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Price Subsidies and the Conduct of Monetary Policy

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Price Subsidies and the Conduct of Monetary Policy

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Abstract

This paper investigates optimized monetary policy rules in the presence of government intervention to stabilize prices of certain categories of goods and services. The paper estimates a small-scale, structural equilibrium model with a sticky-price sector and a subsidized price sector for a large number of countries using Bayesian methods. The main result of this paper is that strict headline inflation targeting could be outperformed by sectoral inflation targeting, output gap stabilization, or a combination of these. In addition, several country cases exhibit lower performance of both headline and core inflation stabilization, the two most common policies in modern central banks' practices. For practical monetary policy design, we numerically identify country specific thresholds for the degree of government intervention in price setting under which core inflation targeting turns out to be the optimal choice in the context of implementable Taylor rules.

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I. INTRODUCTION

Over the recent years, central banks have started paying particular attention to distinguishing short-term movements in the consumer price index (CPI) statistics from underlying or core inflation for both conducting analysis and designing policies. Practically, it turns out that inflation targeters tend to use different specifications of core inflation.[1] Although, many agree that core inflation corresponds to the common (or persistent) component underlying price movements, there is so far no agreement on a particular definition and on a specific method to measure it. The two most commonly used definitions of core inflation assume a priori exclusion of the most volatile prices (typically energy and food prices) and administered and regulated prices which are heavily influenced by government policies (price controls, subsidies, and indirect taxes) from the overall CPI.[2]

From a theoretical perspective, the rationale for excluding the most volatile prices from the overall CPI is discussed in the recent literature where optimal choices through simple monetary policy rules are emphasized. Aoki (2001) shows that in an economy with two sectors differentiated by the way prices are adjusted—flexible versus sticky prices—the best policy a monetary authority can undertake is the one that fully stabilizes inflation in the distorted sector and fully disregards inflation in the flexible price sector. Implicitly, Aoki defines core inflation as the inflation of sticky prices which, therefore, excludes fully flexible prices. This definition of core inflation tends to assume that goods with flexible prices are the ones exhibiting the most volatile prices and correspond to the items central banks are commonly excluding from the components of CPI. This implicit assumption seems intuitive, although debatable, since the author does not report any evidence in favor of the perfect mapping between flexible-price goods and volatile-price goods.[3] In fact, in many countries food and energy prices are to some extent subsidized, hence, not fully flexible by definition.

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[1] Examples are monetary authorities of Korea, Malaysia, Thailand, who target core inflation defined as CPI excluding petroleum products and agricultural products, items with highly volatile or administered prices, or raw food and energy, respectively.

[2] Alternative methods for defining core inflation definition are reviewed by Aucremanne and Wouters (1999). They include median and trimmed mean measures as well as more involved econometric procedures and theoretical aspect of inflation dynamics. While some these alternatives are employed inside central banks for analytical purposes, their complexity limits their usefulness in external communication.

[3] Bodenstein, Erceg, and Guerrieri (2008) take Aoki's analysis one step further in the sense that oil is explicitly introduced into the model. They still show that core inflation—non-oil inflation, is the optimal monetary target (in addition to wage inflation).The authors argue that the optimal monetary policy that maximizes the utility of household should stabilize a weighted average of core and nominal wage inflation as compared to headline inflation targeting under sticky wage and price settings.

On the other hand, the literature is so far silent about whether central banks should be encouraged to target headline inflation or core inflation which abstracts from subsidized prices. In the present paper we revisit the concept of core inflation by assuming that a share of consumption basket goods are partially subsidized and a central bank defines core inflation by subtracting their prices from the overall CPI.[4] In particular, we extend the one-sector benchmark sticky-price New Keynesian economy by assuming the presence of a subsidized share of private consumption expenditures. More explicitly, the government intervenes following a preannounced rule to minimize inflation deviations of a category of goods—subsidized goods—from the historical average of headline inflation. Furthermore, as suggested by the data, the government is assumed to asymmetrically react to price fluctuations given a relative bias toward smoothing upward changes of prices (i.e., upward stickiness). Then, we estimate the model for a number of countries showing strong evidence of governmental price control.[5] Finally, a second order approximation of the model is applied to compare several Taylor rule's specifications based on alternative definitions of inflation rates (headline and sectoral price inflation rates) using household's welfare as a metric.

Results show that strict headline inflation targeting could be easily dominated by sectoral inflation targeting, output gap stabilization, or a combination of these. The appropriate monetary policy to adopt in the presence of subsidized prices and costly adjusting of prices is sensitive to the relative importance of the two distortions. Also, the way governments finance subsidies is crucial for designing the optimized monetary rule. Interestingly, we find cases where price subsidies are relatively more distorting than nominal price inertia in the non-subsidized sector. This is true even for some countries where the subsidized items have a low share in the total consumption basket. The intuition is that when subsidies are financed with distortionary taxes the distortion yielded by deviations from the flexible price equilibrium in the subsidized-good market is magnified. This result is driven by the positive comovement of labor supply elasticity and average tax rates. Higher labor supply elasticites amplify the response of employment to a given shock, leading in turn to a larger consumption volatility and significant welfare losses. The latter mechanism is not straightforward. For instance, under a standard symmetric rule of price smoothing, changes in tax rates under normally distributed shocks tend to virtually cancel out when accounting for their first-level effect on utility. Besides, the asymmetric adjustment of prices, owing to the aggressive reactions of the govern-

[4]At the same time, Aoki's specification of core inflation turns out to be a particular case of our approach and his results could be easily replicated.

[5]Fourteen countries are included in the empirical analysis which are Argentina, Brazil, Czech Republic, Egypt, Hungary, Indonesia, Mexico, Morocco, Philippines, Poland, South Africa, Thailand, Tunisia, and Turkey.

ment towards upward changes in prices, mitigates negative changes in tax rates and amplifies the distortion effect of taxation following the same shocks.

The estimation of the model for a large set of countries shows heterogeneity in the relative importance of sectoral distortions implying multiple scenarios for the design of monetary policy. The results clearly challenge the implementation of inflation targeting in many countries where prices are sticky and fiscal authorities subsidize a share of consumed goods and services. Consequently, policymakers should reduce the extent of price subsidies to allow for an optimized, comprehensive, credible, and transparent monetary policy rule that targets core inflation. Based on the estimated model we numerically identify country-specific thresholds for the degree of government intervention under which core inflation targeting turns out to be optimal.

The remainder of the paper is organized as follows. In Section II, we describe the model. In Section III, we outline the more relevant qualitative implications of the model in terms of optimal monetary policy using a class of modified Taylor rules. We describe the estimation method and discuss the parameter estimates in Section IV. In Section V, we discuss the optimized parameterization for the monetary policy rule under alternative specifications of inflation-targeting Taylor-type rules, and we offer conclusions in Section VI.

II. The Model

The economy consists of a representative household with an infinite planning horizon, a representative final good firm, a collection of monopolistically competitive firms that produce differentiated intermediate goods, and a monetary authority that sets the short-term nominal interest rate following a Taylor rule.

While there is no agreed definition for government intervention in price determination, this concept tends to refer to the existence of prices that are not determined by market forces and that are heavily influenced by the government. This might involve direct price-setting, significant subsidization, or regulation related to production of products by the government. Regulated prices are in general fixed for a relatively long time-period, they do not respond to the business cycle and tend to show important relative price changes, when a change occurs. However, subsidized prices do change reflecting in some cases similar volatility as non-subsidized-goods prices.[6] Furthermore, we assume that the government uses some indirectly transferred resources to stabilize some highly volatile prices such as those of energy, medication, or food. In addition, once the firm's prices differ from the subsidized prices after any structural shock fiscal authorities compensate these expenditures (revenues) through increasing (decreasing) taxes following an explicit rule.[7]

A. Households

The representative household maximizes expected utility given by:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left[u\left(c_t, c_{t-1}, \frac{M_t}{P_t} \right) - \eta V(h_t) \right], \tag{1}$$

where c_t is consumption, M_t is the nominal balances, P_t is the consumer price index, h_t is hours worked, $\beta \in (0,1)$ is a subjective discount factor, and η measures the relative importance of leisure in household's utility.[8] The functional form of period utility is given by:

$$u\left(c_t, c_{t-1}, \frac{M_t}{P_t} \right) = \log(c_t - ac_{t-1}) + b \log\left(\frac{M_t}{P_t} \right) \tag{2}$$

and

$$V(h_t) = \log(1 - h_t), \tag{3}$$

where the parameter a is the degree of habit formation for a typical household and b measures the weight of real balances in the utility function.

The representative household's budget constraint in period t is:

$$P_t c_t + P_t i_t + M_t + P_t CAC_t + \frac{B_t}{R_t} \leq (1 - \tau_t) W_t h_t + Q_t k_t + M_{t-1} + D_t + B_{t-1} + T_t, \tag{4}$$

where R_t is the gross nominal interest rate on debt between t and $t+1$, W_t is the nominal wage, Q_t is the nominal rental rate of capital, B_{t-1} denotes domestic non-state-contingent bonds, D_t denotes nominal dividend payments received from monopolistically competitive firms, τ_t is a distortionary tax on nominal labor revenues, which is endogenously determined

[6]For instance, provided data on subsidized and non-subsidized price inflation rates by the National Institution of Statistics in Tunisia and Morocco exhibit very similar volatilities. In particular, the standard deviations of π_t^S and π_t^S in Tunisia are 0.74 and 0.75 percent, respectively; and are both equal to 0.76 percent in Morocco.

[7]Throughout the paper, references to subsidized goods should be read to include goods subject to subsidized and administered prices.

[8]The parameter η affects the steady-state level of labor in the model.

in each period given a fiscal rule, T_t corresponds to a lump-sum transfer from the government, i_t is real investment, k_t is the stock of capital, and CAC_t is a capital adjustment cost.

Investment increases the household's stock of capital according to

$$k_{t+1} = (1-\delta)k_t + i_t, \tag{5}$$

where $\delta \in (0,1)$ is the depreciation rate of capital. Investment is subject to convex adjustment costs of the following form:

$$CAC_t = \Gamma\left(\frac{k_{t+1}}{k_t}\right)k_t, \tag{6}$$

where Γ is a function that has the following characteristics: $\Gamma(1) = 0$, $\Gamma'(1) = 0$, and $\Gamma''(1) = \psi_k$.

B. Firms

1. Final-good producers

Firms in the final-good sector are perfectly competitive. They combine subsidized (S) and non-subsidized (nS) intermediate goods to produce a single homogenous good using the following Cobb-Douglas technology:

$$y_t = \left(y_t^S\right)^{\phi}\left(y_t^{nS}\right)^{(1-\phi)}, \tag{7}$$

where

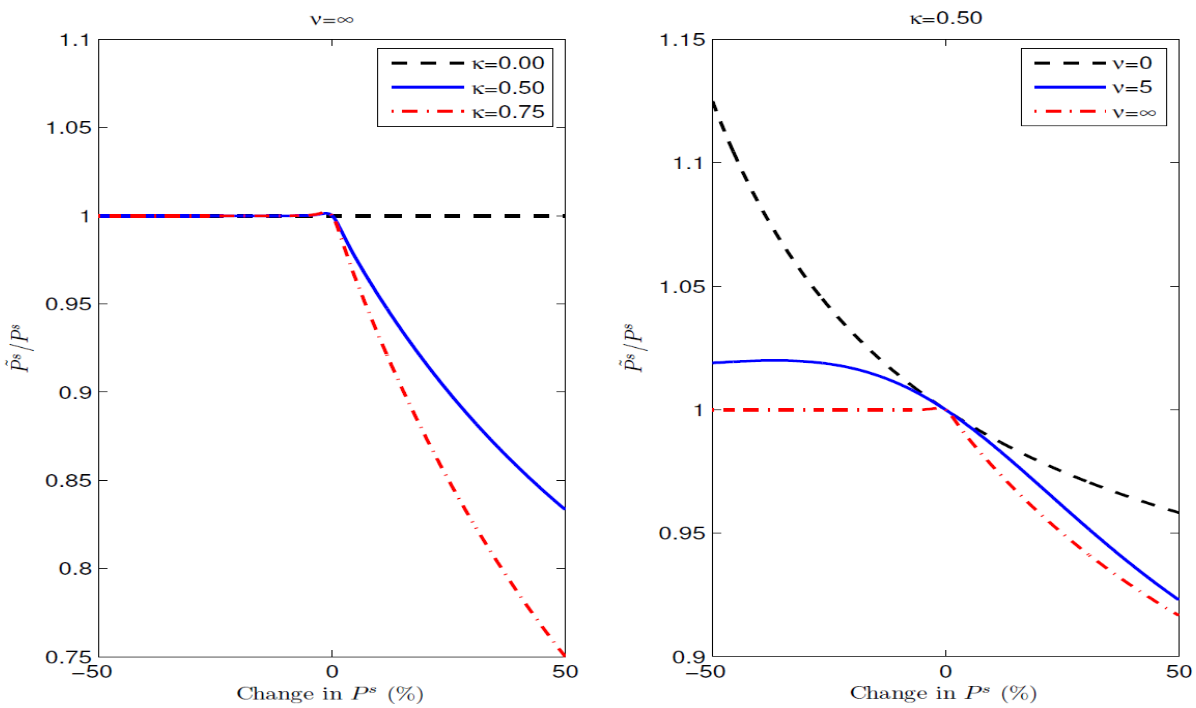
$$y_t^S \equiv \left(\int_0^1 y_t^S(i)^{\left(\vartheta^S-1\right)/\vartheta^S} di\right)^{\vartheta^S/(\vartheta^S-1)} \quad \text{and} \quad y_t^{nS} \equiv \left(\int_0^1 y_t^{nS}(i)^{\left(\vartheta^{nS}-1\right)/\vartheta^{nS}} di\right)^{\vartheta^{nS}/(\vartheta^{nS}-1)}$$

are composite indexes of S- and nS-intermediate goods, respectively; ϑ^S $(\vartheta^{nS}) > 1$ is the elasticity of substitution between S- and nS-intermediate goods; $\phi > 0$ is the weight of the S composite good.

Define

$$P_t^S \equiv \left(\int_0^1 P_t^S(i)^{1-\vartheta^s} di\right)^{1/(1-\vartheta^S)} \quad \text{and} \quad P_t^{nS} \equiv \left(\int_0^1 P_t^{nS}(i)^{1-\vartheta^{nS}} di\right)^{1/(1-\vartheta^{nS})}$$

Figure 1. S-good price dynamics



as the price indexes associated with the aggregators y_t^S and y_t^{nS}. Then, demands for individual S- and nS-intermediate goods are, respectively, given by

$$y_t^S(i) = \left(\frac{P_t^S(i)}{P_t^S}\right)^{-\vartheta^S} y_t^S \quad \text{and} \quad y_t^{nS}(i) = \left(\frac{P_t^{nS}(i)}{P_t^{nS}}\right)^{-\vartheta^{nS}} y_t^{nS}, \qquad i \in (0,1).$$

In addition, we assume that the government subsidizes the price of one sector to keep prices stable around average headline inflation following this rule:[9]

$$\tilde{P}_t^S = \frac{\kappa}{1+\exp\left[-\nu\left(\frac{P_t^S}{\tilde{P}_{t-1}^S}-\pi\right)\right]}\tilde{P}_{t-1}^S + \left(1-\frac{\kappa}{1+\exp\left[-\nu\left(\frac{P_t^S}{\tilde{P}_{t-1}^S}-\pi\right)\right]}\right)P_t^S + \varepsilon^{P_t^S} \qquad (8)$$

where the final price for S goods is $\tilde{P}_t^S$, π is steady-state headline inflation, κ represents the degree of intervention of the government to smooth out price changes in the sector through

[9]This implies that sectoral inflation rates are equal in the long run, $\pi^S = \pi^{nS} = \pi$. Doing so is crucial in the sense that we can solve for relative prices in the model. In practice, relative prices could be trending if sectoral long-term inflation rates are different, but one could argue that the government cannot sustain such policy indefinitely as multiple equilibria could occur.

time, and $\varepsilon_t^{P^S}$ is an iid shock. As illustrated in the right panel of Figure 1, if κ increases, the price of the S goods becomes stickier, however, if this parameter is set close to zero the price is totally set by the firms (see the left panel of Figure 1). Furthermore, the dynamics of the subsidized-goods prices depend on a second parameter, ν, which allows the response of subsidized prices to depend on the sign and magnitude of the market price of S goods, P_t^s. Figure 1 also shows that letting $\nu > 0$ as P_t^S decreases under $\tilde{P}_{t-1}^S$, the linear term dominates and the cost associated with price decreases declines monotonically, and $\tilde{P}_t^S$ fairly mimics the change in P_t^S. In contrast, as P_t^S raises above $\tilde{P}_{t-1}^S$, it is the exponential term that dominates and the cost associated with price increases rises exponentially. Hence, nominal price increases involve a larger frictional cost than decreases. This way of controlling prices reflects the willingness of the government to support consumers in terms of lowering the effective price of some targeted consumption goods and services. Besides, reasonable positive values for ν do not preclude nominal price surges which could be observed in the data.

In addition to the intuitive specification of government intervention following a biased smoothing rule toward upward fluctuations of prices, data tend to corroborate this assumption. Figure 2 shows both core inflation (which excludes controlled items) and controlled-price inflation rates in Morocco and Tunisia (inflation series are demeaned and cover the period starting from 1990Q1 until 2008Q4). Looking at charts during the recent years, one can observe that downward changes are noticeably more frequent in the case of controlled-price inflation as opposed to core inflation. Assuming that shocks in the economy are normally distributed, hence symmetric, empirical characteristics of inflation argue in favor of asymmetric reaction function rules following inflation deviations from the historical average.

The representative final-good producer solves

$$\max_{y_t^S, y_t^{nS}} P_t y_t - \tilde{P}_t^S y_t^S - P_t^{nS} y_t^{nS}, \tag{9}$$

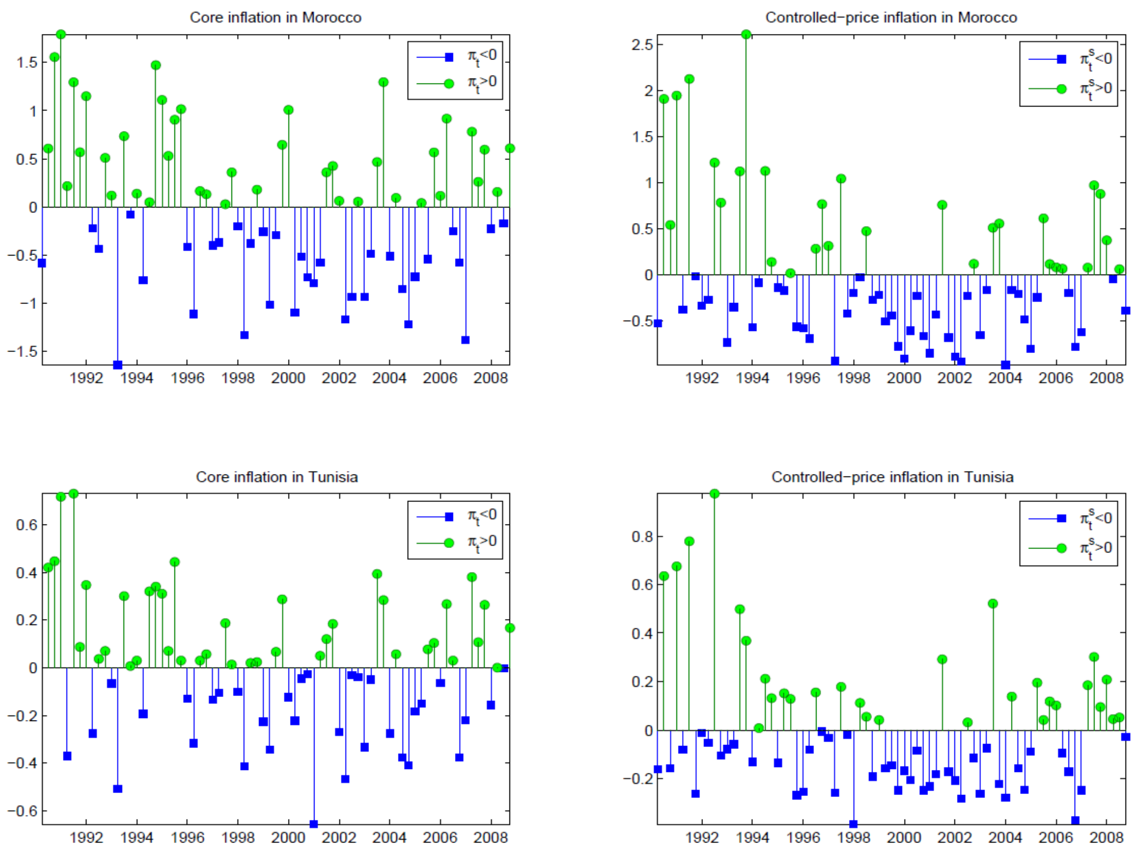
where y_t is given by equation (7). Profit maximization implies

$$y_t^S = \phi \left(\frac{P_t}{\tilde{P}_t^S} \right) y_t, \tag{10}$$

and

$$y_t^{nS} = (1-\phi) \left(\frac{P_t}{P_t^{nS}} \right) y_t. \tag{11}$$

Figure 2. (A)symmetric price fluctuations



Remark: Green circles denote positive inflation observations, blue squares denote negative inflation observations.

The zero-profit condition implies that the price of the final good, P_t, is given by

$$P_t = \left(\frac{\tilde{P}_t^S}{\phi}\right)^{\phi} \left(\frac{P_t^{nS}}{1-\phi}\right)^{(1-\phi)}. \tag{12}$$

2. Intermediate-good producers

S and nS intermediate-good producers have identical Cobb-Douglas production functions given by

$$y_t^j(i) = A_t^j k_t^j(i)^{\alpha^j} h_t^j(i)^{1-\alpha^j}, \tag{13}$$

where $j = S, nS$; $\alpha^j \in (0,1)$; $k_t^j(i)$ and $h_t^j(i)$ are capital and labor inputs used by firm i; and A_t^j is an aggregate technology shock that follows the stochastic process

$$\log(A_t^j) = (1-\rho_A^j)\log(A) + \rho_A^j \log(A_{t-1}^j) + \varepsilon_t^j, \tag{14}$$

where ρ_A^j is strictly bounded between -1 and 1 and the innovation ε_t^j is a normally distributed, serially uncorrelated shock with zero mean and standard deviation σ_A^j.

Intermediate-good producers are monopolistically competitive and are thus price setters. They segment markets by setting different prices for different destinations. That is, firm i chooses a price $P_t^j(i)$ for its sales. Changing prices entails quadratic adjustment à la Rotemberg (1982):[10]

$$\frac{\psi^j}{2}\left(\frac{P_t^j(i)}{\pi^j P_{t-1}^j(i)} - 1\right)^2,$$

$\psi^j \geq 0$ and π^j is the steady-state value of $\pi_t^j \equiv P_t^j / P_{t-1}^j$. Firm i solves the following dynamic problem:

$$\max_{h_t^j(i), k_t^j(i), P_t^j(i)} E_t \sum_{l=0}^{\infty} \beta^s \left(\frac{\lambda_{t+l}}{\lambda_t}\right) \frac{D_{t+l}^j(i)}{P_{t+l}}, \tag{15}$$

where

$$D_t^j(i) \equiv P_t^j(i) y_t^j(i) - W_t h_t^j(i) - Q_t k_t^j(i) - \frac{\psi^j}{2}\left(\frac{P_t^j(i)}{\pi^j P_{t-1}^j(i)} - 1\right)^2 P_t^j(i) y_t^j(i).$$

Given the demand functions in equations (10) and (11), the first-order conditions for firm i are:

$$\frac{w_t}{p_t^j} = (1-\alpha^j)\xi_t^j(i)\frac{y_t^j(i)}{h_t^j(i)}, \tag{16}$$

$$\frac{q_t}{p_t^j} = \alpha^j \xi_t^j(i)\frac{y_t^j(i)}{k_t^j(i)}, \tag{17}$$

[10] As is well known, the pricing behavior under the assumption of costly price adjustment is observationally equivalent, at the first-order approximation, to that resulting from a Calvo-type price setting (Calvo 1983), where firms are randomly selected to change their prices with a constant probability.

$$-\theta\frac{\xi_t^j(i)}{p_t^j(i)} = (1-\theta)\left[1-\frac{\psi^j}{2}\left(\frac{\pi_t^j(i)}{\pi^j}-1\right)^2\right] -\psi^j\left[\frac{\pi_t^j(i)}{\pi^j}\left(\frac{\pi_t^j(i)}{\pi^j}-1\right)-\beta E_t\frac{\lambda_{t+1}}{\lambda_t}\frac{\left(\pi_{t+1}^j(i)\right)^2}{\pi_{t+1}\pi^j}\left(\frac{\pi_t^j(i)}{\pi^j}-1\right)\frac{y_{t+1}^j(i)}{y_t^j(i)}\right] \quad (18)$$

where λ_t and $\xi_t^j(i)$ are the Lagrange multipliers associated with equations (4) and (13), respectively, $w_t \equiv W_t/P_t$, $q_t \equiv Q_t/P_t$, $p_t^j(i) \equiv P_t^j(i)/P_t$, $\pi_t^j(i) \equiv P_t^j(i)/P_{t-1}^j(i)$, and $\pi_t \equiv P_t/P_{t-1}$.

C. Monetary and fiscal authorities

The monetary authority sets the short-term nominal money growth rate, $\zeta_t = \frac{M_t}{M_{t-1}}$, in accordance with the following exogenous rule:

$$\log(\zeta_t) = \rho_\zeta \log(\zeta_{t-1}) + \varepsilon_{\zeta,t}, \quad (19)$$

where $\rho_\zeta \in (0,1)$, and the stochastic shock term $\varepsilon_{\zeta,t}$ is iid normal with a zero mean and a standard deviation of σ_ζ.[11]

Government's expenditures include the cost of subsidizing goods and households' transfers. These revenues are financed with tax collection on labor revenues and newly exogenously issued money. Hence, the government's budget constraint is given by

$$\left(P_t^S - \tilde{P}_t^S\right) y_t^s + T_t = \tau_t W_t h_t + (M_t - M_{t-1}). \quad (20)$$

In the following section we highlight two scenarios: the first assumes that subsidies are fully financed through lump-sum taxes, i.e. $-T_t + (M_t - M_{t-1}) = \left(P_t^S - \tilde{P}_t^S\right) y_t^s$; and the second refers to levying distortionary taxes on revenue to finance subsidies, i.e. $\tau_t W_t h_t = \left(P_t^S - \tilde{P}_t^S\right) y_t^s$.

III. Optimaized Monetary Rules

To assess the impact of alternative monetary policy rules on households' welfare, we use hybrid Taylor rules to reflect inflation targeting policies. This counterfactual exercise involves

[11]This specification describes the historical behavior of the monetary authority and will be substituted later by optimized Taylor rules.

the following process for setting interest rates:

$$\log\left(\frac{R_t}{R}\right) = \rho_R \log\left(\frac{R_{t-1}}{R}\right) + (1-\rho_R)\left[\rho_\pi \log\left(\frac{\pi_t}{\pi}\right) + \rho_{\pi^S}\log\left(\frac{\tilde{\pi}_t{}^S}{\tilde{\pi}^S}\right) + \rho_{\pi^{nS}}\log\left(\frac{\pi_t^{nS}}{\pi^{nS}}\right) + \rho_y \log\left(\frac{y_t}{y}\right)\right]. \tag{21}$$

which substitutes equation (19).

Variables without time subscripts denote deterministic steady-state values. The Taylor rule immediately implies that in the deterministic steady state the rate of inflation will be equal to π. Therefore, it is natural to interpret π as the target level of inflation as well as its deterministic steady-state level.

A. Calibration

We calibrate the structural parameters of the model to values similar to those found in the literature, then, we performed sensitivity analysis on their calibrated values. The baseline model is calibrated at a quarterly frequency. The subjective discount factor, β, is set to 0.98, which implies that the annual nominal interest rate is equal to 8 percent in the deterministic steady state. The preference parameter η is chosen so that the fraction of hours worked in the deterministic steady state is equal to 0.25. Capital shares in production in both sectors, $\alpha^{S,nS}$, are set to 0.36, while the depreciation rate, δ, is chosen to be 0.025. The average tax rate, τ, is set to 0.35. These values, which have become quite standard in the literature, were used, for example, by Backus and Crucini 2000. The elasticity of substitution between S intermediate goods is set to ∞ implying a perfectly competitive market. Its analogue for the nS-good sector, ϑ^{nS}, is set to 8, implying a markup of 14 percent and in the deterministic steady state, which lies between the estimates of the empirical literature (see, for example, Basu 1995).[12]

Prices set by firms in the S-goods sector are assumed to be fully flexible ($\psi^S = 0$). The degree of nominal rigidity in the nS-good sector, in the form of price adjustment cost, is reflected in the parameter ψ^{nS} which is set to 40. In order to have a better understanding of the interpretation of the the latter parameter, we use the commonly known result about the equivalence between the Calvo and Rotemberg pricing assumptions at the first order approximation of the price decision rule. Under our assumption, adjusting prices entails convex costs, as described

[12]Setting the elasticity of substitution to infinity in the S-good sector eliminates the monopolistic power. Therefore, only government intervention through subsidies is considered as a friction specific to this sector.

Table 1. Calibrated Parameters

Parameter	Value	Description
β	$1.08^{-\frac{1}{4}}$	Quarterly subjective discount factor
b	0.005	Weight of real balances in utility
a	0.5	Habit formation
η	*adjusted*	Weight of leisure in utility
δ	$1.1^{\frac{1}{4}}-1$	Quarterly depreciation rate
ψ_k	5	Capital adjustment cost parameter
τ	0.35	Average tax rate
$\alpha^{\{S,nS\}}$	0.35	Cost share of Capital
ϑ^S	∞	Price elasticity of demand
ϑ^{nS}	8	Price elasticity of demand
ψ^S	0	Degree of nominal rigidity
ψ^{nS}	40	Degree of nominal rigidity
ϕ	*changing*	Share of S goods
κ	0.75	First order government price control
ν	500	Asymmetric price adjustment parameter
$\rho_{\{A^S,A^{nS},\zeta\}}$	0.80	first-order serial correlations
$\sigma_{\{A^S,A^{nS}\}}$	0.01	Standard Deviation of technology shocks
σ_ζ	0.005	Standard Deviation of monetary shock
$\sigma_{\varepsilon^{PS}}$	0.005	Standard Deviation of S-good price shock

by Rotemberg (1982). Assuming that prices adjust at random intervals of time in a staggered fashion, following the pricing mechanism introduced by Calvo (1983), one can derive a relation between the adjustment cost parameter, ψ^{nS}, and the probability of keeping prices unchanged, here called ψ^{nS}_{Calvo}. In particular, imposing

$$\psi^{ns} = \frac{(\vartheta - 1)\psi^{nS}_{Calvo}}{(1-\psi^{nS}_{Calvo})(1-\beta\psi^{nS}_{Calvo})}$$

yields the same first-order dynamics in both models. Hence, an average prior price adjustment costs parameter of 40 implies a probability of not changing prices of 0.67, which corresponds to changing prices every three-quarters on average. By doing so we limit our analysis to the case where sticky prices through firms decision is uniquely assumed for the nS-good sector, which will help us to easily reproduce results from the existing literature on optimal monetary policy in the presence of price distortions in models with a unique sector (e.g., Yun, 2005).

The parameters affecting the degree of price distortion in the S-good sector are calibrated as follows. First, the share of S-goods, ϕ, is set to be between 0 and 40 percent which reflects cases of low and high degree of public authorities interventionism in controlling prices. Second, for the degree of linear price smoothing in the S-goods sector, κ, we choose a value of 0.75 which sounds reasonable in a quarterly basis, but, sensitivity analysis is particularly conducted for this parameter. Third, the second parameter affecting the degree of price response asymmetry, ν, is set to be 500. Unfortunately, we don't have empirical evidence on the value of the latter. Nonetheless, Kim and Ruge-Murcia (2009) estimate a similar asymmetry parameter but for nominal wage adjustment which is equal to -3884.4 and find evidence that nominal wages are more downwardly than upwardly rigid. Taking the opposite sign for that parameter to reflect more upward rigidity to price changes, the calibration we are using seems relatively low.[13]

B. Which inflation to target?

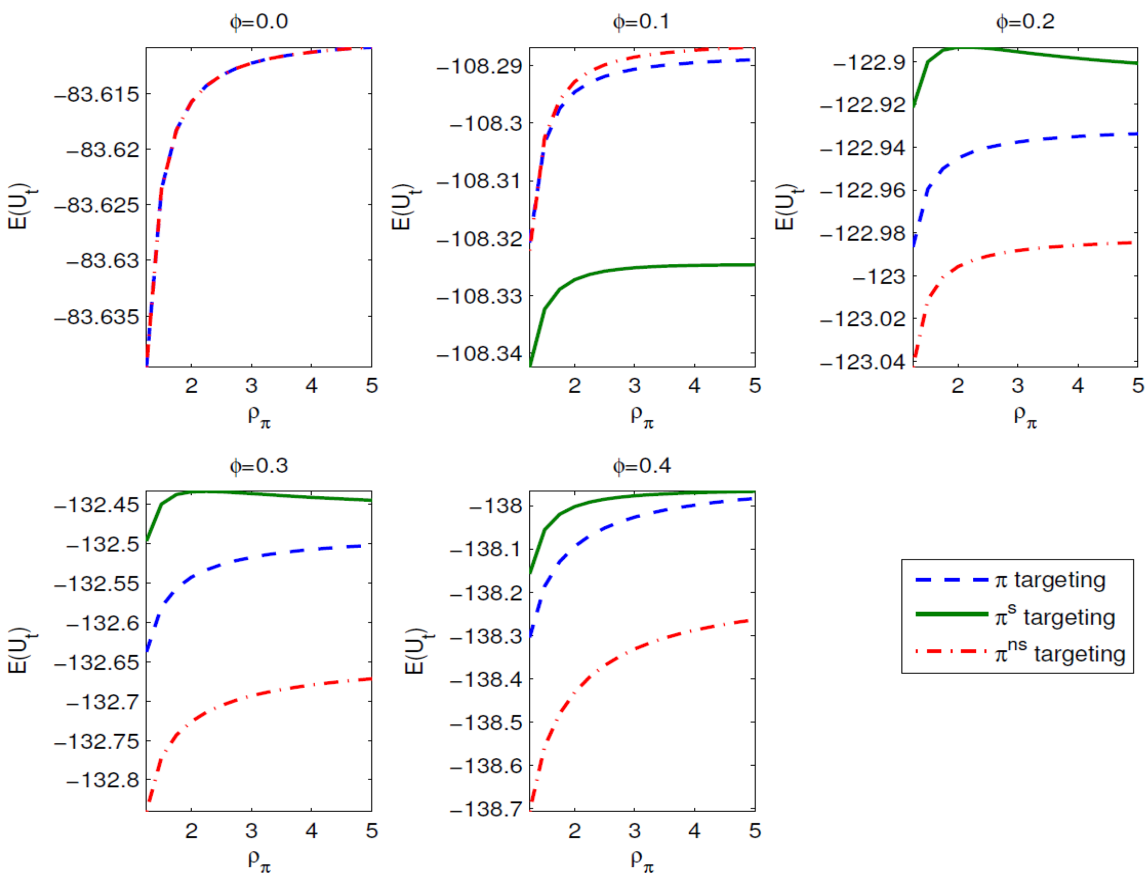
Henceforth we will use in a interchangeable manner nS-good price inflation and the notion of core inflation. Results of the second order approximation of the model and the evaluation of welfare conditional to alternative monetary policy are twofold. First, solely and aggressively reacting to CPI inflation is always dominated by sectoral inflation targeting. Particularly, the friction reflecting government intervention through subsidizing a share of consumption goods does not advocate for an aggressive reaction to CPI inflation. Second, even when the monetary authority should react to both sectoral inflation rates, the optimal weights on each of them do not correspond to the implicit ones implied by the structural parameters as reported in equation (12).

In the case where the only active imperfection involves price adjustment costs in the nS goods ($\kappa = 0$), the optimized policy rule reflects fully stabilizing inflation-rate fluctuations in the same sector (i.e., $\rho_{\pi^{nS}} = \infty$). As shown in Figure 3, CPI inflation is the right variable to target in the situation where $\pi_t = \pi_t^{nS}$ corresponding to $\phi = 0$. Otherwise, targeting CPI inflation becomes suboptimal since the equilibrium largely deviates from the one under total absence of market discrepancies.

Although, household's welfare is lower owing to the imperfection in the S-good sector, CPI inflation targeting becomes suboptimal. In other words, the simultaneous presence of imper-

[13] A sensitivity analysis with respect to the parameter ν is conducted in subsection III.D.

Figure 3. Welfare under CPI, Core, and S-good inflation targeting



fections in all sectors, makes it impossible to reach the first-best equilibrium while having only the interest rate as an instrument for the monetary authority.[14]

Figure 3 also shows that the introduction of government subsidies substantially alters the picture of the optimality of the nS-good inflation targeting, even when the share of S-good sector is not high ($\phi = 0.20$). In particular, the tradeoff generated by the presence of price rigidity and subsidies is apparent in the distinct dynamics of nS-good versus S-good inflation rates. This suggests, in turn, a substantive decrease in welfare for high degree of government interventionism implying sizeable distortion in the S-good sector.

[14]The optimal policy in this context is to eliminate price subsidies and to fully stabilize core inflation.

C. Sources of the tradeoff

The above-mentioned results show that despite the presence of nominal frictions through price stickiness, welfare losses emerge when the monetary authorities target CPI rather than sectoral inflation. Now, looking at sectoral inflation targeting, Figure 4 exhibits cases with considerable welfare gains from targeting S-good inflation rather than nS-good inflation. This demonstrates that the central bank has to target inflation deviations in the most frictional sector, i.e., S-good sector, although it does not correspond to the largest of the production sectors (starting from $\phi = 0.20$).

One other way to understand the result is by studying the log-linearized versions of equations (8) and (17) capturing the mechanisms of price adjustments:

$$\hat{\hat{\pi}}_t^S = \frac{1-\kappa}{\kappa}\left(\hat{p}_t^S - \hat{\hat{p}}_t^S\right)$$

and

$$\hat{\pi}_t^{nS} = \beta \hat{\pi}_{t+1|t}^{nS} + \frac{\vartheta - 1}{\psi^{nS}} \hat{\xi}_t^{nS}.$$

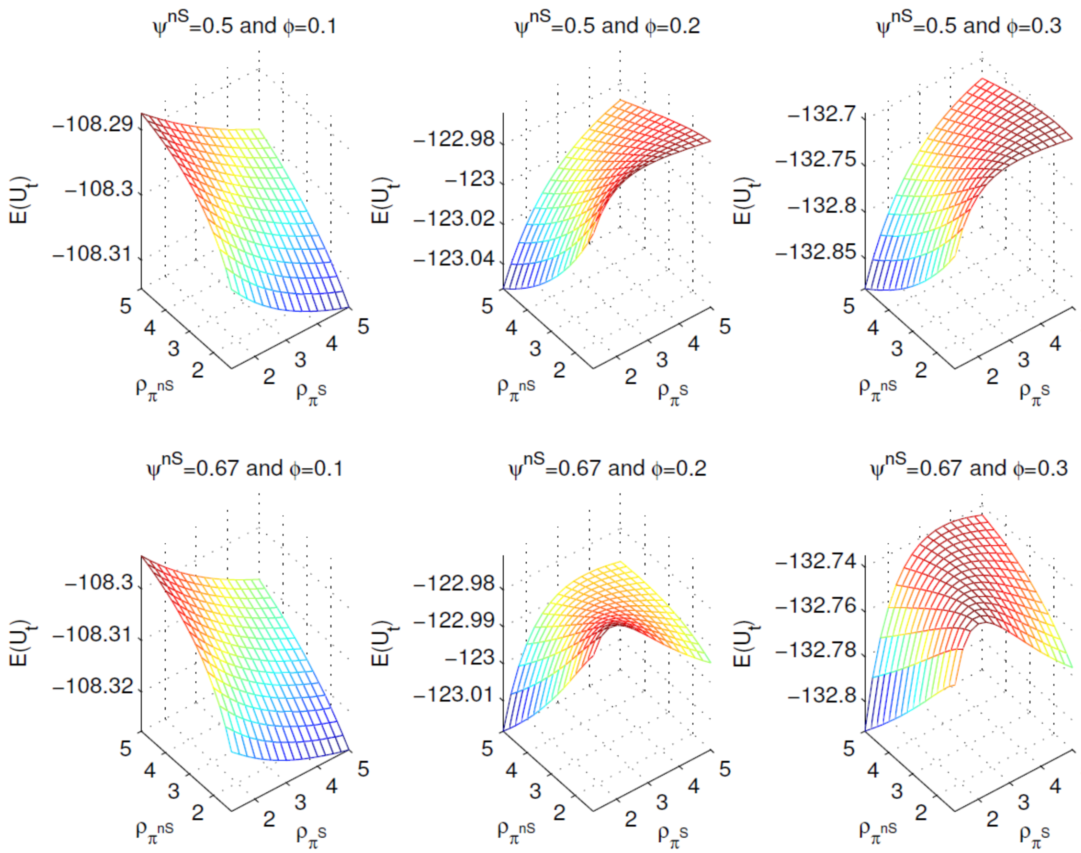
Note that the , “hatted” variables correspond to the relative deviation of each variable from its steady state.[15] The first equation, which summarizes the price setting in the S-good sector, shows that price inflation stabilization is possible only if the government abandons intervening in the price setting process, i.e., $\hat{\hat{\pi}}_t^S = \hat{\hat{\pi}}_{t+1|t}^S$ if and only if $\hat{p}_t^S = \hat{\hat{p}}_t^S$. Similarly, from the second equation, which reflects the price level setting by the firms in the nS-good sector, price inflation remains constant only if firms are continuously equalizing the prices to marginal costs i.e., $\hat{\pi}_t^{nS} = \hat{\pi}_{t+1|t}^{nS}$ if and only if $\hat{\xi}_t^{nS} = 0$.

In short, there is clearly a tradeoff between stabilizing the S-good and the nS-good inflation rates in the presence of the two price setting frictions. Consequently, the monetary authority cannot achieve a Pareto-optimal level of social welfare under the two distortions. Furthermore, in the presence of multiple market imperfections it turns out that the monetary policy that should be undertaken depends on the relative importance of the frictions in the model.

Figure 4 clearly shows that there could be different cases where targeting S-good price inflation provides higher welfare, particularly in cases with a high share of the S-good sector

[15] Since price levels are non-stationary by definition, we first divide them by the CPI price level, P_t, and the new price indexes are denoted in lowercases.

Figure 4. S-good versus nS-good inflation targeting

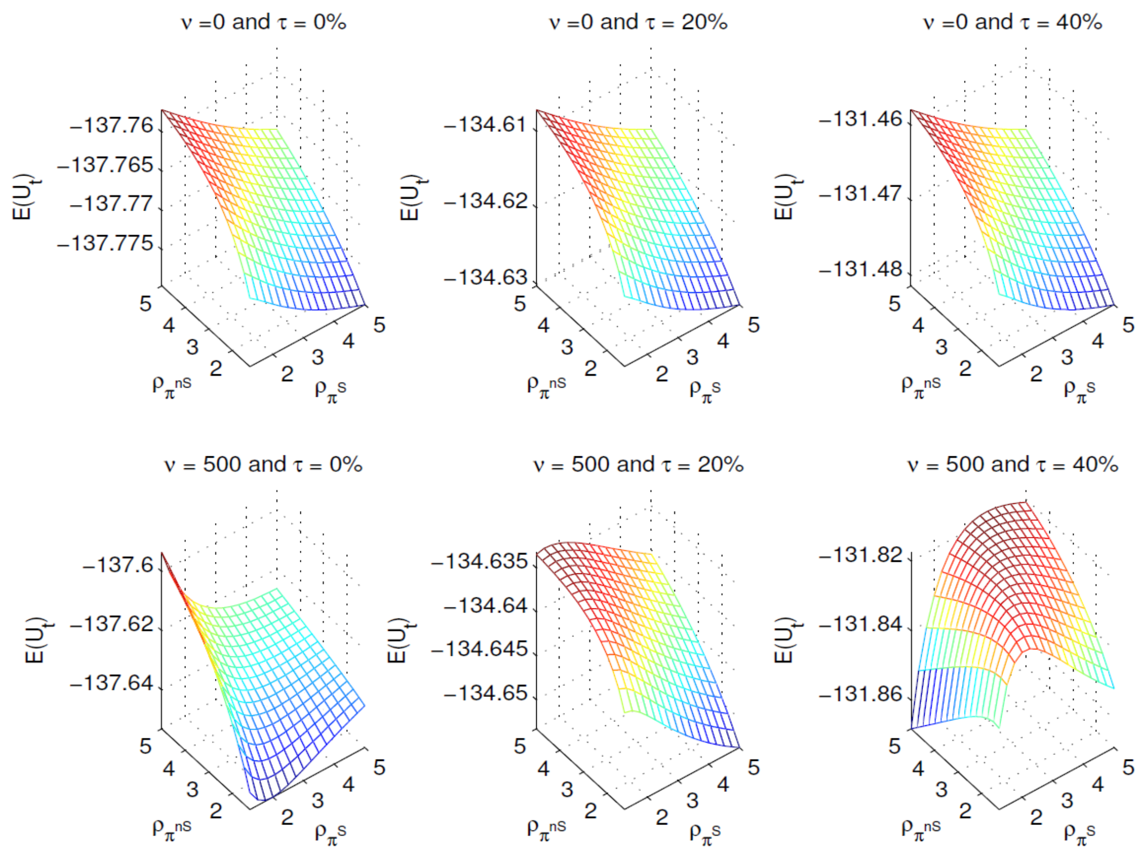


and/or a low degree of price rigidity in the nS-good sector. Obviously, in the opposite scenarios households would be better off when the central bank focuses on reducing the volatility of core inflation. Furthermore, increasing the share of S-good sector does not convey systematically optimality of pure S-good inflation stabilization in a monotonic fashion (see the panel with $\psi^{nS} = 0.67$ and $\phi = 0.3$). In particular, starting from a coefficient on $\tilde{\pi}_t^S$ deviation from its target at around 2.5 in the Taylor rule, welfare turns out to be declining. This result is hard to interpret but our guess is that it could be linked to the functional form of the price stickiness in the S-good sector, which exhibits asymmetry and non-linearity.

D. The role of asymmetric price adjustments and financing subsidies

As previously mentioned, the distortion effect of the presence of deviations of subsidized goods' prices from their market prices could argue in favor of the optimality of targeting inflation rates in that particular sector. Curiously, this could happen even for low levels of

Figure 5. Relative impact of distortions on household utility



the parameter ϕ. This is mainly attributable to the amplified effect of S-good price distortion through higher distorting tax cuts. This point is conveyed with remarkable simplicity by comparing different outcomes of welfare analysis with alternative adjustments of distorting tax rates. The optimality of nS-good inflation stabilization turns out be sensitive to the presence of asymmetric price adjustment and distortionary taxes.

The top panel of Figure 5 shows that the welfare cost of strict S-good inflation targeting can be extremely high when the asymmetric adjustment of prices is set to zero. In other terms, assuming a symmetric rule for price stabilization reduces the distortion effect of subsidies and cancels out the effect of distortionary taxes.

The intuition for why the combination of distortionary taxes and asymmetric adjustment of prices is crucial for the design of monetary policy is the following. Recall that this is an economy in which shocks are normally distributed with zero mean. Therefore, $\nu = 0$ implies that

$\tilde{P}_t^S$ is given by

$$\tilde{P}_t^S = \kappa \tilde{P}_{t-1}^S + (1-\kappa) P_t^S$$

implying symmetric upward or downward changes of the subsidized price following any positive or negative shock in the model. Further, assuming that taxes adjust following the fiscal policy rule, $\tau_t W_t h_t = \left(P_t^S - \tilde{P}_t^S\right) y_t^s$, implies that the tax rate could change positively or negatively in a symmetric manner if $P_t^S > \tilde{P}_t^S$ or $P_t^S < \tilde{P}_t^S$, respectively. As a result, the expected first-level effect of tax changes on welfare cancels out with normally distributed shocks and we are left only with pure price distortions in the S-good sector. The latter are obviously lower than the distortion created by price adjustment costs in the nS-good sector since the share of the latter is bigger in the calibrated benchmark model. Alternatively, in the scenario where $\nu > 0$, negative adjustments of market prices are fully passed through to the subsidized price, hence, tax rates do not need to adjust negatively under the same fiscal rule. On the other hand, shocks leading to higher prices will be smoothed out by the government which yields higher tax rates. Consequently, the higher the asymmetric parameter in the price setting rule the bigger net positive tax rates changes are and the more welfare improving nS-good price inflation targeting is.

The lower panel of Figure 5 shows that for higher average tax rates the net distorting effect of subsidizing prices increases and the welfare gain of allowing for S-good inflation targeting becomes significant. This result is in line with the observed effect resulting from the increase in the labor supply elasticity brought about by a higher tax rate, leading in turn to a larger response of both output and consumption to different shocks (see Gali 1994 for an extended discussion). The more volatile income decreases household's welfare.

E. Sectoral average inflation rates: A caveat

It is worth noting that as in Erceg, Henderson, and Levin (2000); Aoki (2001); Huang and Liu (2004); and Erceg and Levin (2006), we assume equal average inflation rates in the different sectors considered which turns out to be crucial to solve for relative prices in the model. The same symmetric average inflation rate corresponds to the central bank's target. Furthermore, available data on S- and nS-goods prices in Tunisia and Morocco exhibit statistically non-different historical sectoral inflation rates.[16] Nevertheless, in some countries one can observe

[16]In Tunisia, average inflation rates in S- and nS-good sectors are 3.70 and 3.96 percent, respectively; and in Morocco, average inflation rates in S- and nS-good sectors are 4.08 and 3.80 percent, respectively. However, looking at particular items one could distinguish significant deviations from the aggregate average inflation.

particular subsidized prices that are kept literally constant over several periods—zero average inflation. In a frictionless context such policy is suboptimal and welfare costs are tremendous given the continuously widening gap between subsidized prices and prices of other items over time (i.e., non-stationary relative prices). As shown by Taubmane and Rasche (1971), this obviously yields severe resource misallocations leading to deteriorating household's welfare in the long term. The response of the monetary policy in this context is simply to fully stabilize the relative price of subsidized and non-subsidized goods. In other words, given a flat profile of subsidized prices the central bank should fully stabilize non-subsidized (core) inflation around the same targeted level adopted by the government. For simplicity and technical tractability, we abstract in what follows from the possibility of different sectoral average inflation rates.

IV. Estimation

A. Estimation strategy

Since, we are interested in different countries but use the same model, the latter could miss some of the countries' specificities (e.g., openness, fiscal issues, transition policies). To remedy this straightforward shortcoming of the specified model we explicitly introduce measurement errors which aim to capture, among other things, theoretical misspecifications and are expected to explain a small share of observales' fluctuations. From an empirical perspective, the advantages of adding measurement errors are twofold. On the one hand, they might capture weaknesses linked to the quality of data collected in some countries. On the other hand, having more shocks permits the estimation of the model with fewer structural shocks.[17]

The model is estimated using Bayesian techniques that update prior distributions for the deep parameters which are defined according to a reasonable calibration. The estimation is done using recursive simulation methods, more specifically the Metropolis-Hastings algorithm, which has been applied to estimate similar dynamic stochastic general-equilibrium models in the literature, such as Schorfheide (2000) and Smets and Wouters (2003). Let Y^T be a set of observable data while θ denotes the set of parameters to be estimated. Once the model is log-linearized and solved, its state-space representation can be derived and the likelihood function, $L(\theta|Y^T)$, can be evaluated using the Kalman filter. The Bayesian approach places a

[17]As shown later in this section the model is estimated considering a version with only one sector involving dropping one of the two sector-specific technology shocks.

prior distribution $p(\theta)$ on parameters and updates the prior through the likelihood function. Bayes' Theorem provides the posterior distribution of θ:

$$p(\theta|Y^T) = \frac{L(\theta|Y^T)p(\theta)}{\int L(\theta|Y^T)p(\theta)d\theta}$$

Markov Chain Monte Carlo methods are used to generate the draws from the posterior distribution. Based on the posterior draws, we can make inference on the parameters. The marginal data density, which assesses the overall fit of the model, is given by:[18]

$$p(Y^T) = \int L(\theta|Y^T)p(\theta)d\theta.$$

The model has four structural shock processes: two sector-specific technology shocks—to the S-good sector, ε_{A^S}, and the nS-good sector, $\varepsilon_{A^{nS}}$; a monetary policy shock, ε_R; and a shock to the degree of price subsidy, ε^{P^s}. In addition, measurement errors on each of the observable variables are added. To identify the shock processes during the estimation, we need to use at most the same number of actual series. We choose the observables to be as informative as possible.

B. Data and summary statistics

We use seasonally adjusted quarterly series for fourteen countries from different regions covering Africa, Asia, Europe, and Latin America. The choice of countries was based on different criteria including data availability and evidence of a relatively high share of subsidized or controlled prices in the total CPI. For the latter we refer to a survey done by the Bank of International Settlements (BIS) and summarized in a recent paper by Moreno (2009) which identifies a number of countries where governments heavily intervene with the aim of controlling prices. Given the difficulty of identifying the true meaning of administering or controlling prices by some authorities, the study was based on a questionnaire distributed to a number of participating central banks. The questionnaire aims to unveil the nature, prices, and weights of administered/controlled goods and services. This study is very useful for obvious reasons. In particular, knowing that controlled prices can be defined as prices that are either directly set by the government or on which the government has a significant influence, it be-

[18] The marginal data densities are approximated using the harmonic mean estimator that is proposed by Geweke (1999).

comes almost impossible to identify them just by looking at disaggregated data for components and weights of the CPI. We are considering a set of countries with a minimum declared weight of administered/controlled prices of 20 percent in the CPI identified in that survey. The set of countries includes Argentina, Brazil, Czech Republic, Hungary, Mexico, Philippines, Poland, South Africa, Thailand, and Turkey. For the sake of covering larger regions we added four other countries for which we have evidence of relatively high price controls, which are Egypt, Morocco, and Tunisia from Africa and Indonesia from Asia.[19,20]

Since the sources of information about controlled prices are specific, such as government announcements and budgetary documents, it is very hard to obtain historical data for the weight and the level of these prices. Therefore, we use other observables to try to disentangle the impact of explicitly introducing the two sectors in a theoretical model. Theoretically, there is no problem with doing so since we are adopting a general equilibrium optic where almost every assumption could have important implications on virtually all variables. Particularly, we consider production growth, consumption growth, and CPI inflation rates as observed variables.[21] All data are seasonally adjusted and at quarterly frequencies for the period starting at the earliest available date until 2008Q4. Most of the series are obtained from the HAVER (emerging countries) database. Output growth and consumption growth rates are computed as log differences of real gross domestic product and real private consumption, respectively, and scaled by 100 to convert them into quarter-to-quarter percentages. Inflation rates are defined as log differences of the price indices.

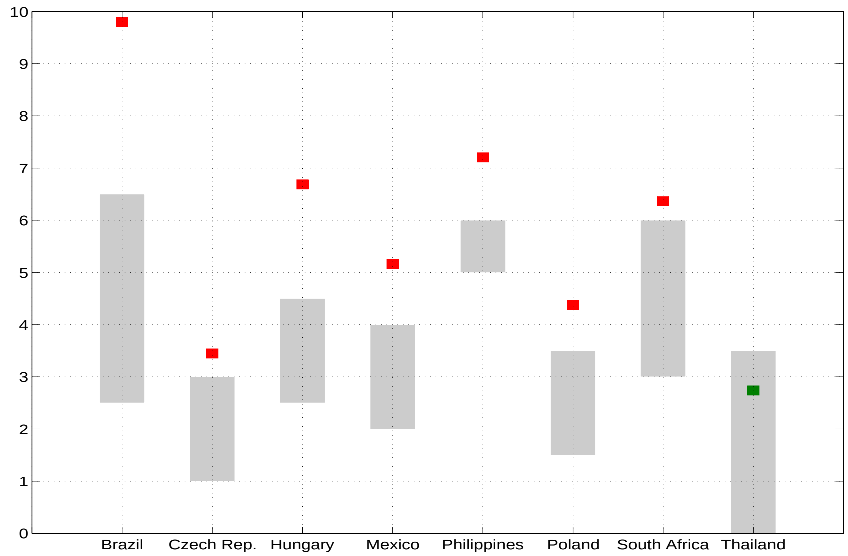
It is worth noting that some central banks, notably in Brazil, Czech Republic, Hungary, Mexico Philippines, Poland, South Africa, and Thailand, have put substantial effort to implement an inflation targeting policy in the recent past. Among the countries considered in our sample, Czech Republic has the longest experience in inflation targeting with a starting date in 1998. Brazil and Poland come next in 1999, followed by South Africa and Thailand one year after. Finally, the Hungarian monetary authority took the necessary decisions to target inflation

[19] The historical average weight of officially declared subsidized goods in the Tunisian CPI corresponds to 32.19 percent. This share is divided between food components of consumption basket, about 8 percent, and non-food products, 24 percent. In Morocco, administered prices account for 31 percent of the consumption basket as derived from official data.

[20] Looking at Indonesia, administered prices, such as fuel prices, transportation tariffs, electricity, and tobacco among others account for about 28 percent of the CPI as announced by the IMF country report for 2006. On the other hand, there is a lack of disaggregated data on controlled prices in Egypt, but some studies estimate goods with controlled prices to represent one third of the consumption basket (see, for instance, Al-Mashat and Billmeier, 2007).

[21] Morocco and Tunisia are the two exceptions since data for administered and non-administered prices are provided by the two National Statistics Institutions. Therefore, we consider output growth and the two sectoral inflation rates as observables.

Figure 6. Inflation targets and outcomes



Remarks: Squares correspond to the average rate of annual inflation from the date of inflation targeting adoption until 2008. The shaded areas are the declared tolerance bands.

in 2001, and Mexico and Philippines joined in 2002.[22] Although the model by construction does not take into account this change in the policy, we are still confident with regard to the robustness of the theoretical specification of the monetary policy rule for two main reasons. First, structural changes in the policy happened late in the sample. Second, as illustrated in Figure 6, looking at average inflation for the period after the announcement of inflation targeting, most countries (except Thailand) failed to bring down annual inflation to the announced tolerance band. Hence, the rationale for assuming pure inflation targeting with full commitment as a decision rule for the central bank in the full sample is simply not realistic.[23]

[22]See Batini and Laxton (2007) for a larger survey.

[23]While the Turkish case is not reported in Figure 6, The Central Bank of the Republic of Turkey adopted inflation targeting in the beginning of 2006. It has set a medium-term target of 4 percent with a ± 2 percent deviation band. In the first year under the new framework, inflation overshot the target. In South Africa, prior to 2006 the target was based on the CPIX annual average (CPI minus mortgage costs) while from 2006 it was replaced by a continuous target of 3 to 6 percent.

C. Choice of prior distributions

Some parameter values are taken as fixed rather than given a prior distribution that will be updated with the data; we calibrate them to values used in the previous sections and similar to those found in the literature. These parameters are the subjective discount rate, β; the steady state rate of inflation, π; the weight of leisure in the utility function, η; the quarterly depreciation rate of capital, δ; the same share of capital in the production function, α^S and α^{nS}; and the elasticity of substitution between intermediate goods in the nS sector, ϑ^{nS}. Average tax rates are calibrated for each country as the ratio of tax revenues over total revenues.

It turns out that simultaneously estimating parameters related to price setting in the S-good sector, ϕ, κ, and ν is very difficult. Different values for ν are plausible given the flat shape of the likelihood function in its neighborhood. In particular, it is straightforward to show that in the linearized version of the model around the steady state all the coefficients including ν cancel out.[24] Therefore, we also use the calibrated value of that parameter, which turns out not to affect qualitatively our results.

The set of parameters we estimate is $\{a, \psi_k, \psi^{nS}, \phi, \kappa, \rho_{A^s}, \rho_{A^{nS}}, \rho_\zeta, \sigma_{A^S}, \sigma_{A^{nS}}, \sigma_\zeta, \sigma_{P^S}\}$. For these parameters we have borrowed some of the prior distributions from the literature, but for those for which we had no references we used common sense while trying to construct the least restrictive priors possible. We selected Beta distributions for those coefficients that we wanted to restrict to lie between 0 and 1, such as the autocorrelation coefficients of the shock processes or the share parameters. Gamma and Inverted Gamma distributions are imposed, when required, to guarantee real positive values.

Table 2 shows the prior distributions we have imposed for the deep parameters of the model. Both sectors—the S- and the nS-good sectors—are treated symmetrically a priori. Hence, we calibrate for both sectors the same technology autocorrelations and shock volatilities, $\rho_{A\{S,nS\}}$ and $\sigma_{A\{S,nS\}}$, of 0.8 and 0.02, respectively. The degree of habit formation, a, was estimated mainly for developed economies for which results are diverging, therefore, we fix the mean of the distribution at 0.5. Capital adjustment costs are generally introduced to match the ratio of investment and output volatilities. In particular, the prior average level of the parameter, ψ_k, reflecting the extent to which changes in capital stock are delayed, is set to 5. The price-adjustment-cost parameter ψ^{nS} is calibrated so that, up to a first-order approximation,

[24] Kim and Ruge-Murcia (2009) succeed in estimating the parameter capturing downward rigidity for wage adjustment using simulated method of moments involving a non-linearized model. It finds a value of 3844.4 for this parameter.

Table 2. Prior distributions

Parameter	Distribution	Mean/Mode*	Std.dev./df
a	Beta	0.5	0.15
ψ_k	Gamma	5	2
ψ^{nS}_{Calvo}	Beta	0.67	0.1
ϕ	Beta	0.25	0.1
κ	Beta	0.75	0.1
ρ_{A^S}	Beta	0.80	0.1
$\rho_{A^{nS}}$	Beta	0.80	0.1
ρ_{A^ζ}	Beta	0.80	0.1
σ_{A^S}	Inverse Gamma	0.02	*Inf*
$\sigma_{A^{nS}}$	Inverse Gamma	0.02	*Inf*
σ_ζ	Inverse Gamma	0.005	*Inf*
σ_{P^S}	Inverse Gamma	0.005	*Inf*

* Note: For the inverse gamma distribution, the mode and the degrees of freedom are reported.

the resulting nominal rigidity is equivalent to that implied by a Calvo-type staggered price setting with an average duration of price contracts of 3 quarters. The share of the S-good sector is set to 0.25 on average, but we allow for a relatively wide prior distribution. Finally, the average prior of the degree of S-good price smoothing is set to 0.75. Since this parameter is not commonly estimated in the literature we do some sensitivity analysis based on its prior distribution and the estimation results are generally robust.

D. Estimation results

Through Bayesian simulation techniques described in detail in Schorfheide (2000), 200, 000 draws from the posterior are generated. The Columns in Table 3 show the mean and 90 percent probability intervals for the estimated parameters. Overall the parameters are precisely estimated and are economically meaningful.

Results show that data are most informative for the adequate parameterization of the shocks processes and the price distortions, since those are the parameters for which posterior distributions differ more from their prior ones. In particular, posterior estimates indicate that nS-good supply shocks are the most volatile followed by shocks to S-good price for the majority of the countries (Argentina, Brazil, Czech Rep., Indonesia, Hungary, South Africa, and Turkey), and the only exceptions are Egypt and Poland.[25]

Looking at the parameters that are not directly affecting the design of monetary policy, one can find similarities with what was previously reported in the literature. The estimated values for the degree of habit formation in consumption, a, vary from 0.15 for Mexico to 0.88 in the Philippines. The degree of habit formation for consumption is not very high reflecting low welfare cost following changes in the level of consumption in the considered countries.[26] Although, the magnitude of habit formation is still consistent with the values of 0.63, reported by Christiano, Eichenbaum, and Evans (2005) and 0.73, reported by Boldrin, Eichenbaum, and Fisher (2001). The capital adjustment cost parameter estimates are consistent with the traditionally low values which have been used to calibrate RBC models.

At first glance, the key parameters that are expected to be crucial for the design of the optimized monetary rule exhibit some heterogeneity among the set of countries considered in this study. The average frequency of changing prices of nS goods is estimated to have a posterior median varying from about 5 months in Argentina to roughly 20 months in Morocco. Except the Argentinean case, price stickiness average duration is in line with the estimates found in the literature covering developed countries in general (see for instance Gali and Gertler, 1999; Christiano, Eichenbaum, and Evans, 2005; Smets and Wouters, 2002; Bils and Klenov, 2004, among many others). The share of S goods in the overall consumption basket is generally precisely estimated and fluctuates from 0.13 in Poland to 0.47 in Philippines. For Tunisia and Morocco, where sectoral disaggregated data for prices were provided, the estimated 90 percent intervals of the share of goods reflecting controlled prices in the consumption basket are $[0.25, 0.44]$ and $[0.24, 0.45]$, respectively. Clearly, declared shares, 0.32 and 0.31, lie within the estimated confidence interval. Further, the parameter κ is estimated at values above 0.50 meaning that the government is actively intervening to stabilize the fluctuations of a subset of goods and services' prices. This represents a substantive deviation from the flexible price equilibrium.

Together with the degree of price stickiness, ψ^{nS}, the two parameters capturing the interventionism of government in setting prices, ϕ and κ, are important in terms of the conduct of the monetary policy and the definition of the appropriate measure of inflation to be targeted.

[25]For Mexico, Morocco, Thailand, and Tunisia the sector specific technology shocks have similar volatilities

[26]In addition, consumption series for developing countries and emerging markets generally exhibit a relatively high volatility once compared to developed countries.

One key assumption that our results depend on is the existence of fiscal authorities' intervention in stabilizing prices. In order to gauge the importance of the sectoral specification and more particularly the existence of the S-good sector, we test this hypothesis by estimating the model separately under the restrictions $\phi > 0$ and $\phi = 0$. We reject one model specification in favor of the other by evaluating the posterior odds ratio corresponding to the assumptions $H_0 : \phi > 0$ and $H_1 : \phi = 0$. To do so, let's define $\pi_{0,0}$ as the prior probability associated with this hypothesis. The posterior odds of H_0 versus H_1 are given by :

$$\frac{\pi_{0,T}}{\pi_{1,T}} = \frac{\pi_{0,0}}{\pi_{1,0}} \frac{p(Y^T|H_0)}{p(Y^T|H_1)}.$$

As shown in this equation, posterior odds are the ratio between the marginal data likelihood of the model under H_0 and H_1, $\frac{p(Y^T|H_0)}{p(Y^T|H_1)}$, multiplied by a prior model odds ratio, $\frac{\pi_{0,0}}{\pi_{1,0}}$. Large values of the posterior odds ratio provide evidence in favor of H_0 over H_1 while small values provide evidence in favor of H_1 over H_0.[27]

The odds ratios, derived from the marginal data densities reported in the last column of Table 4, which are above 1 do not indicate any evidence in favor of $\phi = 0$.[28]

Clearly, there is strong evidence of the existence of a S-good sector in Argentina, Brazil, Egypt, Mexico, Morocco, Tunisia, and Turkey. In addition, the case of Philippines reflects a slight empirical evidence in favor of the one-sector model, although not significant. For all the six other countries: Czech Republic, Hungary, Indonesia, Poland, South Africa, and Thailand the marginal data densities improve when $\phi = 0$ is assumed, advocating for a clear evidence in favor of the irrelevance of the S-good sector. This is not necessarily at odds with the introduction of these countries in the set of economies where governments have significant influence on price setting in the sense that fiscal authorities' interventions may be rather regulatory trough imposing caps, floors, or indirect taxes. Furthermore, another caveat to this test is closely related to the choice of observables used for the estimation of the model. In this context, it is worth reminding that for all the countries, except Tunisia and Morocco, none of the observed variables explicitly refers to sector specific measures. For that reason, the results

[27] Jeffereys (1961) suggests to assess the odds ratio using the following rule of thumb: if $1 < \frac{\pi_{0,T}}{\pi_{1,T}} < 3$ there is only weak evidence for H_0. If $3 < \frac{\pi_{0,T}}{\pi_{1,T}} < 12$ there is weak to moderate evidence for H_0. If $12 < \frac{\pi_{0,T}}{\pi_{1,T}} < 148$ there is moderate to strong evidence for H_0. Finally, if $\frac{\pi_{0,T}}{\pi_{1,T}} > 148$, there is decisive evidence for H_0.

[28] Assuming that prior model preferences are not imposed, i.e., if one sets $\frac{\pi_{0,0}}{\pi_{1,0}} = 1$, the odds ratio simplifies into the Bayes factor comparing two marginal data densities.

Table 3. Parameter Estimation Results

	Argentina	Brazil	Czech Rep.	Egypt	Hungary	Indonesia	Mexico	Morocco	Philippines	Poland	South Africa	Thailand	Tunisia	Turkey
a	0.241	0.226	0.482	0.456	0.462	0.630	0.148	0.446	0.877	0.501	0.583	0.426	0.451	0.325
	[0.110,0.378]	[0.108,0.360]	[0.248,0.716]	[0.202,0.699]	[0.214,0.705]	[0.417,0.836]	[0.049,0.238]	[0.222,0.693]	[0.804,0.950]	[0.250,0.763]	[0.386,0.771]	[0.210,0.658]	[0.204,0.669]	[0.122,0.540]
ψ_k	4.881	4.991	6.050	1.941	6.000	5.689	4.342	3.476	7.667	5.120	7.301	5.801	3.541	5.081
	[2.296,7.729]	[1.365,8.402]	[2.624,9.402]	[1.156,2.634]	[2.357,9.471]	[2.326,8.898]	[1.307,7.356]	[0.955,6.031]	[3.875,11.370]	[2.325,7.965]	[3.098,11.559]	[2.089,9.267]	[1.105,6.152]	[2.143,8.111]
ψ^{nS}_{Calvo} *	0.284	0.696	0.771	0.768	0.776	0.746	0.641	0.847	0.631	0.767	0.731	0.742	0.844	0.731
	[0.176,0.381]	[0.548,0.856]	[0.655,0.887]	[0.620,0.913]	[0.651,0.898]	[0.620,0.889]	[0.486,0.777]	[0.777,0.918]	[0.470,0.798]	[0.667,0.851]	[0.594,0.881]	[0.616,0.865]	[0.774,0.913]	[0.594,0.871]
ϕ	0.356	0.307	0.246	0.336	0.226	0.253	0.373	0.347	0.472	0.134	0.248	0.234	0.342	0.355
	[0.345,0.368]	[0.218,0.419]	[0.125,0.361]	[0.260,0.406]	[0.105,0.339]	[0.122,0.355]	[0.347,0.442]	[0.243,0.448]	[0.374,0.574]	[0.048,0.220]	[0.136,0.413]	[0.119,0.379]	[0.247,0.441]	[0.251,0.457]
κ	0.689	0.573	0.749	0.777	0.673	0.710	0.564	0.588	0.806	0.770	0.701	0.768	0.597	0.741
	[0.531,0.853]	[0.385,0.760]	[0.598,0.919]	[0.631,0.948]	[0.492,0.861]	[0.540,0.891]	[0.400,0.756]	[0.391,0.776]	[0.692,0.936]	[0.624,0.929]	[0.543,0.875]	[0.619,0.914]	[0.407,0.784]	[0.594,0.910]
ρ_{A^S}	0.873	0.774	0.661	0.726	0.745	0.685	0.867	0.716	0.759	0.735	0.760	0.796	0.712	0.792
	[0.808,0.945]	[0.624,0.936]	[0.511,0.805]	[0.563,0.901]	[0.603,0.882]	[0.535,0.845]	[0.787,0.958]	[0.560,0.861]	[0.634,0.875]	[0.591,0.869]	[0.610,0.956]	[0.684,0.912]	[0.560,0.872]	[0.664,0.922]
$\rho_{A^{nS}}$	0.818	0.793	0.775	0.793	0.805	0.716	0.751	0.714	0.778	0.688	0.807	0.783	0.713	0.785
	[0.733,0.907]	[0.681,0.892]	[0.647,0.910]	[0.645,0.952]	[0.682,0.928]	[0.558,0.882]	[0.628,0.896]	[0.560,0.868]	[0.674,0.892]	[0.535,0.839]	[0.700,0.922]	[0.654,0.909]	[0.562,0.872]	[0.651,0.930]
ρ_ζ	0.714	0.773	0.797	0.784	0.696	0.796	0.829	0.397	0.735	0.678	0.680	0.665	0.400	0.805
	[0.566,0.851]	[0.625,0.930]	[0.678,0.918]	[0.647,0.913]	[0.557,0.857]	[0.672,0.937]	[0.722,0.946]	[0.267,0.525]	[0.582,0.877]	[0.526,0.833]	[0.524,0.818]	[0.514,0.812]	[0.271,0.528]	[0.690,0.930]
σ_{A^S}	0.007	0.011	0.006	0.018	0.005	0.005	0.015	0.003	0.008	0.011	0.005	0.012	0.003	0.017
	[0.004,0.009]	[0.005,0.018]	[0.004,0.008]	[0.004,0.026]	[0.004,0.006]	[0.004,0.007]	[0.011,0.020]	[0.002,0.003]	[0.005,0.010]	[0.007,0.014]	[0.004,0.006]	[0.006,0.017]	[0.002,0.003]	[0.009,0.024]
$\sigma_{A^{nS}}$	0.024	0.032	0.009	0.012	0.009	0.009	0.014	0.004	0.018	0.008	0.011	0.011	0.003	0.021
	[0.014,0.033]	[0.005,0.050]	[0.005,0.013]	[0.002,0.024]	[0.005,0.013]	[0.005,0.013]	[0.004,0.025]	[0.002,0.005]	[0.011,0.026]	[0.004,0.011]	[0.005,0.016]	[0.005,0.018]	[0.002,0.005]	[0.005,0.039]
σ_ζ	0.003	0.004	0.002	0.004	0.002	0.002	0.005	0.001	0.003	0.002	0.002	0.002	0.001	0.004
	[0.001,0.004]	[0.001,0.006]	[0.001,0.003]	[0.002,0.005]	[0.001,0.003]	[0.001,0.003]	[0.002,0.008]	[0.001,0.001]	[0.001,0.004]	[0.001,0.003]	[0.001,0.003]	[0.001,0.003]	[0.001,0.001]	[0.002,0.006]
$\sigma_{p^{nS}}$	0.006	0.004	0.004	0.005	0.004	0.004	0.008	0.002	0.005	0.005	0.003	0.004	0.002	0.005
	[0.001,0.011]	[0.001,0.008]	[0.001,0.009]	[0.001,0.011]	[0.001,0.007]	[0.001,0.008]	[0.001,0.019]	[0.001,0.003]	[0.001,0.009]	[0.001,0.009]	[0.001,0.005]	[0.001,0.008]	[0.001,0.003]	[0.001,0.009]
τ **	0.284	0.350	0.400	0.267	0.435	0.187	0.208	0.246	0.166	0.400	0.257	0.205	0.172	0.321
$\mathscr{L}$***	532.386	438.868	560.963	199.550	572.469	396.237	913.476	620.285	996.2493	521.484	539.270	577.070	573.613	320.714

* For interpretation purposes the adjustment cost parameter is transformed as a Calvo probability for keeping prices unchanged.

** The average tax rate on revenue was calibrated based on the share of tax revenues over GDP taken from Haver Database.

*** This row shows the estimated log-likelihood data density.

Remark: 90 percent confidence intervals are shown in square brackets.

Table 4. Posterior Odds

Country	Log marginal data densities		Odds
	Benchmark	$\phi = 0$	$\phi = 0$
Argentina	−532.39	−523.34	8518.54
Brazil	−438.87	−437.23	5.16
Czech Rep.	−560.96	−568.98	0.00
Egypt	−201.47	−199.52	7.03
Hungary	−572.47	−580.32	0.00
Indonesia	−396.24	−400.06	0.02
Mexico	−913.48	−905.54	2807.36
Morocco	−620.29	−576.83	7e18
Philippines	−996.25	−997.80	0.21
Poland	−521.48	−527.10	0.00
South Africa	−539.27	−549.76	0.00
Thailand	−577.07	−592.28	0.00
Tunisia	−573.61	−530.96	3e18
Turkey	−320.71	−316.14	96.54

of the test may change once sectoral variables, such as inflation rates, are used to estimate the model.

Concerning the estimated values of the parameters it is worth mentioning that the most affected one by using one version or the other of the model is the degree of price stickiness. This result is straightforward knowing that the model with one sector tends to overestimate the value of price stickiness. Assuming only one sector in the economy, the estimated adjustment cost would be the only candidate to capture menu costs, administrative costs, information costs, and public authority controls of prices which would yield a high parameter of price stickiness. For instance, the estimated two- and one-sector models for Argentina produce values for ψ^{nS}_{calvo} of 0.284 and 0.920, reflecting average price stickiness for about 4 months and 3 years, respectively.[29] Most likely, this could be the outcome of the one-sector model misspecification.

[29]Looking at the 90 percent confidence intervals for the two point estimates of ψ^{nS}_{calvo} in the one- and two-sector models, $[0.176, 0.381]$ and $[0.882, 0.961]$ respectively, reveals the clear difference between the two estimates

V. Quantitative Implications of the Model

In this section, we search for the parameterizations of alternative feedback Taylor-type interest rate rules similar to Section III that maximize household welfare given our estimated model. In particular, the optimized policy rule under commitment implies a rigorous choice for parameters reflecting the reaction of the monetary authority to changes in sectoral inflation rates as well as output gap and the degree of interest rate smoothing. To do so, we evaluate the welfare gains under alternative policies compared to the headline inflation stabilization policy (or "standard rule").

A. Welfare evaluation

The search for the welfare-maximizing feedback monetary policy rules is set out as follows. We maximize the unconditional expectation of lifetime utility of households over the parameters of the Taylor rule.[30] This implies:

$$\max_{\rho_{\pi^S},\rho_{\pi^{nS}},\rho_y,\rho_R} E_t\left\{U_t\right\},$$

where $U_t = \sum_{l=t}^{\infty} \beta^{t+l}\left[u\left(c_{t+l}, c_{t+l-1}\right) - \eta v\left(h_{t+l}\right)\right]$.

We measure the welfare gain associated with a particular monetary policy in terms of its compensating variation. That is, we calculate the percentage of lifetime consumption, ω, that should be added to that obtained under headline inflation targeting in order to give households the same unconditional expected utility as under the new monetary policy rule scenario:

$$E\left\{U((1+\omega)c_t, m_t, h_t)\right\} = E\left\{u(\tilde{c}_t, \tilde{m}_t, \tilde{h}_t)\right\},$$

where variables without tildes are obtained under CPI inflation targeting rule and variables with tildes correspond to the optimized Taylor rule case. Based on the results found in Kim and Kim (2003) and the subsequent literature, we compute the long-run average utility by

[30] Schmitt-Grohé and Uribe (2007) adopt the conditional welfare optimization in their framework and they consider the non-stochastic steady state as an initial state of the economy. By computing the unconditional long-run utility, we do not consider the effect of the initial state. Transition costs are crucially dependent on that initial state, especially if the real state of the economy is never at the deterministic level. In addition, Schmitt-Grohé and Uribe (2007) show that the optimal rule is robust to these definitions of welfare, but that the welfare improvement could be different in the sense that it is higher in the case of unconditional welfare given that no short-term transition costs are incurred.

means of a second-order approximation around the steady-state utility. In particular, we follow the approach of Schmidt-Grohé and Uribe (2004):

$$E\left(U\left(\tilde{c}_t,\tilde{m}_t,\tilde{h}_t\right)\right)=U(c,m,h)+U'E\left(\widehat{\tilde{c}}_t,\widehat{\tilde{m}}_t,\widehat{\tilde{h}}_t\right)+\frac{1}{2}E\left(\widehat{\tilde{c}}_t,\widehat{\tilde{m}}_t,\widehat{\tilde{h}}_t\right)'U''\left(\widehat{\tilde{c}}_t,\widehat{\tilde{m}}_t,\widehat{\tilde{h}}_t\right)+\mathscr{O},$$

where U_t'' and U'' are the first and second derivatives, respectively, of the utility function with respect to its arguments, evaluated at their deterministic steady-state values, and variables with hats measure deviations from their levels in the deterministic steady state.

B. Welfare analysis

Table 5 reports the welfare gains measured as percentage of compensating variation of consumption. In what follows, we limit our attention to the Taylor-type rules that guarantee the existence of a unique and stable equilibrium in the neighborhood of the deterministic steady state. Three alternative policies are considered: (i) S-good inflation stabilization; (ii) core inflation stabilization; and (iii) optimal choice for parameters reflecting the reaction of the monetary authority to changes in sectoral inflation rates as well as output gap and the degree of interest rate smoothing.

The last column of Table 5 clearly shows that headline inflation targeting is always suboptimal given the possibility of reaching positive welfare gains evolving from 0.0013 to 0.1455 percent in permanent increase of consumption for Tunisia and Argentina, respectively. Globally two classes of countries emerge from the welfare analysis under different policies. The first ones are countries where the right policy is to simply stabilize core inflation and fully discard S-good inflation which are Tunisia and Indonesia where the optimized Taylor rule is simply:

$$\log\left(\frac{R_t}{R}\right)=\infty\log\left(\frac{\pi_t^{nS}}{\pi^{nS}}\right). \quad (22)$$

This result is consistent with the theoretical outcome of the model suggesting lower distorting effect generated by subsidies when average tax rates are sufficiently low (tax rates are below 20 percent for Tunisia and Indonesia). This explains the dominant role of price distortions in the nS-good sector which unsurprisingly yields full stabilization of core inflation.

Table 5. Optimized hybrid Taylor rules versus pure CPI inflation targeting

Country	Welfare loss compared to CPI inflation stabilization			
	π^S stabilization	π^{nS} stabilization	Optimized rule	Welfare loss
Argentina	−0.0451	0.1332	ρ_{π^S} = 1.3079 $\rho_{\pi^{nS}}$ = 0.0000 ρ_y = 0.0000 ρ_R = 0.0016	−0.1455
Brazil	0.0272	0.3358	ρ_{π^S} = 2.5947 $\rho_{\pi^{nS}}$ = 1.9917 ρ_y = 0.4296 ρ_R = 0.0002	−0.0295
Czech Rep.	0.1701	0.0439	ρ_{π^S} = 1.1553 $\rho_{\pi^{nS}}$ = ∞ ρ_y = 0.0000 ρ_R = 0.0000	−0.0304
Egypt	0.1464	0.0929	ρ_{π^S} = 1.5716 $\rho_{\pi^{nS}}$ = ∞ ρ_y = 0.0000 ρ_R = 0.0000	−0.0444
Hungary	0.1094	0.0427	ρ_{π^S} = 0.7854 $\rho_{\pi^{nS}}$ = 2.2877 ρ_y = 0.0000 ρ_R = 0.0000	−0.0111
Indonesia	0.1093	−0.0481	ρ_{π^S} = 0.0000 $\rho_{\pi^{nS}}$ = ∞ ρ_y = 0.0000 ρ_R = 0.0000	−0.0481
Mexico	0.1241	0.0203	ρ_{π^S} = 0.7130 $\rho_{\pi^{nS}}$ = 2.8322 ρ_y = 0.0000 ρ_R = 0.0000	−0.0098
Morocco	0.0086	−0.0080	ρ_{π^S} = 0.4673 $\rho_{\pi^{nS}}$ = ∞ ρ_y = 0.0000 ρ_R = 0.0000	−0.0116
Philippines	0.0453	−0.0044	ρ_{π^S} = 1.9879 $\rho_{\pi^{nS}}$ = ∞ ρ_y = 0.0000 ρ_R = 0.0000	−0.0177
Poland	0.0538	0.0265	ρ_{π^S} = 0.9009 $\rho_{\pi^{nS}}$ = 2.3143 ρ_y = 0.0000 ρ_R = 0.0000	−0.0014
South Africa	0.0252	0.0074	ρ_{π^S} = 1.5786 $\rho_{\pi^{nS}}$ = ∞ ρ_y = 0.0000 ρ_R = 0.0000	−0.0018
Thailand	0.0188	−0.0143	ρ_{π^S} = 0.0000 $\rho_{\pi^{nS}}$ = ∞ ρ_y = 0.0000 ρ_R = 0.0000	−0.0143
Tunisia	0.0020	−0.0013	ρ_{π^S} = 0.0000 $\rho_{\pi^{nS}}$ = ∞ ρ_y = 0.0000 ρ_R = 0.0000	−0.0013
Turkey	0.1444	0.3197	ρ_{π^S} = 3.6436 $\rho_{\pi^{nS}}$ = ∞ ρ_y = 0.0000 ρ_R = 0.0000	−0.0096

The second class of countries exhibits suboptimal headline and core inflation targeting regimes. Brazil is an interesting case where the optimized policy is:

$$\log\left(\frac{R_t}{R}\right) = 2.59\log\left(\frac{\pi_t^S}{\pi^S}\right) + 1.99\log\left(\frac{\pi_t^{nS}}{\pi^{nS}}\right) + 0.43\log\left(\frac{Y_t}{Y}\right), \tag{23}$$

which displays a policy that is mildly reacting to deviations of π_t^S and π_t^{nS} from the target. Curiously, reacting to output gap is also welfare improving in the same country with an optimal coefficient of 0.43. Besides, targeting uniquely one sectoral inflation is welfare deteriorating compared to headline inflation targeting. Consistently with the theoretical benchmark results, estimates for Brazil reveal reasonable degree of price rigidity in the nS-good sector, $\psi^{nS} = 0.696$, a relatively high share of subsidized goods, $\phi = 0.307$, and a substantive tax rate, $\tau = 0.35$. The high average tax rate exacerbates the distortionary effect of subsidies.

Optimized policy coefficients for Argentina, Hungary, Mexico, and Poland show the importance of targeting sectoral inflation rates. This result is obviously linked to the competing distortions in the S- and nS-good sectors. Excluding Argentina, the three other countries would maximize their welfare under more aggressive reactions to core inflation. Nevertheless, solely reacting to core inflation and fully ignoring S-good inflation is welfare deteriorating in all these countries with records registered in Argentina and Hungary corresponding to permanent drops in consumption of 0.13 and 0.04 percent, respectively.

Finally, Egypt, South Africa, Philippines, and Turkey would be better off if they completely stabilize core inflation but simultaneously react to S-good prices fluctuations with coefficients of 1.57, 1.58, 1.99, and 3.64, respectively. At the same time, if the monetary authority neglects the S-good inflation through a pure core inflation stabilization policy, welfare gains conditional to the optimized policy could switch to welfare losses. Quantitatively, Turkey and Egypt for instance could permanently loose 0.32 percent and 0.09 percent of lifetime consumption, respectively.

As shown earlier, the right monetary policy in the presence of subsidized prices and costly adjusting prices in terms of which inflation to target is very sensitive to the relative importance of these distortions. Interestingly, the task of policy makers is compounded owing to the multiple cases of optimized Taylor rules they could adopt: (i) solely stabilizing core inflation (e.g., Indonesia and Tunisia); (ii) mildly reacting to both sectoral inflation rates (e.g., Argentina, Brazil, Hungary, Mexico, and Poland); and (iii) stabilizing core inflation and still reacting to S-good inflation (e.g., Egypt, Philippines, South Africa, and Turkey). Furthermore, as reported by Erceg, Henderson, and Levin (2000), we also find evidence for welfare improving output gap targeting in the present model. This happens when the distortion generated by controlling prices by the public authorities is sufficiently important (see the case of Brazil). In some sense, the two models have similarities in terms of the presence of multiple sources of price distortions. Hence, policy makers imperatively need to be cautious when identifying the right anchors and the degree of aggressiveness toward their fluctuations. This sensitive choice urges for a very careful analysis of the sources of distortions and their quantitative impact on welfare, which is obviously very challenging.

C. Optimal core inflation targeting: Some preconditions

As seen by comparing the third and fifth columns of Table 5, the welfare loss under aggressive core targeting can be several times larger than under the optimized rule. The larger loss is attributable to higher share of subsidized goods and to higher tax rates. Countries where tax rates are relatively low, such as Indonesia, Thailand, and Tunisia, are already favorable to the adoption of a core inflation targeting policy.

For an inflation targeting regime to be operational, we assume that the measure of inflation to be targeted is core inflation. This is in accordance with central banks' practices consistent with excluding administered prices from official measures of core inflation. Therefore, in what follows we ask the question: to what extent government intervention in setting prices should be reduced in order to allow core inflation targeting to be the best policy choice?

Table 6 states the reductions in the share of subsidized goods, ϕ, each country has to undertake in order to be able to optimally implement core inflation targeting. In particular, Argentina has to reduce ϕ by almost a half to eliminate welfare costs associated with core inflation targeting. This substantial change in the conduct of fiscal policy is mainly due to the low cost of price adjustments. In addition, if Brazil, Mexico, Philippines, and South Africa would be able to reduce the share of subsidized goods by 10 percentage or less, core inflation targeting may give a better outcome than the initial monetary dual mandate objective function that penalizes volatility in both sectoral inflation rates. The Czech Republic, Hungary, and Turkey have to drastically reduce that policy parameter—by almost a third, given the high tax rates in these countries: 40, 43.5, and 32.1 percent, respectively. Also, Egypt has to bring down its subsidized goods share from 33.6 percent to 18.3 percent, before starting to implement a monetary policy that seeks core inflation stability.

Table 6. Threshold share of subsidized goods for optimal core inflation targeting policy

Country	Estimated ϕ	Threshold ϕ
Argentina	0.356	0.186
Brazil	0.307	0.204
Czech Republic	0.246	0.068
Egypt	0.336	0.182
Hungary	0.226	0.088
Indonesia	0.253	—
Mexico	0.373	0.262
Morocco	0.347	0.200
Philippines	0.472	0.360
Poland	0.134	0.094
South Africa	0.248	0.196
Thailand	0.234	—
Tunisia	0.342	—
Turkey	0.355	0.132

Clearly, the exercise we are conducting here is mechanical. The implementation of the necessary fiscal reforms often faces several obstacles such as (i) weak capacity to target the poor; (ii) lack of transparency in reporting of subsidies; (iii) opposition to reforms by vested interests; (iv) spillover effects; and (v) ad hoc price setting mechanisms. Reform strategies need to address these issues.

VI. Conclusion

We analyze welfare-improving monetary policy reaction functions in the context of a New Keynesian economy model with subsidized- and a non-subsidized-good sectors where the latter exhibits sticky prices. The model is estimated for a number of countries, then, used to evaluate the welfare gains of alternative specifications of the nominal interest rate feedback rule under full commitment and transparency.

We explore what would be the optimal parametrization of an implementable interest rate rule where the central bank smooths out interest rates, stabilizes inflation measures, and reduces output gap. We find welfare losses in responding aggressively to headline inflation deviations from target compared to targeting sectoral inflation rates and output gap. The right policy is intimately dependent on the relative importance of competing markets distortions. The estimation of the model for a large set of countries shows heterogeneity in the relative importance of each sector in distorting the economy implying multiple scenarios for optimal monetary policy design. Clearly, results challenge the implementation of inflation targeting in many countries where prices are sticky and fiscal authorities subsidize some of consumption goods and services. Finally, we propose practical policies aiming to reduce the extent to which governments intervene in the process of price setting allowing core inflation targeting to be optimal in the context of simple implementable Taylor rules.

APPENDIX A. THE MODEL'S EQUATIONS

The behavioral nonlinear dynamic equations of the structural model are the following

$$
\begin{aligned}
\lambda_t &= \frac{1}{c_t - ac_{t-1}} - E_t\left(\frac{\beta a}{c_{t+1} - ac_t}\right), \\
\lambda_t &= \frac{\eta(1-h_t)^{-1}}{(1-\tau_t)w_t}, \\
\lambda_t &= \beta R_t E_t\left(\frac{\lambda_{t+1}}{\pi_{t+1}}\right), \\
\lambda_t &= \frac{\beta E_t\{\lambda_{t+1}[1+q_{t+1}-\delta+\psi_k(\frac{i_{t+1}}{k_{t+1}}-\delta)+\frac{\psi_k}{2}(\frac{i_{t+1}}{k_{t+1}}-\delta)^2]\}}{1+\psi_k(\frac{i_t}{k_t}-\delta)}, \\
k_{t+1} &= (1-\delta)k_t + i_t, \\
y_t &= c_t + i_t + CAC_t, \\
y_t &= \left(y_t^S\right)^{\phi}\left(y_t^{nS}\right)^{(1-\phi)}, \\
y_t^S &= \phi\left(\frac{p_t}{\tilde{p}_t^S}\right)y_t, \\
y_t^{nS} &= (1-\phi)\left(\frac{p_t}{p_t^{nS}}\right)y_t, \\
\tilde{p}_t^S &= \frac{\kappa}{1+\exp\left[-\nu\left(\frac{p_t^S}{\tilde{p}_{t-1}^S}\pi_t - 1\right)\right]}\frac{\tilde{p}_{t-1}^S}{\pi_t} + \left(1 - \frac{\kappa}{1+\exp\left[-\nu\left(\frac{p_t^S}{\tilde{p}_{t-1}^S}\pi_t - 1\right)\right]}\right)p_t^S + \varepsilon^{p_t^S}, \\
y_t^S &= A_t^S(k_t^S)^{\alpha^S}(h_t^S)^{1-\alpha^S}, \\
\frac{w_t}{p_t^S} &= (1-\alpha^S)\frac{y_t^S}{h_t^S}, \\
\frac{q_t}{p_t^S} &= \alpha^S\frac{y_t^S}{k_t^S}, \\
y_t^{nS} &= A_t^{nS}(k_t^{nS})^{\alpha^{nS}}(h_t^{nS})^{1-\alpha^{nS}}, \\
\frac{w_t}{p_t^{nS}} &= (1-\alpha^{nS})\xi_t^{nS}\frac{y_t^{nS}}{h_t^{nS}}, \\
\frac{q_t}{p_t^{nS}} &= \alpha^{nS}\xi_t^{nS}\frac{y_t^{nS}}{k_t^{nS}}, \\
-\theta\frac{\xi_t^{nS}}{p_t^{nS}} &= (1-\theta)\left[1 - \frac{\psi^{nS}}{2}\left(\frac{\pi_t^{nS}}{\pi^{nS}} - 1\right)^2\right] \\
&\quad -\psi_{nS}\left[\frac{\pi_t^{nS}}{\pi^{nS}}\left(\frac{\pi_t^{nS}}{\pi^{nS}} - 1\right) - \beta E_t\frac{\lambda_{t+1}}{\lambda_t}\frac{\left(\pi_{t+1}^{nS}\right)^2}{\pi_{t+1}\pi^{nS}}\left(\frac{\pi_t^{nS}}{\pi^{nS}} - 1\right)\frac{y_{t+1}^{nS}}{y_t^{nS}}\right],
\end{aligned}
$$

$$
\begin{aligned}
\zeta_t &= \frac{m_t}{m_{t-1}}\pi_t, \\
\log(\zeta_t) &= \rho_\zeta \log(\zeta_{t-1}) + \varepsilon_{\zeta,t}, \text{ or} \\
\log\left(\frac{R_t}{R}\right) &= \rho_R \log\left(\frac{R_{t-1}}{R}\right) \\
&\quad + (1-\rho_R)\left[\rho_\pi \log\left(\frac{\pi_t}{\pi}\right) + \rho_{\pi^S} \log\left(\frac{\tilde{\pi}_t^{\,S}}{\widetilde{\pi}^S}\right) + \rho_{\pi^{nS}} \log\left(\frac{\pi_t^{nS}}{\pi^{nS}}\right) + \rho_y \log\left(\frac{y_t}{y}\right)\right], \\
\tau_t w_t h_t &= \left(p_t^S - \tilde{p}_t^S\right) y_t^s, or \\
-tr_t &= \left(p_t^S - \tilde{p}_t^S\right) y_t^s - (m_t - m_{t-1}), \\
\pi_t^{nS} &= \frac{p_t^{nS}}{p_{t-1}^{nS}}\pi_t.
\end{aligned}
$$

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