which is close to the USDA estimate.
[24] For advanced economies, the values typically used in the literature range from 0.005 to 0.009.

## 4. Baseline Results

We first consider the relevance of our model to evaluating policy rules in emerging markets. Table 6 shows key second moments from the complete and incomplete markets versions of our model. The former can be considered as a stand-in for advanced economies while the latter represents emerging market economies.

The incomplete markets model does a much better job of matching business cycle fluctuations in emerging markets relative to advanced economies—output and consumption are more volatile in emerging markets (Fraga, Goldfajn and Minella, 2004; Kose, Prasad and Terrones, 2010), the ratio of consumption volatility to income volatility is higher (Aguiar and Gopinath, 2007), and inflation is on average higher and more volatile (Fraga, Goldfajn and Minella, 2004; Bowdler and Malik, 2005; Petursson, 2008). To take one specific example, Aguiar and Gopinath (2007) find that consumption is more volatile than output in emerging markets, while consumption is less volatile than output (as anticipated based on the consumption smoothing motive) in advanced economies. These authors report that $\frac{\sigma(c)}{\sigma(Y)}$ is 1.45 for EMs and 0.94 for the advanced economies. In our model, the comparable ratios are 1.92 for economies with incomplete markets and 0.71 for economies with complete markets. While it is not our objective to match specific moments, the incomplete markets version of our model clearly does better at reflecting key properties of business cycles in emerging markets relative to the traditional complete markets model.

Using this model, we now present the conditional welfare gains associated with different policy rules. Welfare gains are defined as the additional lifetime consumption needed to make the level of welfare under strict core inflation targeting identical to that under the chosen policy rule. A positive number indicates that welfare is higher under the alternative policy than under strict core inflation targeting, which serves as the benchmark as prior literature has concluded that it is the optimal policy choice for maximizing welfare. We present results for three alternative policy regimes – strict headline inflation targeting, flexible headline inflation targeting and flexible core inflation targeting.

Table 7 shows the welfare gains from targeting different price indices under complete and incomplete market settings. Under complete markets, the choice of targeting strict core inflation is the best policy, as in Aoki (2001).[25] Figure 4 plots the impulse responses of various macroeconomic variables to a one percent negative food productivity shock under complete markets. Each variable's response is expressed as the percentage deviation from its steady state level. Impulse responses under strict core inflation targeting rule are shown by the solid lines (in red). The dashed lines (in blue) are impulse responses under the strict headline inflation targeting rule.[26] The strict headline inflation targeting regime results in a higher volatility of consumption and output. Also, the policy response is more aggressive under strict headline inflation targeting which leads to a further decline in output. These results are similar to those documented in the existing literature on inflation targeting.

Following an increase in inflation, the central bank raises interest rates, reducing aggregate demand (as consumers postpone their consumption following an increase in interest rates) and, thus, inflation. So, under complete markets, inflation and output move in the same direction and, therefore, stabilizing inflation is equivalent to stabilizing the output gap (Aoki, 2001). It also implies that there are no additional welfare gains from adopting flexible inflation targeting. Thus, under complete markets, strict core inflation targeting is the welfare maximizing policy choice for the central bank.

However, in the presence of credit constrained consumers, flexible headline inflation targeting appears to be a better policy choice (Table 7, right panel). Figure 5 plots the impulse responses of various macroeconomic variables to a one percent negative food productivity shock. Aggregate demand responds differently to monetary tightening under strict core inflation targeting and headline inflation targeting. The central bank is able to reduce aggregate demand by increasing interest rates only when it targets headline inflation. Aggregate demand, instead of going down, goes up in response to the shock if the central bank follows strict core inflation targeting. Thus, headline inflation targeting (both strict and flexible) outperforms strict core inflation targeting. Since in the presence of financial frictions inflation and output may move in opposite directions in response to interest rate changes, stabilizing output results in welfare gains. Thus, flexible headline inflation targeting is the optimal policy choice when markets are not complete.

[25] Our model with complete markets and without subsistence level food consumption is identical to that of Aoki (2001).

[26] We only plot the impulse responses under strict core inflation targeting and strict headline inflation targeting as the welfare losses are much higher under the other policy regimes (Table 7).

In order to examine the mechanics behind this result, we look at the properties of aggregate demand under incomplete markets. In the presence of financial frictions, the consumption choices of different households vary (as opposed to complete markets, where the consumption choice of each household is identical). While consumption demand of unconstrained households is responsive to interest rates (as they optimize inter-temporally), consumption demand of credit-constrained households is independent of interest rate changes (their horizon is static and they consume their entire income each period) and depends only on their current period wage income. Since only a fraction of aggregate demand is influenced by interest rate changes, a monetary tightening does not automatically result in the decline of aggregate demand. The response of aggregate demand crucially depends on the behavior of credit-constrained households.

Figure 5 shows that, following a negative shock to food productivity, the central bank raises the interest rate, lowering the demand of unconstrained households (as it is optimal for them to postpone consumption). However, it has no bearing on the demand of credit-constrained consumers. An increase in the relative price of food following a negative food productivity shock increases the wage income and, therefore, consumption demand of credit-constrained households. Thus, the demand of the two types of households moves in opposite directions following a negative shock to food productivity.

Which of the two demands dominates is determined by the policy regime. Under core inflation targeting, the increase in food prices (and, therefore, the wage income of food sector households) is higher than under headline inflation targeting. This higher wage income translates into higher consumption demand by credit-constrained consumers (who consume all of their current wage income), more than compensating for the lower consumption demand of unconstrained consumers. Consequently, aggregate demand rises. By contrast, when the central bank targets headline inflation, price increases in the food sector are lower and the rise in income and, therefore, the increase in consumption demand in that sector is not enough to compensate for the decline in the demand of unconstrained consumers. Thus, monetary intervention is effective in achieving its objective of reducing aggregate demand only when the central bank targets headline inflation.

To formalize the above arguments, we examine the log-linearized aggregate demand equation, which is given by[27]

$$\hat{c}_t = -\frac{\varsigma_s}{\sigma} E_t\left(\hat{R}_t - \hat{\pi}_{t+1}\right) + E_t\,\hat{c}_{t+1} - \varsigma_f E_t \Delta \hat{c}_{f,t+1} \tag{37}$$

where $\varsigma_s = \frac{\bar{C}_s}{\bar{C}}$ is the steady state share of the sticky price households' consumption,

$\varsigma_f = \frac{\lambda \bar{C}_f}{\bar{C}}$ is the steady state share of flexible price households' consumption and

$$\hat{c}_{f,t} = \left[\frac{1+\frac{a}{\psi}}{1+\frac{a\sigma}{\psi}}\right]\hat{W}_t^f + \left[\frac{a-1}{1+\frac{a\sigma}{\psi}}\right]\hat{A}_{f,t} \tag{38}$$

where $a = \frac{x_{f,t} * y_{f,t}}{\bar{C}_f} > 1$

and $\hat{W}_t^f = \hat{x}_{f,t} + \hat{A}_{f,t}$ (39)

Equations (38) and (39) suggest that, in the presence of credit-constrained consumers, there is a link between aggregate demand and the relative price of food. In this setting, relative prices affect aggregate demand in addition to aggregate supply.[28] Thus, the presence of financial frictions implies that managing aggregate demand requires the central bank to choose a policy regime that would limit the rise in wages of credit-constrained consumers (and, therefore, the increase in their demand).

Next, we examine if the choice of the sector in which households are credit constrained matters for our results. In this experiment, we assume that the food sector households have access to formal finance while the nonfood sector households are credit constrained. We find once again that targeting flexible headline is welfare improving. The welfare gain relative to core inflation targeting is 0.16 percent of lifetime consumption. In this setting,

[27] Aggregate demand is the sum of the log-linearized consumption demand of households in the two sectors. Variables with a hat denote log deviations from corresponding steady state values.
[28] Under complete markets, relative prices only affect aggregate supply (Aoki, 2001).

when the central bank targets headline inflation, food prices rise by less than when it targets core inflation. Aggregate demand declines under both headline and core inflation targeting (unlike in our baseline case). But, since the households in the nonfood sector spend a substantial amount on food and cannot smooth consumption, these households are better off under flexible headline inflation targeting.

## 5. Sensitivity Analysis

Our main result is that in the presence of financial frictions flexible headline inflation targeting is the welfare-maximizing policy choice. We now evaluate the robustness of this result to changes in key parameters – the elasticity of substitution between food and nonfood goods ($\eta$), inverse of Frisch elasticity ($\psi$), the degree of price stickiness ($\alpha$), the elasticity of substitution between different nonfood goods which determines the mark-up in the sticky price sector ($\theta$), and the proportion of credit-constrained households in the economy ($\lambda$).We conduct additional sensitivity analysis with respect to the persistence and volatility of the food productivity shock and Taylor rule coefficients. It should be noted that, since the steady state values of the models differ, it is only possible to make a comparison across regimes and not across different models.

Our key results are driven by the behavior of credit-constrained consumers. Since the wage income of constrained consumers depends crucially on the price elasticity of the demand for food, we first conduct sensitivity analysis with respect to parameters influencing the price elasticity of demand. The presence of a subsistence level for food expenditures affects the marginal utility of food and nonfood consumption. It also lowers the elasticity of substitution between food and nonfood. The demand for food is given by equation (18), which is the sum of an iso-elastic term $\gamma(x_{f,t})^{-\eta}C_t$ and a price inelastic term $(1+\lambda)C^*$. The price elasticity of demand is a weighted sum of these two terms (the weights are $\eta$ and zero, respectively). Thus, the presence of subsistence food consumption lowers the price elasticity of the demand for food. Table 8 shows welfare gains from different policy rules in the absence of a subsistence level of food consumption. Clearly, our main result does not depend on the presence of subsistence level of food consumption although that feature of the model increases the welfare gains from flexible headline inflation targeting.

Next, we examine the sensitivity of the results to the elasticity of substitution between food and nonfood goods, denoted by $\eta$ (Table 9). Under complete markets, core inflation targeting is the best policy choice for any value of the elasticity of substitution. However, under incomplete markets, flexible headline inflation targeting continues to dominate other policies for values of the elasticity as high as $\eta$ = 0.9. For higher values of this elasticity, strict core inflation targeting seems to do marginally better than strict headline inflation targeting. The difference between strict core inflation targeting and strict headline inflation targeting is almost negligible for high values of this elasticity.

The elasticity of substitution has an important influence on the income of credit-constrained households. For low values of this elasticity, following a negative shock to productivity of food the demand for food does not go down substantially and leads to a large increase in the wage income of food-producing (credit-constrained) households. Increased demand of credit-constrained consumers is enough to counteract the decline in the demand of unconstrained households. However, when the elasticity of substitution is high, demand for food goes down substantially and the increase in the income and demand of credit-constrained households is no longer sufficient to compensate for the decline in the demand of unconstrained households. In fact, for sufficiently high values of the elasticity of substitution, the wage income of credit-constrained households may even go down.

Again, even though we cannot strictly compare the impulse responses, it is instructive to plot them for different values of the elasticity of substitution to understand how varying the elasticity of substitution affects various macroeconomic variables. Figure 6 shows the impulse responses of various macroeconomic variables to a 1 percent negative food productivity shock under flexible headline inflation targeting for a high value of the elasticity of substitution ($\eta$ = 2) and also a low value ($\eta$ = 0.6). For low values of the elasticity of substitution, a positive deviation (from the respective steady state) in the food price and wage of credit-constrained households is large. When the elasticity of substitution is high, the wage of credit-constrained consumers in fact declines relative to the steady state value (as the increase in the price of food is significantly lower).

In Tables 10-13, we present the results of sensitivity analysis with respect to the inverse of the Frisch elasticity ($\psi$), price stickiness ($\alpha$), fraction of credit-constrained households (

$\lambda$ ) and the mark-up in the sticky price sector ( $\theta$ ). We have selected the most common values of these parameters used in the literature to carry out the sensitivity experiments. Our results are robust to the selection of parameter values around their baseline values.[29]

Following Gali et al. (2004), we also conduct sensitivity analysis with respect to the coefficients of the Taylor rule (Table 14). Flexible headline inflation targeting performs better than other regimes irrespective of the choice of Taylor rule coefficients. We also compute the Taylor rule parameters associated with optimal strict core inflation targeting under the baseline case and compare the welfare gains associated with adopting flexible headline inflation targeting.[30] We find that the welfare gains are still positive. This exercise suggests that our results reflect the superior performance of the relevant policy rules rather than any specific choice of parameters for the rules.

Shocks to productivity in the food sector are regarded as transitory and highly volatile. So we do additional sensitivity analysis for various combinations of the degrees of persistence and volatility of these shocks. From the results shown in Table 15, it is evident that our results are robust to various combinations and also that welfare gains from adopting flexible headline targeting are even higher if shocks are more persistent and highly volatile. Of course, in the case of an advanced economy like the U.S. where the volatility of these shocks is an order of magnitude smaller than in typical emerging markets, the potential welfare gains are considerably smaller.

Finally, we consider the case where there are only aggregate shocks rather than sector-specific shocks. To this point, we have focused on the impact of a shock to productivity in the flexible price sector as it most clearly illustrates the point about what monetary policy rule is better in response to a shock to the flexible price part of the economy. Of course,

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[29] Note that we assume full flexibility of food prices. Price rigidity of components of the CPI not included in core CPI would strengthen the case for targeting headline inflation. The same is true if we take into account that food prepared and consumed at home may have different price stickiness than food away from home. On the other hand, food away from home has higher price elasticity than food prepared at home. The sensitivity analysis shows that this would not overturn our results.

[30] For computing optimal parameters, we restrict our search to [0,3] for $\rho_\pi$ and [0,1] for $\rho_i$. We find that the best rule requires $\rho_\pi = 3$ and $\rho_i = 0.95$. The value of $\rho_\pi$ is the largest value that we allow for in our search. If we left this parameter unconstrained, then optimal policy would call for an arbitrarily large coefficient on inflation. Under the optimal policy, the economy would be characterized by zero inflation volatility (Schmitt-Grohe and Uribe, 2007).

while the impulse responses that we analyzed highlight different models' responses to only a food productivity shock, the simulation results include both types of shocks. We now recompute the model with a productivity shock that is common to both sectors. Intuitively, this would increase the welfare gain from adopting headline inflation targeting as there are no longer any shocks specific to the rigid price sector. This is indeed what we find.

Table 16 shows the welfare gains from alternative inflation targeting rules when the only shock in the economy is an aggregate shock—a shock hitting both sectors symmetrically. We implement this by setting the two sector-specific shock processes in equations 28 and 29 to be the same. Note that the classical result that core inflation targeting is a better policy holds up in the complete markets setting. But this result is overturned in our incomplete markets model.

*5.1 Extensions of the Model*

In order to further generalize our findings, we consider two extensions of our baseline model. The first extension looks at an alternative characterization of complete markets. Most existing models with complete markets assume that agents can insure against income risks ex ante. In other words, insurance contracts are written before households know which sector they are in (see, e.g., Aoki, 2001). Given the same initial wealth, consumers will then choose identical consumption streams. A more realistic way of characterizing complete markets is to assume that consumers can insure against income risks but only after being assigned to a particular sector. One could regard this as a complete market setting conditional on worker assignment to sectors, which is determined ex-ante (before insurance contracts are written). In other words, a household cannot insure against cross-sector income risk. Under this alternate market structure, each type of household chooses a consumption stream to maximize its lifetime utility subject to its idiosyncratic budget constraint (see Appendix III of Anand and Prasad, 2010, for more details). In Table 17, we present the welfare gains under this market structure and with flexible headline inflation targeting. Clearly, flexible headline inflation targeting produces better outcomes than strict core inflation targeting even with this alternative market structure.

A second extension of our baseline model looks at a more general case where agents in both sectors can be credit constrained. We assume that a fraction $\lambda_1 > 0$ and $\lambda_2 > 0$ of households in the flexible price sector and sticky price sector, respectively, can insure against income risks ex post. We look at combinations of $\lambda_1$ and $\lambda_2$ such that 40 percent of the households in the economy are credit constrained.[31] Table 18 presents the welfare gains of pursuing flexible headline inflation targeting for some possible combinations of $\lambda_1$ and $\lambda_2$. Even under this more general setting, targeting flexible headline inflation outperforms a strict core inflation targeting rule.

## 6. Concluding Remarks

The primary objective of most central banks, whether or not they explicitly target inflation, is to keep inflation low and stable. To achieve this objective, the question of whether to target core or headline inflation remains a key operational issue. Previous research has concluded that central banks should focus on stabilizing core inflation. However, those results rely on the assumption that markets are complete and that price stickiness is the only source of distortion in the economy. In this paper, we have developed a more realistic model with the following key features –incomplete markets with credit-constrained consumers; households requiring a minimum subsistence level of food to survive; low price elasticity of demand for food items; and a high share of expenditure on food in households' total expenditure. These features are especially relevant for emerging markets.

We show that, in the presence of credit-constrained consumers, targeting core inflation is no longer welfare maximizing. Also, stabilizing inflation is not sufficient to stabilize output when markets are not complete. Under these conditions, flexible headline inflation targeting—which involves targeting headline inflation and putting some weight on the output gap—improves welfare relative to the practical alternatives that we consider.

Our results differ from those of traditional models due to the presence of financial frictions in the economy. Lack of access to finance makes the demand of credit-constrained households insensitive to interest rate fluctuations. Their demand is determined by real wages, which depend on prices in the flexible price sector. Thus, if the central bank ignores fluctuations in the flexible price sector, aggregate demand may in fact move in the opposite

[31] This is consistent with the empirical evidence that only about 42 percent of households in emerging markets have access to formal finance (Table 3). The fraction of credit-constrained households is given by $1+\lambda-(\lambda_1+\lambda_2)$.

direction to what is intended by the monetary policy intervention. To have the desired effect on aggregate demand, the central bank has to target a price index that would dampen the response of credit-constrained consumers. In our setting, this means that the central bank should target headline inflation. Our results have special significance for central banks in emerging markets. Given the prevalence of financial frictions in these economies, the conventional view that targeting core CPI inflation can best stabilize inflation and output needs to be re-examined.[32]

One possible extension of our model is to include money explicitly. While this would provide a saving mechanism for hand-to-mouth consumers, it would in fact strengthen the case for headline inflation targeting to preserve the value of monetary savings. Another extension would be to include physical capital in the model. This would highlight a practical dilemma that emerging market central banks are grappling with in pursuit of their objective of price stability (low inflation). For instance, in India, the central bank was forced to raise policy rates during 2011 to deal with surging food price inflation even though the rate hikes hurt industrial activity. Similar patterns can be found in many other emerging markets. Indeed, this issue has just flared up again with the recent surge in worldwide food prices.

In emerging market and low-income economies, the classical result, which implies that the central bank should ignore food price inflation, is not politically tenable. Raising interest rates in response to a transitory negative shock to agricultural sector productivity may seem counter-intuitive. But our results suggest that such a policy could in fact be welfare improving in an incomplete markets setting and with additional features of emerging markets such as the high level of food expenditure in household consumption expenditure.

[32] In related work, Catao and Chang (2010) show that, for a small open economy that is a net buyer of food, the high volatility of world food prices imply that headline CPI inflation targeting is welfare improving relative to core CPI targeting.

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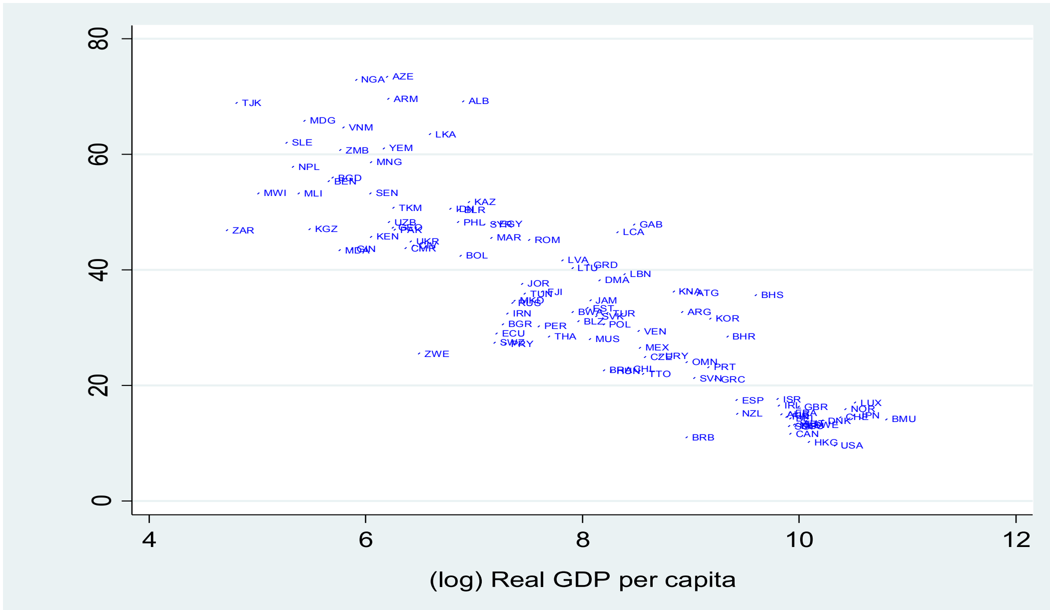
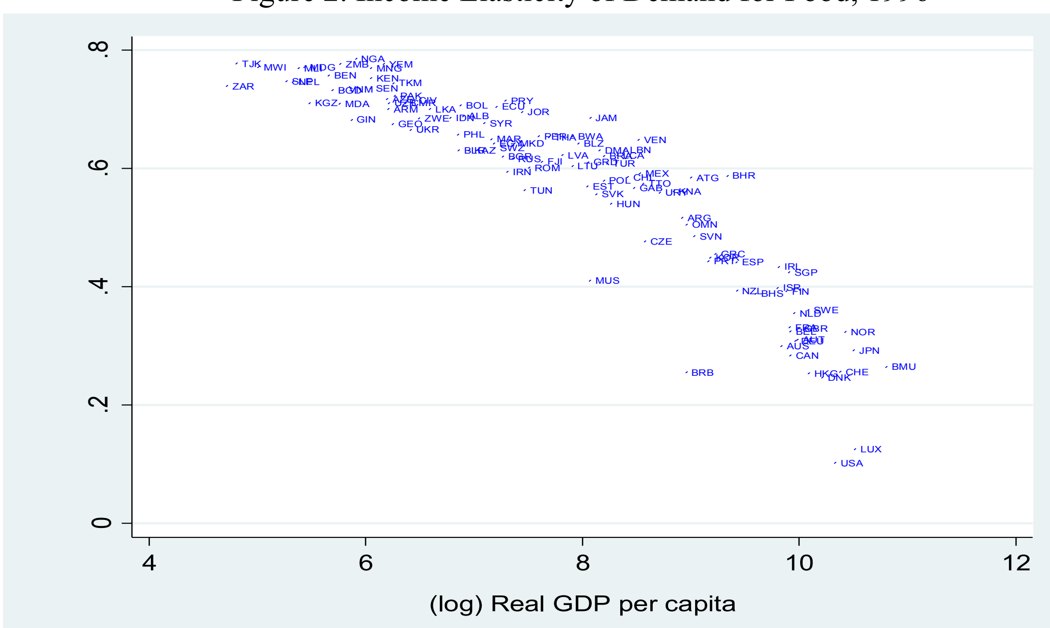
Figure 1. Share of Expenditure on Food, 1996
(as percent of total household expenditure)



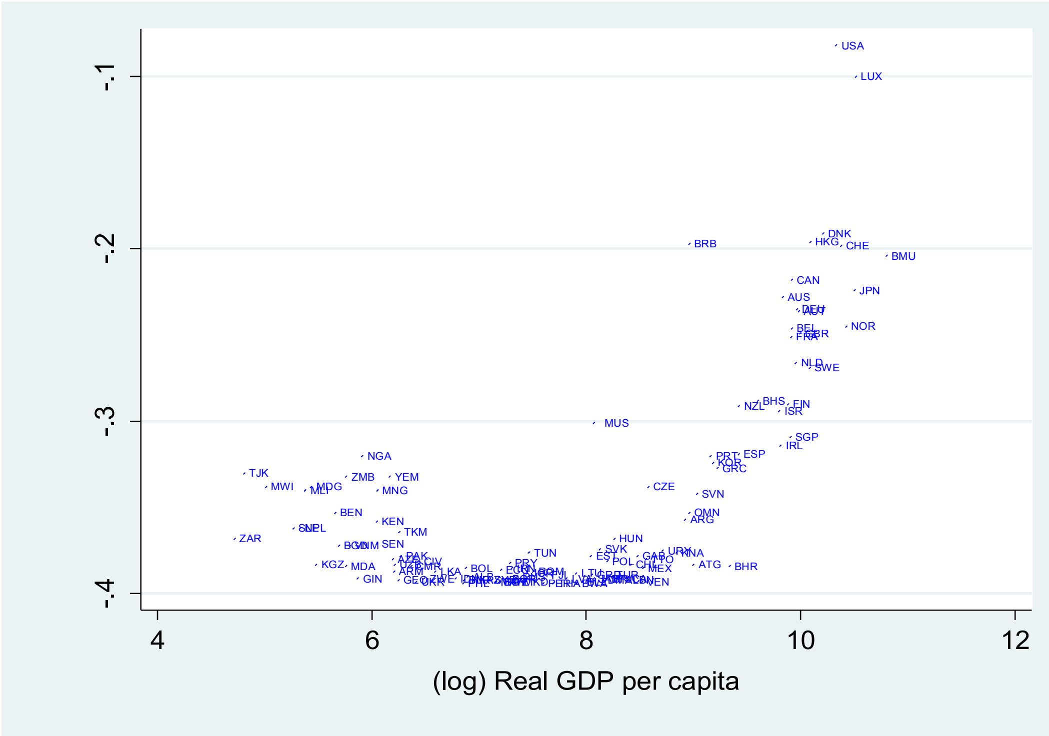

Source: WDI and International Food Consumption Patterns Dataset, Economic Research Service, USDA.
Note: Expenditure on food includes expenditure on food prepared and consumed at home plus beverages and tobacco.

Figure 2. Income Elasticity of Demand for Food, 1996



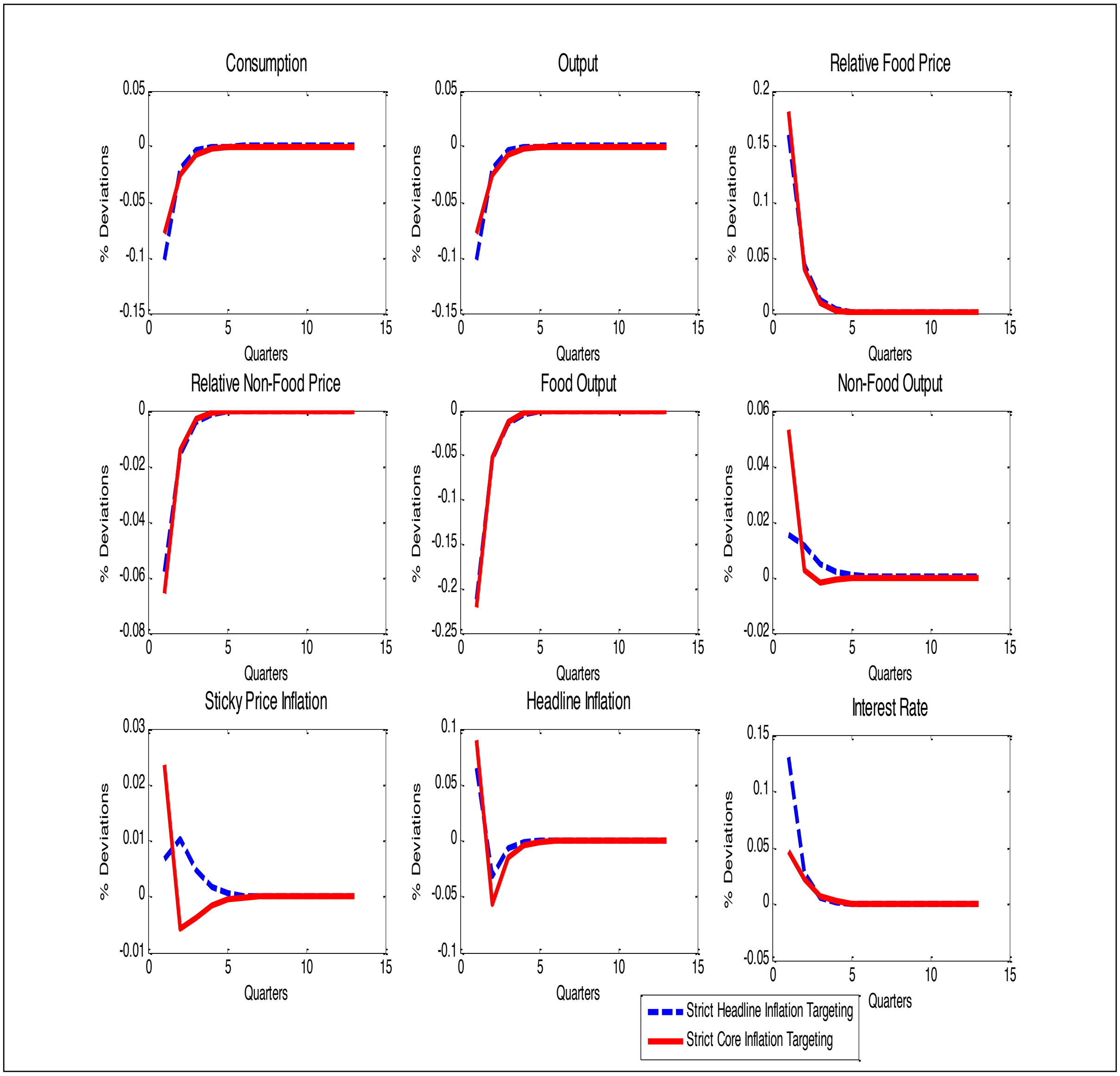

Source: WDI and International Food Consumption Patterns Dataset, Economic Research Service, USDA.
Notes: These country-specific income-elasticity values represent the estimated percentage change in demand for food if total income increases by 1 percent. Food includes food prepared and consumed at home plus beverages and tobacco.

Figure 3. Slutsky Own-Price Elasticity of Demand for Food, 1996



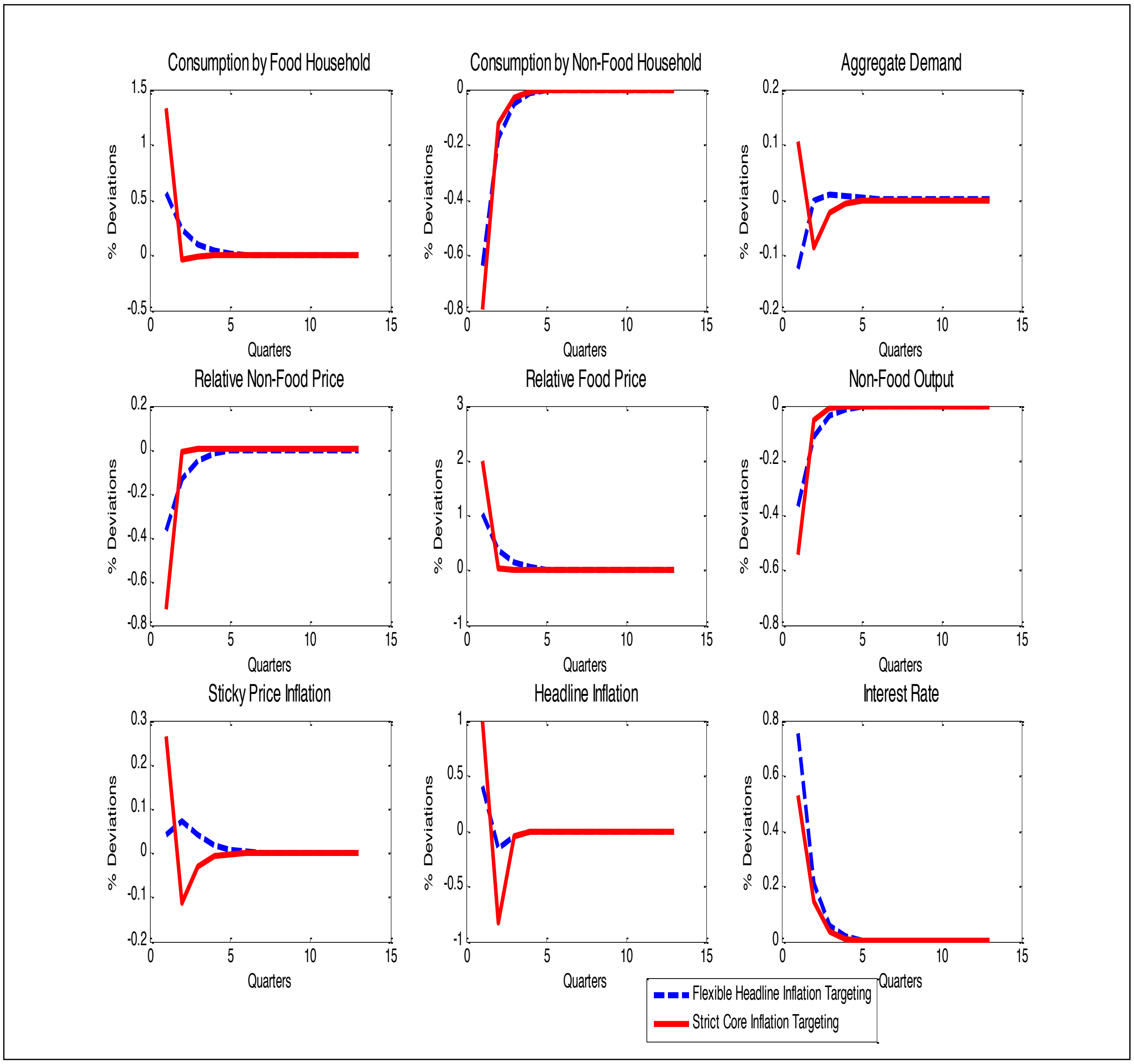

Source: WDI and International Food Consumption Patterns Dataset, Economic Research Service, USDA.
Notes: Country-specific elasticity value represents a percentage change in demand for food if food prices increase by 1 percent (keeping real income constant). Food includes food prepared and consumed at home plus beverages and tobacco.

Figure 4. Impulse Responses to a Negative Food Productivity Shock
(Complete Markets, with subsistence level food consumption)



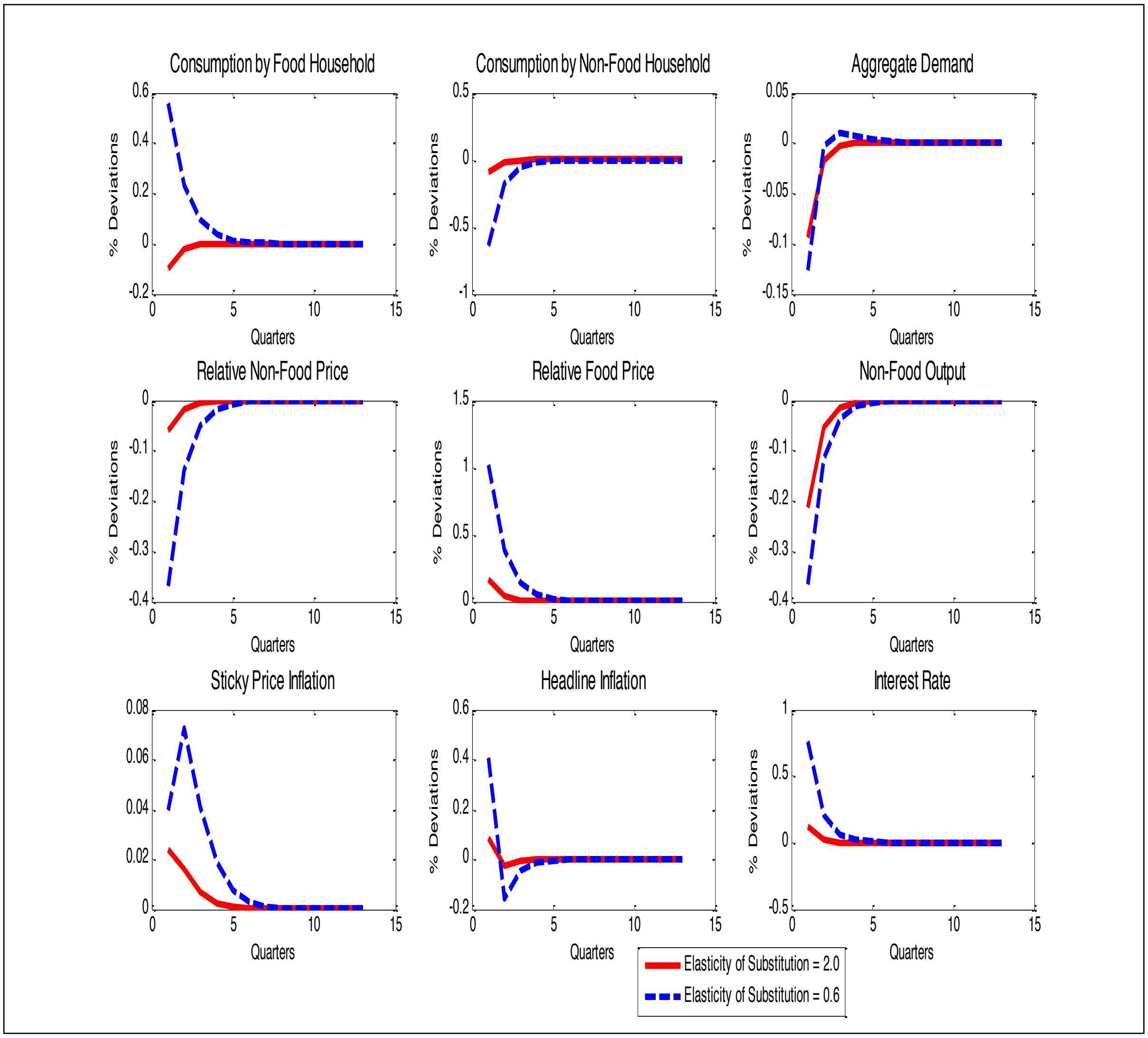

Notes: The impulse responses shown above are to a one percent negative shock to food productivity. Each variable's response is expressed as the percentage deviation from its steady state level. Strict core inflation targeting means that central bank follows the policy regime given by equation (24). Strict headline inflation targeting means that central bank follows the policy regime given by equation (25).

Figure 5. Impulse Responses to a Negative Food Productivity Shock
(Incomplete Markets, with subsistence level food consumption)




Notes: The impulse responses shown above are to a one percent negative shock to food productivity. Each variable's response is expressed as the percentage deviation from its steady state level. Strict core inflation targeting means that central bank follows the policy regime given by equation (24). Flexible headline inflation targeting means that central bank follows the policy regime given by equation (27).

Figure 6. Impulse Responses to a Negative Food Productivity Shock under Flexible Headline Inflation Targeting Rule
(Incomplete Markets, with different elasticities of substitution for food)




Notes: The impulse responses shown above are to a one percent negative shock to food productivity. Each variable's response is expressed as the percentage deviation from its steady state level. These impulse responses are generated with the central bank following the flexible headline inflation targeting rule given by equation (27).

Table 1. Share of Food Expenditure in Total Household Expenditure

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

Source: Household Surveys, CEIC, International Food Consumption Patterns Dataset, Economic Research Service, USDA and authors' calculations.
Notes: Data for emerging markets are for 2005 while for advanced economies it is for 2006. Expenditure on food includes expenditure on food consumed at home only and does not include expenditure on beverages and tobacco.

Table 2. Income (Expenditure) Elasticity and Slutsky Own-Price Elasticity of Food (1996)

| *Emerging Markets* | *Income Elasticity* | *Price Elasticity* | *Advanced Economies* | *Income Elasticity* | *Price Elasticity* |
|---|---|---|---|---|---|
| Vietnam | 0.73 | -0.37 | New Zealand | 0.39 | -0.29 |
| Pakistan | 0.72 | -0.38 | Finland | 0.39 | -0.29 |
| Jordan | 0.70 | -0.39 | Sweden | 0.36 | -0.27 |
| Indonesia | 0.69 | -0.39 | Netherlands | 0.36 | -0.27 |
| Philippines | 0.66 | -0.39 | France | 0.33 | -0.25 |
| Peru | 0.66 | -0.39 | United Kingdom | 0.33 | -0.25 |
| Thailand | 0.65 | -0.39 | Belgium | 0.33 | -0.25 |
| Egypt | 0.64 | -0.39 | Norway | 0.32 | -0.24 |
| Brazil | 0.62 | -0.39 | Austria | 0.31 | -0.24 |
| Russia | 0.62 | -0.39 | Germany | 0.31 | -0.23 |
| Turkey | 0.61 | -0.39 | Australia | 0.30 | -0.23 |
| Iran | 0.60 | -0.39 | Japan | 0.29 | -0.22 |
| Mexico | 0.59 | -0.38 | Canada | 0.28 | -0.22 |
| Chile | 0.59 | -0.38 | Switzerland | 0.26 | -0.20 |
| Poland | 0.58 | -0.38 | Denmark | 0.25 | -0.19 |
| Hungary | 0.54 | -0.37 | Luxembourg | 0.13 | -0.10 |
| Argentina | 0.52 | -0.36 | United States | 0.10 | -0.08 |
| **Average** | **0.63** | **-0.38** | **Average** | **0.30** | **-0.22** |

Source: WDI and International Food Consumption Patterns Dataset, Economic Research Service, USDA.
Notes: Data only for selected countries from the full sample (plotted in Figure 3) are shown here. These country-specific income-elasticity values represent the estimated percentage change in demand for food if total income increases by 1 percent. Country-specific price-elasticity value represents a percentage change in the demand for food if food prices increase by 1 percent (keeping real income constant). Food includes food prepared at home and consumed plus beverages and tobacco.

Table 3. Composite Measure of Access to Financial Services in Emerging Markets

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

Source: Global Findex Database, World Bank, 2011.
Note: The composite indicator measures the percentage of the adult population with access to an account with a financial intermediary. The table only shows data for a selected group of individual emerging markets (EMs). Reported medians are based on full set of emerging markets and advanced economies (per IMF country classification) available in the database.

Table 4. Properties of Food and Nonfood Inflation

| | *Food Inflation* | | | *Nonfood Inflation* | | |
|---|---|---|---|---|---|---|
| | Mean | Std. Deviation | Std. Dev. of innovations | Mean | Std. Deviation | Std. Dev. of innovations |
| Emerging Markets | 6.63 | 5.00 | 5.61 | 5.38 | 2.92 | 3.72 |
| Advanced Economies | 2.08 | 2.45 | 2.75 | 2.09 | 1.10 | 1.24 |

Notes: The data used in constructing this table are from Walsh (2011), and are based on monthly price indices from 1985 – 2008. The numbers reported are medians for 23 emerging markets and 26 advanced economies. Means and standard deviations are based on the month-to-month log changes in the price indices. The standard deviation of innovations indicates the volatility of changes in food and nonfood inflation.

Table 5. Parameter Calibration: Baseline Model

| *Parameters* | *Definitions* | ***Values*** |
|---|---|---|
| $\sigma$ | Risk aversion | 2 |
| $\beta$ | Subjective discount factor | 0.9902 |
| $\psi$ | Inverse of Frisch elasticity | 3 |
| $\alpha$ | Probability of firm not changing price | 0.66 |
| $\eta$ | Elasticity of substitution between food and nonfood | 0.60 |
| $\gamma$ | Weight on food in the consumption index | 0.26 |
| $\lambda$ | Household with credit constraint | 0.66 |
| $\theta$ | Elasticity of substitution between different nonfood goods | 10 |
| $\rho_Y$ | Weight on output gap in Taylor rule | 0.5 |
| $\rho_\pi$ | Weight on inflation gap in Taylor rule | 2 |
| $\rho_i$ | Weight on interest rate smoothing in Taylor rule | 0.70 |
| $\rho_{af}$ | Persistence of food productivity shock | 0.25 |
| $\rho_{as}$ | Persistence of nonfood productivity shock | 0.95 |
| $\sigma_{af}$ | Standard deviation of food productivity shock | 0.03 |
| $\sigma_{as}$ | Standard deviation of nonfood productivity shock | 0.02 |

Table 6. Model Properties: Volatility of Selected Variables under Strict Core Inflation Targeting

| | Complete markets (no frictions) | Incomplete markets |
|---|---|---|
| Consumption | 0.25 | 1.45 |
| Consumption (food households) | 0.25 | 1.78 |
| Consumption (nonfood hholds.) | 0.25 | 1.23 |
| Output | 0.35 | 0.76 |
| Output (food) | 0.36 | 0.79 |
| Output (nonfood) | 0.35 | 0.73 |
| Headline Inflation | 0.11 | 0.33 |
| Core Inflation | 0.01 | 0.02 |

Notes: This table shows the standard deviations of selected variables from the two versions of the model, with both versions based on the parameterization as per Table 5.

Table 7. Welfare Gains from Various Inflation Targeting Rules

| | *Complete Markets* | | | *Incomplete Markets* | | |
|---|---|---|---|---|---|---|
| | Strict Headline Targeting | Flexible Headline Targeting | Flexible Core Targeting | Strict Headline Targeting | Flexible Headline Targeting | Flexible Core Targeting |
| Welfare gain (relative to strict core inflation targeting) | -0.005 | -0.011 | -0.006 | 0.271 | 0.314 | 0.076 |

Notes: Welfare gain here represents the welfare gain associated with each policy choice. Welfare gains ( $\omega$ *100) are defined as the percent increase in the strict core inflation targeting consumption process necessary to make the level of welfare under strict core inflation targeting policy identical to that under the evaluated policy. Thus, a positive number indicates that welfare is higher under alternative policy than under the strict core inflation targeting policy. Targeting policy rules are defined in equations (24) - (27).

Table 8. Welfare Gains from Various Inflation Targeting Rules Without Subsistence Level Food

| *Welfare gain (in percent of strict core inflation targeting consumption)* | | | | | | |
|---|---|---|---|---|---|---|
| | *Complete Markets* | | | *Incomplete Markets* | | |
| Elasticity of Substitution | Strict Headline Targeting | Flexible Headline Targeting | Flexible Core Targeting | Strict Headline Targeting | Flexible Headline Targeting | Flexible Core Targeting |
| 0.4 | -0.010 | -0.013 | -0.003 | 0.127 | 0.145 | 0.025 |
| 0.5 | -0.008 | -0.012 | -0.004 | 0.031 | 0.038 | 0.010 |
| 0.6[a] | -0.007 | -0.011 | -0.004 | 0.007 | 0.011 | 0.004 |

Notes: The superscript *a* denotes the baseline value of this parameter.

Table 9. Welfare Gains from Various Inflation Targeting Rules for Different Values of Elasticity of Substitution ($\eta$)

| *Welfare gain (in percent of strict core inflation targeting consumption)* | | | | | | |
|---|---|---|---|---|---|---|
| | *Complete Markets* | | | *Incomplete Markets* | | |
| Elasticity of Substitution | Strict Headline Targeting | Flexible Headline Targeting | Flexible Core Targeting | Strict Headline Targeting | Flexible Headline Targeting | Flexible Core Targeting |
| 0.6[a] | -0.005 | -0.011 | -0.006 | 0.271 | 0.314 | 0.076 |
| 0.7 | -0.004 | -0.011 | -0.006 | 0.058 | 0.074 | 0.022 |
| 0.8 | -0.004 | -0.010 | -0.006 | 0.017 | 0.024 | 0.009 |
| 0.9 | -0.004 | -0.010 | -0.006 | 0.005 | 0.008 | 0.004 |
| 1.5 | -0.002 | -0.008 | -0.006 | -0.001 | -0.004 | -0.003 |
| 2.0 | -0.001 | -0.007 | -0.006 | -0.001 | -0.005 | -0.003 |

Notes: The superscript *a* denotes the baseline value of this parameter.

Table 10. Welfare Gains for Different Parameter Values of Inverse of Frisch Elasticity ($\psi$)

| *Inverse of Frisch Elasticity* | *Strict Headline Targeting* | *Flexible Headline Targeting* | *Flexible Core Targeting* |
|---|---|---|---|
| 2.5 | 0.570 | 0.652 | 0.159 |
| 3.0[a] | 0.271 | 0.314 | 0.076 |
| 3.5 | 0.166 | 0.195 | 0.048 |

Notes: Parameter value of 2.5 implies labor supply elasticity of 0.4 while a value of 3.5 implies labor elasticity of 0.28. The superscript *a* denotes the baseline value of this parameter.

Table 11. Welfare Gains for Different Degrees of Price Rigidity ($\alpha$)

| *Probability of firms not changing prices* | *Strict Headline Targeting* | *Flexible Headline Targeting* | *Flexible Core Targeting* |
|---|---|---|---|
| 0.50 | 0.141 | 0.161 | 0.027 |
| 0.66[a] | 0.271 | 0.314 | 0.076 |
| 0.75 | 0.435 | 0.506 | 0.165 |

Notes: Parameter value of 0.50 implies that the mean duration for which prices remain fixed is 2 quarters while a value of 0.75 implies that the mean duration for which prices remain fixed is 4 quarters. The superscript *a* denotes the baseline value of this parameter.

Table 12. Welfare Gains for Different Proportions of Credit Constrained Consumers ($\lambda$)

| *Credit constrained consumers* | *Strict Headline Targeting* | *Flexible Headline Targeting* | *Flexible Core Targeting* |
|---|---|---|---|
| 0.50 | 1.095 | 1.319 | 0.368 |
| 0.66[a] | 0.271 | 0.314 | 0.076 |
| 0.75 | 0.113 | 0.117 | 0.015 |

Notes: Parameter value of 0.50 implies that 33 percent of households are in the flexible price sector and are credit constrained. A value of 0.75 implies that 43 percent of households are in the flexible price sector and are credit constrained. The superscript *a* denotes the baseline value of this parameter.

Table 13. Welfare Gains for Different Parameter Values of Elasticity of Substitution between Different Nonfood Goods ($\theta$)

| *Elasticity of substitution between food and non- food goods* | *Strict Headline Targeting* | *Flexible Headline Targeting* | *Flexible Core Targeting* |
|---|---|---|---|
| 5 | 0.231 | 0.254 | 0.056 |
| 10[a] | 0.271 | 0.314 | 0.076 |
| 15 | 0.306 | 0.368 | 0.096 |

Notes: The parameter $\theta$ determines the mark-up in the sticky price sector. A value of 5 implies a mark up of 25 percent and a value of 15 implies a mark up of 7 percent. The superscript *a* denotes the baseline value of this parameter.

Table 14. Welfare Gains for Different Taylor Rule Parameters
(a) Sensitivity to Coefficient on Inflation Gap in Taylor rule ($\rho_\pi$)

| *Weight on inflation gap* | *Strict Headline Targeting* | *Flexible Headline Targeting* | *Flexible Core Targeting* |
|---|---|---|---|
| 1.00 | 0.350 | 0.506 | 0.255 |
| 1.50 | 0.301 | 0.371 | 0.124 |
| 2.00[a] | 0.271 | 0.314 | 0.076 |
| 2.50 | 0.252 | 0.281 | 0.053 |
| 3.00 | 0.238 | 0.261 | 0.040 |

Notes: Other Taylor rule parameters are kept at their baseline values ($\rho_i$ =0.7, $\rho_Y$ =0.5). The superscript *a* denotes the baseline value of this parameter.

(b) Sensitivity to Coefficient on Output Gap in Taylor Rule ($\rho_Y$)

| *Weight on output gap* | *Strict Headline Targeting* | *Flexible Headline Targeting* | *Flexible Core Targeting* |
|---|---|---|---|
| 0.00 | 0.271 | | |
| 0.50[a] | | 0.314 | 0.076 |
| 0.75 | | 0.343 | 0.120 |
| 1.00 | | 0.378 | 0.168 |
| 1.50 | | 0.463 | 0.276 |
| 2.00 | | 0.567 | 0.400 |

Notes: Other Taylor rule parameters are kept at their baseline values ($\rho_i$ =0.7, $\rho_\pi$ =2). The superscript *a* denotes the baseline value of this parameter.

(c) Sensitivity to Interest Smoothing Parameter in Taylor Rule
($\rho_i$)

| *Weight interest rate smoothing* | *Strict Headline Targeting* | *Flexible Headline Targeting* | *Flexible Core Targeting* |
|---|---|---|---|
| 0.00 | 0.268 | 0.340 | 0.106 |
| 0.10 | 0.267 | 0.332 | 0.098 |
| 0.20 | 0.267 | 0.326 | 0.092 |
| 0.30 | 0.267 | 0.322 | 0.088 |
| 0.40 | 0.268 | 0.319 | 0.084 |
| 0.50 | 0.269 | 0.317 | 0.081 |
| 0.60 | 0.270 | 0.315 | 0.078 |
| 0.70[a] | 0.271 | 0.314 | 0.076 |
| 0.80 | 0.273 | 0.312 | 0.074 |
| 0.90 | 0.274 | 0.312 | 0.073 |

Notes: Other Taylor rule parameters are kept at their baseline values ($\rho_\pi$ =2, $\rho_Y$ =0.5). The superscript *a* denotes the baseline value of this parameter.

Table 15. Welfare Gains from Flexible Headline Inflation Targeting for Different Combinations of Persistence and Volatility of Food Productivity Shocks

| | | *Volatility of Shocks* | | |
|---|---|---|---|---|
| | | 0.02 | 0.03 | 0.04 |
| *Persistence* | 0.10 | 0.198 | 0.212 | 0.231 |
| | 0.25 | 0.243 | 0.314 | 0.412 |
| | 0.50 | 0.354 | 0.564 | 0.858 |
| | 0.95 | 0.811 | 1.547 | 2.504 |

Notes: Persistence of food productivity is the coefficient of AR (1) process in equation (28). Volatility of food productivity shocks is the standard error of these shocks. Persistence and volatility of nonfood shocks is held constant at 0.95 and 0.02, respectively.

Table 16. Welfare Gains Under Different Policy Rules With Only Aggregate Shocks

| | Flexible Core Targeting | Strict Headline Targeting | Flexible Headline Targeting |
|---|---|---|---|
| Complete Markets | -0.006 | -0.012 | -0.017 |
| Incomplete Markets | 0.048 | 0.811 | 0.845 |

Notes: We set the two sector-specific shock processes (equations 28 and 29) to be the same.

Table 17. Welfare Gains under Alternate Complete Markets Structure

| *Elasticity of Substitution* | *Flexible Headline Inflation Targeting* |
|---|---|
| 0.6[a] | 0.163 |
| 0.7 | 0.045 |
| 0.8 | 0.015 |
| 0.9 | 0.005 |

Notes: The superscript *a* denotes the baseline value of this parameter.

Table 18. Welfare Gains under General Model

| *Fraction of households in flexible price sector with access to formal finance* | *Fraction of households in sticky price sector with access to formal finance* | *Welfare gains from flexible headline inflation targeting* |
|---|---|---|
| 0.10 | 0.93 | 1.196 |
| 0.30 | 0.80 | 0.679 |
| 0.50 | 0.67 | 0.538 |
| 0.70 | 0.53 | 0.475 |
| 0.90 | 0.40 | 0.444 |

Notes: We have chosen combinations of the parameters $\lambda_1$ and $\lambda_2$ such that overall 40 percent of households in the economy are credit constrained.