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Asset Market Structures and Monetary Policy in a Small Open Economy

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Abstract

This paper sets up a canonical new Keynesian small open economy model with nominal price rigidities to explore the impact of habit persistence and exchange rate pass-through on the welfare ranking of alternative monetary policy rules. It identifies three factors that can affect the welfare ranking: the degree of habit persistence, the degree of exchange rate pass-through, and labor supply elasticity. In contrast to the findings of De Paoli (2009a, 2009b), the analysis reveals a reversal in the welfare ranking of alternative monetary policy rules for unitary intertemporal and intratemporal elasticities of substitution, depending on the asset market structures of small open economies with external habit. The paper also finds that exchange rate pegging outperforms domestic producer price index inflation targeting at high degrees of intratemporal elasticity of substitution and external habit, regardless of asset market structures. Finally, the paper finds that exchange rate pegging outperforms domestic or consumer price index inflation targeting if the exchange rate is misaligned.

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Contents

1. INTRODUCTION

At the heart of the policy debate in international finance lies the question of whether monetary authorities should react to both fluctuations in international relative prices and domestic output and inflation. Several papers have explored how monetary policy should react to disturbances in open economies with complete asset markets. These papers have emphasized that monetary policy is influenced by the presence of a terms of trade externality.

Evidence from the literature suggests that strict domestic inflation targeting would be the optimal monetary policy in producer currency pricing circumstances, except where the trade elasticity of substitution (i.e., the elasticity of substitution between domestic and foreign goods) is implausibly high. In particular, Gali and Monacelli (2005) showed that the optimal monetary policy in a small open economy is isomorphic to the one in the closed economy, when both the intertemporal and intratemporal elasticities of substitution one in the producer currency pricing model.[1]

The recent financial turmoil has generated greater interest in feasible monetary policy prescriptions not only for economies with sophisticated financial structures, but also for economies with fragile financial structures. Although many emerging economies have shifted from a fixed exchange rate to a floating exchange rate regime, the extent to which monetary policy should adjust to account for the impact of the exchange rate on the domestic economy remains highly controversial. Some policymakers in emerging economies still believe in a trade-off between inflation and exchange rate stability, thus bringing into question the desirable form of monetary policy. They believe that monetary policy which preserves the competitiveness of domestic products in the exchange market is necessary to improve the welfare of economies with fragile financial structures.

More recently, Corsetti, Dedola, and Leduc (2010) and De Paoli (2009b) have argued that the configuration of the domestic asset market significantly affects the performance of monetary policy rules, by changing the degree of risk-sharing. In a complete asset market, optimal risk-sharing severs the link between domestic consumption and domestic output, allowing domestic agents to reduce their labor supply without causing a corresponding fall in their consumption levels. In an incomplete asset market, on the other hand, where domestic consumption and domestic output are closely related, domestic households cannot decrease their disutility of labor supply without decreasing their utility from consumption. Therefore, the monetary policy prescription for open economies with complete markets may not hold for open economies with incomplete asset markets.

According to De Paoli (2009b), the domestic price index inflation targeting (hereafter DPI) rule outperforms the exchange rate pegging (hereafter PEG) rule and the consumer price index inflation targeting (hereafter CPI) rule in financial autarkies as well as incomplete markets, except when the elasticity of substitution between home and foreign goods is low.[2] Corsetti, Dedola, and Leduc (2010) have also argued that near divine coincidence holds for economies characterized by a high trade elasticity of substitution, i.e., where domestic and foreign goods are close substitutes. This is true even in incomplete markets where inefficiencies are present due to exchange rate misalignments. In particular, they showed that an inward-looking monetary policy is optimal for unitary intratemporal and intertemporal elasticities of substitution, if there are only efficient technology shocks.

More recent papers have shown that incorporating real rigidities—such as internal or external habit formation—improves the explanatory power of dynamic stochastic general equilibrium (hereafter DSGE) models over business cycles. For example, Adolfson et al. (2007) and Christiano, Trabant, and Walentin (2007) have reported that incorporating habit

[1] See De Paoli (2009) and Faia and Monacelli (2008) for a small open economy model.

[2] The DPI rule outperforms the PEG rule and the CPI rule in an incomplete market as well as in a financial autarky when the domestic and foreign goods are not close substitutes---i.e. when the intratemporal elasticity of substitution between domestic and foreign goods is higher than 0.7.

formation improves the empirical performance of small-scale, open macroeconomic models by introducing persistence into structural equations (such as the Euler equation and the Phillips curve in the open economy new Keynesian model). Sticky price models with habit persistence in consumption generate the expected hump-shaped response of consumption and output to a monetary shock; the monetary policy implications of such models therefore warrant a closer look.

This paper sets up a small open economy with internal and external habit persistence and alternative asset market structures, to explore the welfare implications of alternative monetary policy rules. Households with external habit unconsciously overheat the economy during expansionary phases, and disproportionately cool down the economy during contractionary phases. Households with external habit tend to work harder than necessary to keep up with the Joneses, causing the economy to produce more than the efficient level of output. In a small open economy, this leads to a deterioration in its terms of trade, while the terms of trade for the rest of the world remains unchanged. In this way, external habit generates the welfare-relevant real exchange rate gap and output gap.

The deterioration in the terms of trade hurts the purchasing power of domestic households and intensifies the negative impact of externality on consumption in a small open economy. Since both consumption and leisure critically depend on the asset market structure that provides options for risk-sharing, the welfare ranking of alternative monetary policy prescriptions can differ depending on the prevailing asset market structure.

The objective of the paper is to explore the implications of alternative monetary policy rules under different asset market structures, when households have external or internal habit formation in consumption. Specifically, does habit formation matter for the welfare ranking of alternative monetary policy rules in small open economies with alternative asset market structures? This paper will address this issue by utilizing an explicit utility-based welfare analysis.

The main findings of this paper can be summarized as follows:

First, asset market structure is relevant for the welfare ranking of alternative monetary policy rules in a small open economy with habit persistence. In particular, inward-looking monetary policy is not invariant in a small open economy with external habit under alternative asset market structures, even if both the intertemporal and intratemporal elasticities of substitution equal one. Contrary to De Paoli (2009a, 2009b), and Corsetti, Dedola, and Leduc (2010), the DPI rule is better than the CPI rule in a complete market, but the CPI rule can be better than the DPI rule in a financial autarky with external habit, even if both intertemporal and intratemporal elasticities of substitution equal one.

Second, the existence of external habit can reverse the welfare ranking of simple monetary policy rules in a complete market as well as in a financial autarky, for moderate values of intratemporal elasticity of substitution: with external habit, the PEG rule regime outperforms the DPI rule regime for high values of intratemporal elasticity of substitution between home and foreign goods when households are catching up with the Joneses, irrespective of asset market structure. For example, the DPI rule can be inferior to the CPI rule in a small open economy sticky price model with high degree of external habit and financial autarky, while the DPI rule is best among the considered simple rules in a complete asset market. This finding starkly contrasts to the findings of De Paoli (2009b).

Third, the existence of habit matters for the welfare ranking of alternative monetary policy rules, irrespective of internal and external habit. For example, the PEG rule is the best among the considered simple rules if there exits inefficiency in the exchange rate due to incomplete exchange rate pass-through, irrespective of internal and external habit. Finally, we show that the Frisch elasticity of labor supply as well as the intratemporal elasticity between home goods and imported goods plays a pivotal role in determining the welfare ranking of simple monetary rules in a small open economy with nominal rigidities.

The remainder of the paper is organized as follows. Section 2 presents a canonical small open economy model with habit persistence and nominal price rigidities. Section 3 discusses

equilibrium conditions and the welfare ranking of alternative monetary policy rules. Section 4 concludes the paper.

2. THE MODEL

This section sets up a variant of the new Keynesian model with habit formation applied to a small, open-economy. The world is composed of two countries, home *(H)* and foreign *(F)* with population size *n* and *1-n,* respectively. In this paper, the small open economy is characterized as a limiting-case approach, as in Faia and Monacelli (2008) and Gali and Monacelli (2005). It is assumed that the relative size of the domestic economy is negligible relative to the rest of the world, i.e. $n \longrightarrow 0$.

2.1 Households

Abel (1990, 1999) and Smets and Wouters (2007) specified a simple recursive preference, in which a representative household derives utility from the level of consumption relative to a time-varying subsistence or habit level. In particular, we assume that the utility function of the representative household takes the form[3]:

$$E_0\left[\sum_{t=0}^{\infty}\beta^t\left(\frac{(C_t^d)^{1-\sigma}}{1-\sigma}-\frac{N_t^{1+\upsilon}}{1+\upsilon}\right)\right],\ 0<\beta<1, \tag{1}$$

where β is the household's discount factor; E_0 denotes the conditional expectations operator on the information available in period 0; $C_t^d = C_t - bH_t$. C_t, N_t, and H_t represent the household's consumption for composite goods, work hours, and the time-varying habit level of consumption at time *t*, respectively; and $0 \le b \le 1$ measures the degree of external habit persistence. To make the discussion more concrete, a specific domestic constant elasticity of substitution (CES) consumption index is assumed as follows:

$$C_t \equiv [(1-\alpha)^{\frac{1}{\eta}} C_{Ht}^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} C_{Ft}^{\frac{\eta-1}{\eta}}]^{\frac{\eta-1}{\eta}}, \tag{2}$$

where $\alpha \equiv (1-n)\theta$ is the share of domestic consumption allocated to imported goods, and η is the elasticity of substitution between domestic and foreign goods. Similarly, a foreign CES consumption index is assumed as follows:

$$C_t^* \equiv [(1-\alpha^*)^{\frac{1}{\eta}} C_{Ft}^{*\frac{\eta-1}{\eta}} + \alpha^{*\frac{1}{\eta}} C_{Ht}^{*\frac{\eta-1}{\eta}}]^{\frac{\eta-1}{\eta}},^4 \tag{3}$$

where $\alpha^* \equiv n\theta^*$.4 To consider home bias in consumption, it is assumed that

$$(1-\alpha) > \alpha^*. \tag{4}$$

Here, C_{Ht} and C_{Ft} are indices of consumption of domestic and foreign goods, respectively; these are given by the following CES aggregators of the consumed amounts of each type of good:

$$C_{Ht} \equiv \left(\frac{1}{n}\right)^{\frac{1}{\bullet}} \left(\int_0^1 C_{Ht}(j)^{\frac{\bullet-1}{\bullet}} dj\right)^{\frac{\bullet}{\bullet-1}},\ C_{Ft} \equiv \left(\frac{1}{1-n}\right)^{\frac{1}{\bullet}} \left(\int_0^1 C_{Ft}(j)^{\frac{\bullet-1}{\bullet}} dj\right)^{\frac{\bullet}{\bullet-1}}, \tag{5}$$

[3] When the financial market is complete, each household's behavior can be rewritten in the same way as in Woodford (2003).

[4] Foreign values of the corresponding domestic variables are denoted by an asterisk (*).

where ε measures the elasticity of substitution among goods within each category. In this context, the consumer price index is given by

$$P_t \equiv [(1-\alpha)\, P_{Ht}^{1-\eta} + \alpha P_{Ft}^{1-\eta}]^{\frac{1}{1-\eta}}, \qquad (6)$$

where P_{Ht} and P_{Ft} respectively denote the price of domestic goods and imported foreign goods in domestic currency unit in period *t*, given by

$$P_{Ht} = \left[\left(\frac{1}{n}\right)\int_0^n P_{Ht}(j)^{1-\epsilon} dj\right]^{\frac{1}{1-\epsilon}}, \quad P_{Ft} = \left[\left(\frac{1}{1-n}\right)\int_n^1 P_{Ft}(j)^{1-\epsilon} dj\right]^{\frac{1}{1-\epsilon}}. \qquad (7)$$

The law of one price is assumed to hold, i.e., $P_{Ht}(j) = S_t P_{Ht}^*(j)$, and $P_{Ft}(j) = S_t P_{Ft}^*(j)$, where S_t is the nominal exchange rate in period *t*. H_t summarizes the influence of past consumption levels on today's utility. The utility of a representative household depends on a utility of the difference between consumption and habit. Two types of habit persistence are considered in this paper. In the case of external habit persistence, the stochastic sequence of habits $\{H_t\}_{t=0}^{\infty}$ is regarded as exogenous by the household and tied to the stochastic sequence of aggregate consumption, $\{C_t\}_{t=0}^{\infty}$. For simplicity, H_t is specified as an external habit dependent only on aggregate consumption, as in Abel (1990, 1999) and Smets and Wouters (2007). That is,

$$H_t = \widetilde{C}_{t-1}, \qquad (8)$$

where $\widetilde{C}_{t-1}$ is aggregate past consumption. In this specification of habit formation, habit depends on one lag of consumption. In the case of internal habit persistence, it is assumed that

$$H_t = C_{t-1}.$$

The optimal allocation of any given domestic expenditure within each category of goods is given by

$$\begin{aligned} C_{Ht} &= (1-\alpha)\left[\frac{P_{Ht}}{P_t}\right]^{-\eta} C_t, \qquad (9) \\ C_{Ft} &= \alpha\left[\frac{P_{Ft}}{P_t}\right]^{-\eta} C_t, \end{aligned}$$

Similarly, the optimal allocation of any given foreign expenditure within each category of goods is given by

$$\begin{aligned} C_{Ht}^* &= (1-\alpha^*)\left[\frac{P_{Ht}^*}{P_t^*}\right]^{-\eta} C_t^*, \qquad (10) \\ C_{Ft}^* &= \alpha^*\left[\frac{P_{Ft}^*}{P_t^*}\right]^{-\eta} C_t^*, \end{aligned}$$

where P_t^*, P_{Ft}^*, and P_{Ht}^* denote the foreign consumer price index and the price of foreign goods and domestic goods in foreign currency unit in period *t*, respectively.

2.2 Asset Markets

Having looked at habit persistence in households, we now consider three alternative asset markets: the complete market, the incomplete market, and financial autarky.

2.2.1 Complete Markets

As in Gali and Monacelli (2005), there exists a complete market for state-contingent claims in domestic currency units that are traded internationally. Hence, households can optimally share risk with the rest of the world because they have access to a full set of assets, contingent on all possible states of nature. This asset market structure implies

$$\mathcal{E}_t = \frac{S_t P_t^*}{P_t} = \kappa \frac{U_C(C_t^*)}{U_C(C_t)}$$

.

Here, $\mathcal{E}_t \equiv \frac{S_t P_t^*}{P_t}$ is the real exchange rate, and

$$U_C(C_t) = \begin{cases} (C_t - bC_{t-1})^{-\sigma} & \text{for external habit} \\ (C_t - bC_{t-1})^{-\sigma} - b\beta E_t (C_{t+1} - bC_t)^{-\sigma} & \text{for internal habit} \end{cases} \quad (11)$$

Here, κ is a parameter capturing the initial cross-country distribution of wealth. $U_C(C_t^*)$ is similarly defined. Following Gali and Monacelli (2005), we assume symmetric initial conditions without loss of generality, in which we have $\kappa = 1$.

2.2.2 Incomplete Markets

In an incomplete market, it is assumed that domestic households can trade only one-period nominal riskless bonds, denominated in both home and foreign currencies; meanwhile, foreign households can trade only one-period nominal riskless bonds denominated in foreign currency. It is also assumed that the international trade of foreign currency-denominated bonds is subject to intermediation costs, as in Benigno (2008) .[5] Accordingly, the domestic household's budget constraint can be written as

$$P_t C_t + \frac{B_{Ht}}{R_t} + \frac{B_{Ft}}{R_t^* F(\frac{S_t B_{Ft}}{P_t})} \leq B_{Ht-1} + B_{Ft-1} + W_t(1-\tau_t)N_t + TR_t. \quad (12)$$

Here B_{Ht} and B_{Ft} denote domestic and foreign currency denominated nominal bonds, respectively; R_t and R_t^* are the corresponding interest rates; and W_t, TR_t, and τ_t denote nominal wages, government transfers given to the domestic household, and the tax rate on labor income in period *t*. The function $F(\frac{S_t B_{Ft}}{P_t})$ represents the cost of, or the risk premium on, international borrowings. The risk premium is increasing with the country's foreign debt, i.e. $F'(.) < 0,$ and is equal to zero when the economy is in the steady state, i.e., $F(B_F) = 1$ in the steady state.

Because foreign households are assumed to trade only in foreign currency bonds, their budget constraint can be written as

$$P_t^* C_t^* + \frac{B_{Ft}^*}{R_t^*} \leq B_{Ft-1}^* + W_t^*(1-\tau_t^*)N_t^* + TR_t^* + \Gamma_t, \quad (13)$$

where Γ_t is the intermediation profits from loans to the small country.

First order conditions for the household can be summarized as follows:

[5] This intermediation cost assumption is made for technical reasons. See Schmitt-Grohe and Uribe (2003) for alternative assumptions to overcome the stationary problem in a small open economy model.

$$U_C(C_t) = \beta R_t E_t[U_C(C_{t+1})\frac{P_t}{P_{t+1}}], \quad (14)$$

$$U_C(C_t) = \beta R_t^* F(\frac{S_t B_{Ft}}{P_t}) E_t[U_C(C_{t+1})\frac{S_{t+1}P_t}{S_t P_{t+1}}]. \quad (15)$$

where foreign values of the corresponding domestic variables are denoted by an asterisk (*). Similarly, the foreign household's intertemporal decision of bond holdings is given by

$$U_C(C_t^*) = \beta R_t^* E_t[U_C(C_{t+1}^*)\frac{P_t^*}{P_{t+1}^*}]. \quad (16)$$

(15) and (16) imply that the equilibrium real exchange rate $\mathcal{E}_t$ is determined by

$$E_t[\frac{U_C(C_{t+1}^*)}{U_C(C_t^*)}\frac{P_t^*}{P_{t+1}^*}] = F(\mathcal{B}_{Ft}) E_t[\frac{U_C(C_{t+1})}{U_C(C_t)}\frac{S_{t+1}P_t}{S_t P_{t+1}}], \quad (17)$$

where $\mathcal{B}_{Ft} \equiv \frac{S_t B_{Ft}}{P_t}$. The log-linearization of (17) shows that the expected depreciation of the real exchange rate is determined by the net foreign asset as well as by the difference of the expected future, current, and past domestic and foreign consumption:

$$E_t[\Delta \ln \mathcal{E}_{t+1}] = \sigma[E_t(\Delta \ln(U_C(C_{t+1}^*)/U_C(C_t^*)) - E_t(\Delta \ln(U_C(C_{t+1})/U_C(C_t))] - \eta_B b_{Ft}, \quad (18)$$

where $b_{Ft} \equiv \frac{B_{Ft}}{C}$ and C is the steady-state consumption, and η_B is the sensitivity of intermediation cost or risk premium to the net foreign asset.

2.2.3 Financial Autarky

In a financial autarky, households do not have access to international borrowing or lending. Hence, there is no risk-sharing across borders. Assuming that the initial distribution of wealth across domestic households is symmetrical, the domestic and foreign households' budget constraints can be written as

$$P_t C_t \leq W_t(1-\tau_t)N_t + TR_t, \quad (19)$$

$$P_t^* C_t^* \leq W_t^*(1-\tau_t^*)N_t^* + TR_t^* + \Gamma_t. \quad (20)$$

Meanwhile, the value of domestic production equals the value of consumption, and the value of exports equals the value of imports:

$$P_{Ht}(Y_t - G_t) = P_t C_t,$$

$$(1-n)S_t P_{Ht} C_{Ht}^* = n P_{Ft} C_{Ft},$$

where G_t is domestic government spending in period *t*.

2.3 Domestic Firms

Differentiated goods and monopolistic competition are introduced along the lines of Dixit and Stiglitz (1977). Suppose there is a continuum of firms producing differentiated goods, and each firm indexed by $0 \leq i \leq 1$, produces its product with constant returns to scale and a

concave production technology. Each domestic firm i takes P_{Ht} and the aggregate demand as given, and chooses its own product price $P_{Ht}(i)$. In this economy, the distortion occurs due to the existence of monopolistic competition in the goods market. On average, the firm sets its price above marginal cost. In equilibrium, this makes the marginal rate of substitution between consumption and labor different from their corresponding marginal rate of transformation. Because we do not assign any explicit value to the holding of money balances, we can eliminate the distortion associated with the Friedman rule.

Each monopolistic firm i produces a homogenous good according to

$$Y_t(i) = A_t N_t(i), \tag{21}$$

where A_t is the home country resident's technology process at period *t*. $Y_t(i)$ and $N_t(i)$ are the output and total labor input of the ith firm, respectively. We assume that the productivity shock follows an *AR(1)* process as $\log A_t = (1-\rho_A)\log A + \rho_A \log A_{t-1} + \xi_{At}$, where $E(\xi_{At}) = 0$ and ξ_{At} is i.i.d. over time. Since the input markets are perfectly competitive, the firm $j's$ demand for labor is determined by its cost minimization as follows:

$$w_t = \mathrm{mc}_t A_t \frac{P_{Ht}}{P_t}, \tag{22}$$

where $w_t \equiv \frac{W_t}{P_t}$ and $mc_t \equiv \frac{MC_t}{P_{Ht}}$ are the domestic real wage and domestic firm's markup in period *t*, respectively. Since the household's labor supply is given by

$$N_t^{\upsilon} = U_C(C_t)(1-\tau_t)w_t, \tag{23}$$

plugging (22) into (23) implies a labor market equilibrium condition

$$N_t^{\nu} = \mathrm{mc}_t(1-\tau_t)A_t U_C(C_t)\frac{P_{Ht}}{P_t}. \tag{24}$$

Next, the CPI-PPI ratio $\frac{P_t}{P_{Ht}}$ can be expressed in terms of the terms of trade $\mathcal{T}_t = \frac{P_{Ft}}{P_{Ht}}$ as follows

$$\frac{P_t}{P_{Ht}} = [(1-\alpha) + \alpha \mathcal{T}_t^{1-\eta}]^{\frac{1}{1-\eta}} \equiv k(\mathcal{T}_t). \tag{25}$$

The real exchange rate is also linked to the terms of trade through the following expression:

$$\mathcal{E}_t = \mathcal{T}_t[(1-\alpha) + \alpha \mathcal{T}_t^{1-\eta}]^{\frac{1}{\eta-1}} \equiv J(\mathcal{T}_t).$$

Next, a discrete time version of the Calvo (1983)-style staggered price setting rule is introduced to consider the nominal price rigidities. Each firm resets its optimal price $\widetilde{P}_{Ht}(j)$ with probability $(1-\alpha)$ in any given period, independent of the time elapsed since the last adjustment . The other fraction of firms, α , set their current prices at their previous price levels. Firm j's profit maximization problem can be written as follows.

$$\max_{\widetilde{P}_{Ht}(j)} E_t\{\sum_{k=0}^{\infty} \alpha^k Q_{t,t+k}\left(\frac{P_t}{P_{t+k}}\right)[\widetilde{P}_{Ht}(j)Y_{Ht,t+k}(j) - MC_{Ht+k}Y_{Ht,t+k}(j)]\}, \tag{26}$$

subject to the sequence of demand constraints

$$Y_{Ht,t+k}(j) \leq \left(\frac{\widetilde{P}_{Ht}(j)}{P_{Ht+k}}\right)^{-\epsilon} Y_{Ht+k},$$

where $Q_{t,t+k} \equiv \beta^k \frac{U_C(C_{t+1})}{U_C(C_{t+1})}$, $\widetilde{P}_{Ht+k}(j) = \widetilde{P}_{Ht}(j)$ with a probability α^k and $k = 0,1,2....\infty$.

The problem can be rewritten as

$$\max_{\widetilde{P}_{Ht}(j)} E_t\{\sum_{k=0}^{\infty} \alpha^k Q_{t,t+k} \left(\frac{P_t}{P_{t+k}}\right) P_{Ht+k}[\left(\frac{\widetilde{P}_{Ht}(j)}{P_{Ht+k}}\right)^{1-\epsilon} Y_{Ht+k} - \frac{MC_{Ht+k}}{P_{Ht+k}} \left(\frac{\widetilde{P}_{Ht}(j)}{P_{Ht+k}}\right)^{-\epsilon} Y_{Ht+k}]\}, \tag{27}$$

Since $\widetilde{P}_{Ht}(j)$ is the same for the reoptimizing firms, i.e. $\widetilde{P}_{Ht}(j) = \widetilde{P}_{Ht}$, the optimal price setting equation can be written as

$$E_t\{\sum_{k=0}^{\infty} \alpha^k Q_{t,t+k} \left(\frac{P_t}{P_{t+k}}\right) \left(\frac{\widetilde{P}_{Ht}}{P_{Ht+k}}\right)^{-1-\epsilon} Y_{Ht+k}[\mathrm{mc}_{t+k} - \mathcal{M}^{-1} \frac{\widetilde{P}_{Ht}}{P_{Ht+k}}] = 0, \tag{28}$$

where $mc_{t+k} \equiv \frac{MC_{Ht+k}}{P_{Ht+k}}$ and $\mathcal{M}^{-1} \equiv \frac{\epsilon}{\epsilon-1}$ represent the domestic markup and the average markup in goods market, respectively. The optimal price setting equation can be expressed as a recursive form as in Schmitt-Grohe and Uribe (2004) and Yun (2005):

$$\frac{\epsilon}{\epsilon - 1} \mathcal{K}_t = \mathcal{F}_t, \tag{29}$$

where

$$\begin{aligned} \mathcal{K}_t &\equiv E_t \sum_{k=0}^{\infty} \alpha^k Q_{t,t+k} \left(\frac{P_t}{P_{t+k}}\right) \left(\frac{\widetilde{P}_{Ht}}{P_{Ht+k}}\right)^{-1-\epsilon} Y_{Ht+k} \mathrm{mc}_{t+k} \qquad (30) \\ &= \widetilde{p}_{Ht}^{-1-\epsilon} Y_{Ht} \mathrm{mc}_t + \alpha\beta E_t[\pi_{Ht+1}^{1+\epsilon} \pi_{t+1}^{-1} Q_{t,t+1} \left(\frac{\widetilde{p}_{Ht}}{\widetilde{p}_{Ht+1}}\right)^{-1-\epsilon} \mathcal{K}_{t+1}], \end{aligned}$$

and

$$\begin{aligned} \mathcal{F}_t &\equiv E_t \sum_{k=0}^{\infty} \alpha^k Q_{t,t+k} \left(\frac{P_t}{P_{t+k}}\right) \left(\frac{\widetilde{P}_{Ht}}{P_{Ht+k}}\right)^{-\epsilon} Y_{Ht+k} \qquad (31) \\ &= \widetilde{p}_{Ht}^{-\epsilon} Y_t + \alpha\beta E_t[Q_{t,t+1} \pi_{Ht+1}^{\epsilon} \pi_{t+1}^{-1} \left(\frac{\widetilde{p}_{Ht}}{\widetilde{p}_{Ht+1}}\right)^{-\epsilon} \mathcal{F}_{t+1}]. \end{aligned}$$

Here, $\widetilde{p}_{Ht} \equiv \frac{\widetilde{P}_{Ht}}{P_{Ht}}$ is the relative price of any domestic good whose price was adjusted in period *t*, and $\pi_{Ht+1} \equiv \frac{P_{Ht+1}}{P_{Ht}}$ and $\pi_t \equiv \frac{P_{t+1}}{P_t}$ represent the domestic price index inflation rate and the consumer price index inflation rate at time *t+1*,respectively. Equation (29) is a short-run nonlinear aggregate supply relation between inflation and output, given expectations

regarding future inflation, output, and disturbances. The domestic price aggregator implies that the relative price $\widetilde{p}_{Ht}$ satisfies the relationship:

$$1 = (1-\alpha)\widetilde{p}_{Ht}^{1-\epsilon} + \alpha\pi_{Ht}^{\epsilon-1}. \qquad (32)$$

2.4 Importing Firms

In this section, we consider two cases of the price-setting mechanism for goods imported from the rest of the world. The first is the case of a perfect exchange rate pass-through, wherein foreign companies do not have any role in setting prices, as in Gali and Monacelli (2005) and De Paoli (2009a, 2009b). The second is the case of an imperfect exchange rate pass-through, wherein foreign companies have market power and affect the consumer price.

2.4.1 Perfect Pass-Through

First, assume that the Law of One Price holds, such that the price of foreign good j in domestic currency, $P_{Ft}(j)$, equals its price denominated in foreign currency, $P_{Ft}^{*}(j)$, multiplied by the nominal exchange rate, S_t:

$$P_{Ft}(j) = S_t P_{Ft}(j). \qquad (33)$$

In the rest of the world, a representative household faces a problem identical to the one outlined above. The only difference is that a negligible weight is assigned to consumption goods produced in the small economy $(\theta^{*} = 1)$. Therefore, $P_t^{*} = P_{Ft}^{*}$, and $C_t^{*} = C_{Ft}^{*}$, for all *t*. This is the case of perfect pass-through (PPT), in which a change in the exchange rate is perfectly reflected in the domestic price of imported goods. In PPT, the ratio between the price of foreign imports and the nominal exchange rate is one to one.

2.4.2 Imperfect Pass-Through

To take into account possible delays between movements in the exchange rate and adjustments in imported goods prices, suppose that domestic importers set prices in advance by maximizing the present value of profits as in the monopolistically competitive domestic firms. That is, suppose that domestic local retailers import differentiated goods for which the law of one price holds at the dock, but they face a Calvo-type price optimization problem in setting the domestic currency price of the goods as in Monacelli (2005). A fraction $1-\alpha^{*}$ of the local retailer, who import good j at a cost $S_t P_{Ft}^{*}(j)$, reoptimize their price $P_{Ft}(j)$ in domestic currency unit to maximize their current market value of profit; the other fraction of firms, α^{*} set their current prices at their previous price levels. Since the importer j imports the foreign goods at a cost $S_{t+k} P_{Ft,t+k}^{*}(j)$, the domestic importer j's profit maximization problem can be written as follows:

$$\max_{\widetilde{P}_{Ft}(j)} E_t\{\sum_{k=0}^{\infty} \alpha^{*k} Q_{t,t+k} \left(\frac{P_t}{P_{t+k}}\right) [\widetilde{P}_{Ft}(j) - S_{t+k} P_{Ft+k}^{*}(j)] C_{Ft+k}(j)\}, \qquad (34)$$

subject to the sequence of demand constraints

$$C_{Ft+k}(j) \leq \left(\frac{\widetilde{P}_{Ft}(j)}{P_{Ft+k}}\right)^{-\epsilon} C_{Ft+k},$$

Where α^{*k} is the probability that the reoptimized price $\widetilde{P}_{Ft}(j)$ at time *t* still holds k periods ahead.

The profit maximization problem can be rewritten as

$$\max_{\widetilde{P}_{Ft}(j)} E_t\{\sum_{k=0}^{\infty}\alpha^{*k}Q_{t,t+k}\left(\frac{P_t}{P_{t+k}}\right)P_{Ft+k}[\left(\frac{\widetilde{P}_{Ft}(j)}{P_{Ft+k}}\right)^{1-\epsilon}-\frac{S_{t+k}P^*_{Ft+k}(j)}{P_{Ft+k}}\left(\frac{\widetilde{P}_{Ft}(j)}{P_{Ft+k}}\right)^{-\epsilon}]C_{Ft+k}\}. \quad (35)$$

The optimal price setting equation can be written as

$$E_t\{\sum_{k=0}^{\infty}\alpha^{*k}Q_{t,t+k}\left(\frac{P_t}{P_{t+k}}\right)\left(\frac{\widetilde{P}_{Ft}}{P_{Ft+k}}\right)^{-1-\epsilon}C_{Ft+k}[\mathcal{E}^*_{t+k}-\mathcal{M}^{-1}\frac{\widetilde{P}_{Ft}}{P_{Ft+k}}]=0, \quad (36)$$

where $\mathcal{E}^*_{t+k}\equiv\frac{S_{t+k}P^*_{Ft+k}}{P_{Ft+k}}$ is the ratio of world price of imports j to the domestic price. This term measures the deviation from the law of one price. The optimal price setting equation can be expressed as a recursive form as before:

$$\frac{\epsilon}{\epsilon-1}\mathcal{K}^*_t=\mathcal{F}^*_t, \quad (37)$$

where

$$\begin{aligned}\mathcal{K}^*_t &\equiv E_t\sum_{k=0}^{\infty}\alpha^{*k}Q_{t,t+k}\left(\frac{P_t}{P_{t+k}}\right)\left(\frac{\widetilde{P}_{Ft}}{P_{Ft+k}}\right)^{-1-\epsilon}C_{Ft+k}\mathcal{E}^*_{t+k} \quad (38)\\ &= \widetilde{p}_{Ft}^{-1-\epsilon}C_{Ft}\mathcal{E}^*_t+\alpha^*\beta E_t[\pi^{1+\epsilon}_{Ft+1}\pi^{-1}_{t+1}Q_{t,t+1}\left(\frac{\widetilde{p}_{Ft}}{\widetilde{p}_{Ft+1}}\right)^{-1-\epsilon}\mathcal{K}^*_{t+1}],\end{aligned}$$

and

$$\begin{aligned}\mathcal{F}^*_t &\equiv E_t\sum_{k=0}^{\infty}\alpha^{*k}Q_{t,t+k}\left(\frac{P_t}{P_{t+k}}\right)\left(\frac{\widetilde{P}_{Ft}}{P_{Ft+k}}\right)^{-\epsilon}C_{Ft+k} \quad (39)\\ &= \widetilde{p}_{Ft}^{-\epsilon}C_{Ft}+\alpha^*\beta E_t[Q_{t,t+1}\pi^{\epsilon}_{Ft+1}\pi^{-1}_{t+1}\left(\frac{\widetilde{p}_{Ft}}{\widetilde{p}_{Ft+1}}\right)^{-\epsilon}\mathcal{F}^*_{t+1}].\end{aligned}$$

Here $\widetilde{p}_{Ft}\equiv\frac{\widetilde{P}_{Ft}}{P_{Ft}}$ is the relative price of any import whose price was adjusted in period t, and $\pi_{Ft+1}\equiv\frac{P_{Ft+1}}{P_{Ft}}$ represents the importables price index inflation rate at time *t+1*. The importable goods price aggregator implies that the relative price $\widetilde{p}_{Ft}$ satisfies the relationship:

$$1=(1-\alpha)\widetilde{p}_{Ft}^{1-\epsilon}+\alpha\pi^{\epsilon-1}_{Ft}. \quad (40)$$

2.5 Equilibrium

Aggregating individual output across firms reveals a wedge between the aggregate output Y_t and aggregate labor hours N_t

$$Y_{Ht} = \frac{A_t N_t}{\Delta_{Ht}}, \tag{41}$$

where $\Delta_{Ht} \equiv \int_0^1 \left(\frac{P_{Ht}(j)}{P_{Ht}} \right)^{-\varepsilon} dj$ is the relative price dispersion in period *t*. The relative price distortion Δ_{Ht} that results from the firms' staggered price setting practice in the Calvo-type model can be rewritten as a recursive form:

$$\Delta_{Ht} = (1-\alpha)\tilde{p}_{Ht}^{-\epsilon} + \alpha \pi_{Ht}{}^{\epsilon} \Delta_{Ht-1}, \tag{42}$$

with $\Delta_{H,-1}$ given. Note that the domestic government budget constraint is given by

$$\tau_t W_t N_t = P_{Ht}(G_t + TR_t). \tag{43}$$

Assuming a symmetric degree of home bias across countries, and the negligible relative size of home country as in Faia and Monacelli (2008), goods market clearing in both home and foreign countries requires that

$$Y_t = (1-\alpha)\left(\frac{P_{Ht}}{P_t}\right)^{-\eta} C_t + \alpha \left(\frac{P_{Ht}^*}{P_t^*}\right)^{-\eta} C_t^* + G_t, \tag{44}$$

$$Y_t^* = C_t^*. \tag{45}$$

For analytical simplicity, assume that the government spending and tax rate are always equal to zero, i.e. $, \tau_t = G_t = TR_t = 0$. The competitive equilibrium conditions consist of the efficiency conditions and the budget constraint of households and firms, and the market clearing conditions of each goods market, labor market, money, and bond market. Accordingly, the symmetric equilibrium is an allocation of $\left\{C_t, C_t^*, N_t, N_t^*, Y_t, Y_t^*\right\}_{t=0}^{\infty}$, a sequence of prices and costate variables for the home and foreign country $\left\{P_{Ht}, P_{Ft}, P_{Ht}^*, P_{Ft}^*, P_t, P_t^*, B_{Ft}, B_{Ft}^*, mc_t, mc_t^*, \Delta_{Ht}, \Delta_{Ft}^*\right\}_{t=0}^{\infty}$, and a sequence of the real exchange rate $\{\mathcal{E}_t\}_{t=0}^{\infty}$ such that (i) the households' decision rules solve their optimization problem given the states and prices; (ii) the demand for labor solves each firm's cost minimization problem and price setting rules solve its present value maximization problem given the states and the prices; and (3) each goods market, labor market, and bond market are cleared at the corresponding prices, given the initial conditions for the state variables $\left(C_{-1}, \Delta_{H,-1}, C_{-1}^*, \Delta_{F,-1}^*\right)$, and the exogenous productivity shock processes $\left\{A_t, A_t^*\right\}_{t=0}^{\infty}$ as well as the monetary and fiscal policies $\left\{\tau_t, \tau_t^*, R_t, R_t^*\right\}_{t=0}^{\infty}$.

3. WELFARE UNDER ALTERNATIVE ASSET MARKET STRUCTURES

In this section, we explore the effect of external habit on welfare under alternative monetary regimes, using a small open economy as benckmark. Specifically, we explore the welfare rankings of alternative monetary policy rules by employing tsecond-order approximation methods along the line of Schmitt-Grohe and Uribe (2006).

3.1 Parameter Values

Table 1 summarizes all the parameter values used in this paper, as derived from De Paoli (2009), Faia and Monacelli (2008), and Gali and Monacelli (2005). First, we set both the intertemporal and intratemporal elasticities of substitution, σ^{-1} and η to 1, and the intratemporal elasticity of labor supply ν^{-1} to 0.5 in the benchmark model. Because these parameter values play a key role in the welfare ranking of simple monetary policy rules, we also consider other alternative values, as reflected in Table 1. In particular, the intratemporal elasticity between home and foreign goods—which plays a key role in the dynamic properties of the selected macroeconomic variables in the model—is set to values in [1,6]. We set the subjective discount factor to $1.04^{(-1/4)}$, which is consistent with an annual real interest rate of 4 percent, as in Prescott (1986). Next, we set the elasticity of substitution among varieties ε to 6, implying the average size of markup to be 1.2, as in Gali and Monacelli (2005). The values of the nominal rigidity parameter, iα and α^*, are chosen to reflect the fact that on average, firms reoptimize their prices annually in the Calvo-type sticky price model.

Table 1: Parameter Values

Parameter	Values	Description and definitions
B	0, 0.5, 0.7	Degree of habit in consumption
E	6	Elasticity of demand for a good with respect to its own price
Σ	1	Relative risk aversion parameter
H	1, 2, 4, 6	Elasticity of substitution between home and foreign goods
N	0,5, 1, 3	Inverse of elasticity of labor supply
R	0.016	Steady state real interest rate

Sources: De Paoli (2009), Faia and Monacelli (2008), and Gali and Monacelli (2005).

Finally, the exogenous driving process, i.e. the (log) productivity, $a(t)$ and , $y^*(t)$ is assumed to follow an AR(1) as in De Paoli (2009), Faia and Monacelli (2008), and Gali and Monacelli (2005).

$$\begin{aligned} a_t &= 0.95a_{t-1} + \varepsilon_t^a, \quad \sigma_a = 0.007, \\ y_t^* &= 0.95y_{t-1}^* + \varepsilon_t^*, \quad \sigma_{y^*} = 0.007. \end{aligned} \tag{48}$$

3.2 Real Exchange Rate and Welfare

As described in Obstfeld and Rogoff (1998) and Corsetti and Pesenti (2001), internal monopolistic distortion and external terms of trade distortion influence welfare in a small open economy where domestic and foreign goods are imperfect substitutes. In a small open economy with external habit, externality in consumption habit also influences welfare, in addition to the terms of trade externality. One can address the full implications of the effect of external distortions on welfare using a second-order Taylor expansion to the utility function of the representative household.

More importantly, the performance of monetary policy rules depends on the presence of external habit and asset market structure. We will discuss how the presence of external habit affects monetary policy prescription in a complete market and a financial autarky, using the first-order terms of the approximated logarithmic utility.

Equilibrium conditions in a complete market imply that the utility function of the household with external habit can be linearly approximated as

$$\begin{aligned} & \sum_{k=0}^{\infty} \beta^k E_t[U(C^d_{t+k}, N_{t+k})] \qquad (49) \\ \approx & \sum_{k=0}^{\infty} \beta^k U_C \overline{C} E_t[(1-b\beta)c_{t+k} - (1-\tau)\mathcal{M}^{-1} y_{t+k}] + t.i,p. + O(||\xi||^2) \\ = & \sum_{k=0}^{\infty} \beta^k \mathcal{C}_E E_t[q_{t+k}] + t.i.p. + O(||\xi||^2), \end{aligned}$$

where $\mathcal{C}_E \equiv (1-b) - (1-\tau)\mathcal{M}^{-1}\left(\frac{(1-b)(1-\theta)}{1-b\beta}\right) - \frac{(1-\tau)\mathcal{M}^{-1}\eta(2-\theta)\theta}{(1-\theta)}]$, $U(C^d_t, N_t) = \ln(C_t - b\widetilde{C}_{t-1}) - \frac{N_t^{1+\nu}}{1+\nu}$, and $\widetilde{C}_{t-1}$ is aggregate consumption at *t-1*. $O(||\xi||^2)$ refer to terms of order higher than one, and $t.i.p.$ refers to terms independent of policy, such as foreign consumption and exogenous shocks. Note that $\mathcal{C}_E$ has a negative value and decreases as either the degree of external habit or the degree of intratemporal elasticity of substitution between home and foreign goods increases (Figures 1A, 1B, 2A, and 2B). On average, therefore, an appreciated real exchange rate (i.e. the low value of $E_t[q_{t+k}]$ is more likely to be welfare improving under complete markets as the degree of external habit and the intratemporal trade elasticity of substitution increases.

Figure 1A: Degree of External Habit and Elasticity of Substitution: Complete (σ=1)

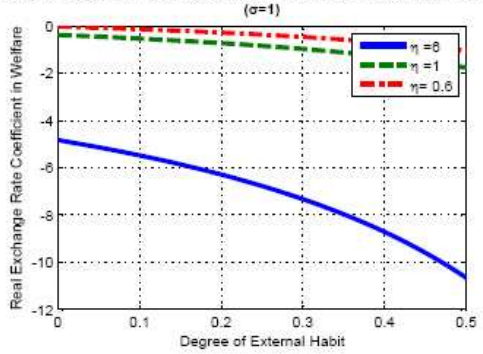


Figure 1B: Degree of External Habit and Elasticity of Substitution: Complete (η=2)

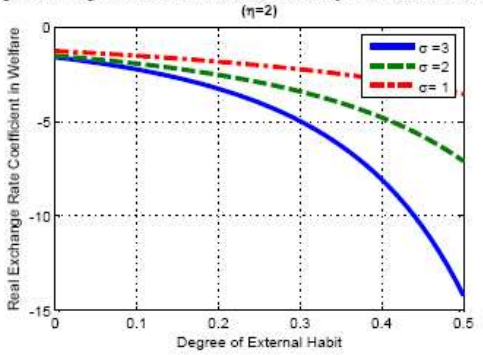


Figure 1C: Degree of External Habit and Elasticity of Substitution: Autakry (σ=1)

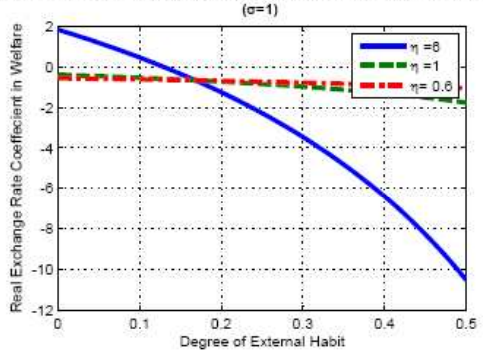
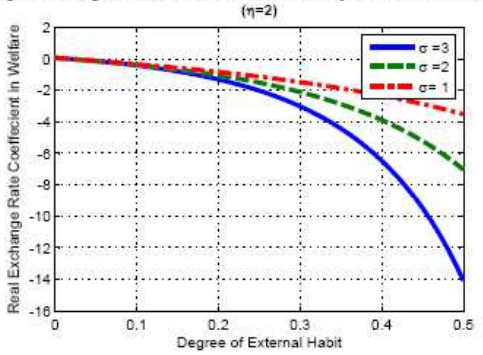


Figure 1D: Degree of External Habit and Elasticity of Substitution : Autakry (η=2)



Meanwhile, the equilibrium conditions in a financial autarky imply that the utility function of the household can be approximated as

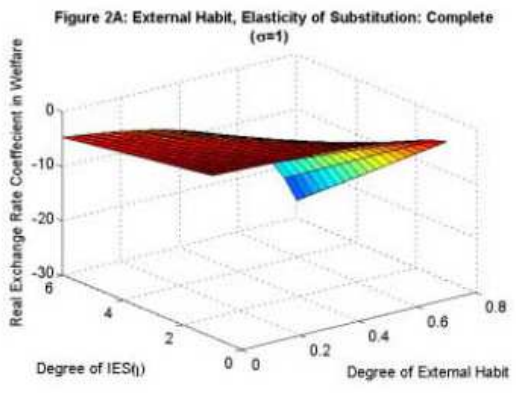
$$\begin{aligned} & \sum_{k=0}^{\infty} \beta^k E_t[U(C^d_{t+k}, N_{t+k})] \qquad (50) \\ \approx & \sum_{k=0}^{\infty} \beta^k U_C \overline{C} E_t[(1-b\beta)c_{t+k} - (1-\tau)\mathcal{M}^{-1} y_{t+k}] + t.i.p. + O(||\xi||^2) \\ = & \sum_{k=0}^{\infty} \beta^k \mathcal{A}_E \overline{C} E_t[q_{t+k}] + t.i.p. + O(||\xi||^2), \end{aligned}$$

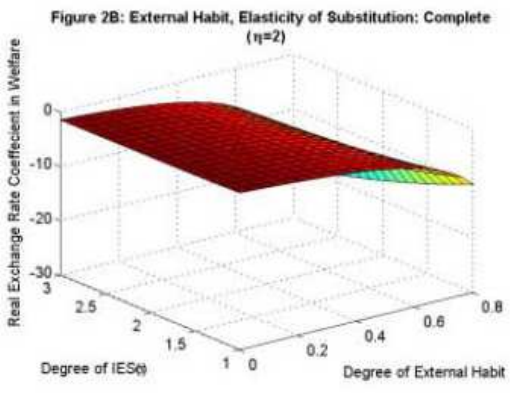
where $\mathcal{A}_E = \frac{\eta(2-\theta)[(1-b\beta)-(1-\tau)\mathcal{M}^{-1}]-[(1-b\beta)-(1-\tau)\mathcal{M}^{-1}(1-\theta)]}{(1-\theta)}$. In (50), the sign of the term $\mathcal{A}_E$ is ambiguous. $\mathcal{A}_E$ depends not only on the elasticity of substitution between home and foreign goods η, but also on the degree of external habit b and the degree of openness θ. As either the degree of external habit or the degree of intratemporal elasticity of substitution between home and foreign goods increases, $\mathcal{A}_E$ decreases (Figures 2C and 2D). $\mathcal{A}_E$ takes a positive value when the intratemporal elasticity of substitution is high and the degree of external habit is low (Figure 1C). That is, on average, an appreciated real exchange rate is welfare improving under financial autarky with a higher degree of external habit, while the reverse is true in a financial autarky with a lower degree of external habit.

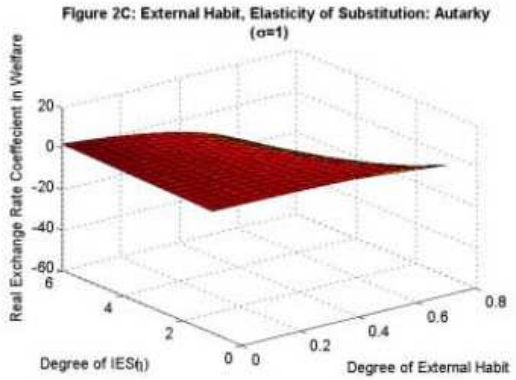
In the case of internal habit, the first-order approximation of the utility function can be written as

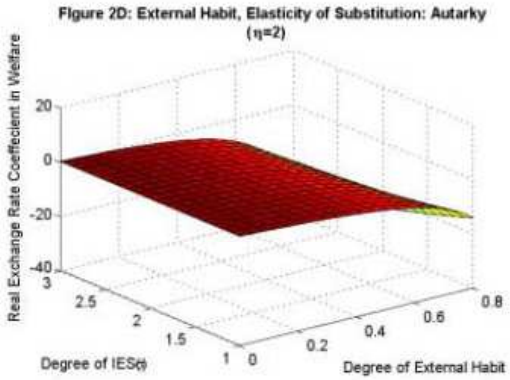
$$\begin{aligned} & \sum_{k=0}^{\infty} \beta^k E_t[U(C^d_{t+k}, N_{t+k})] \qquad (51) \\ \approx & \sum_{k=0}^{\infty} \beta^k \mathcal{A}_I E_t[q_{t+k}] + t.i.p + O(||\xi||^2), \end{aligned}$$

where $\mathcal{A}_I \equiv \{\frac{\eta(2-\theta)[1-(1-\tau)\mathcal{M}^{-1}]-[1-(1-\tau)\mathcal{M}^{-1}(1-\theta)]}{(1-\theta)}\}$ and $U(C^d_t, N_t) = \log(C_t - bC_{t-1}) - \frac{N_t^{1+\nu}}{1+\nu}$. If $(1-\tau)\mathcal{M}^{-1} = 1-\theta$ as in Gali and Monacelli (2005) and De Paoli (2009b), then $\mathcal{A}_I = \frac{(2-\theta)\theta(\eta-1)}{(1-\theta)}$, whose value is positive (negative) if $\theta < 1 (\theta > 1)$. Hence, the presence of internal habit does not monetary policy prescription in a small open economy.









3.3 Price Stability vs. Exchange Rate Stability in the Case of Perfect Exchange Rate Pass-Through

In this section, we discuss the welfare implications of alternative monetary policy rules in the case of perfect exchange rate pass-through, by exploiting the recursive nature of the life-time utility function (1) to compute the welfare cost, as in Schmitt-Grohe and Uribe (2006).[6]

3.3.1 Welfare Ranking of Alternative Monetary policy Rules in Financial Autarkies

In the case of a financial autarky, consumption is fully linked to domestic output. Moreover, households work more than necessary in the presence of external habit, producing output that exceeds the efficient level. Hence, monetary policy that lowers production to a more efficient level improves welfare by decreasing the disutility of (excessive) labor hours. An additional improvement in welfare is possible if the policy leads to a real exchange rate appreciation, leading households with higher purchasing power to divert some of their consumption from domestic goods to foreign goods.

Since lowering the volatility of the real exchange rate is associated with a real exchange rate appreciation, monetary policy aimed at stabilizing either the general price index or the

[6] Suppose that λ_c is the welfare cost of adopting monetary policy regime (fore example PEG) $\mathbb{A}$ instead of monetary policy regime $\mathbb{B}$ (for example PPI), conditional on a particular state in period zero (s_0). If λ_c is the fraction of policy regime $\mathbb{B}$'s consumption process that the domestic household would be willing to give up in order to be equally well off under regimes $\mathbb{A}$ and $\mathbb{B}$, then, Schmitt-Grohe and Uribe (2006) show that the conditional welfare cost measure is given by

$$\lambda_c = [1 - \frac{(1-\sigma)V^{\mathbb{B}}(s_0, \sigma_\epsilon) + (1-\beta)^{-1}}{(1-\sigma)V^{\mathbb{A}}(s_0, \sigma_\epsilon) + (1-\beta)^{-1}}]^{\frac{1}{(1-\sigma)}}$$

.

exchange rate will tend to cause a bigger appreciation in the real exchange rate, much than more than stabilizing the domestic price index would (As shown in equation (50), either the CPI rule or the PEG rule is more likely to outperform the DPI rule under a financial autarky, if there exists a substantial degree of external habit.

Table 2: Welfare Cost Relative to the DPI Rule: Perfect Pass-Through with External Habit (σ=1, η=1, b=0.8)

Asset Market	Autarky	Incomplete	Complete
N=1/2			
CPI	-1.2715×10^{-4}	0.0794	0.0042
PEG	0.0057	0.1069	0.0105
N=1			
CPI	2.9245×10^{-4}	0.0587	0.0050
PEG	0.0075	0.0865	0.0131
N=3			
CPI	0.0017	0.0318	0.0069
PEG	0.0133	0.0639	0.0215

CPI = consumer price index inflation targeting rule; PEG= exchange rate pegging rule

Note: Entries are % units of steady state consumption.

The presence of external habit plays an important role in ranking alternative monetary policy rules even if the intratemporal elasticity of substitution is low, i.e. even if home and foreign goods are complementary. Consider the benchmark case, where both the intertemporal and intratemporal elasticities are equal to one, i.e. $\sigma = \eta = 1.$ In the absence of external habit, there is no expenditure switching effect under the benchmark case, because the income and substitution effects due to international relative price movements cancel each other out. In contrast, international relative price movements will have an expenditure switching effect even if $\sigma = \eta = 1,$ in the presence of external habit.

Asset market structure is likewise relevant for the dynamics of the small open economy as well as for the welfare characterization for $\sigma = \eta = 1.$ As Table 2 shows, the CPI rule outperforms the DPI rule for $\mu = 1$ and $b = 0.8$, i.e., if households have a high degree of external habit. The following tables report differences in welfare measured as a % of the permanent shift in steady-state consumption, between a policy that targets domestic inflation (PPI rule) and one that pegs the exchange rate (PEG rule). They also show the difference between the PPI rule and the CPI rule (which targets consumer price index inflation).

Tables 3–5 show that the CPI rule is better than the DPI rule in a small economy with financial autarky for the degree of external habit equal to 0.7, when intratemporal elasticity of substitution is higher than 2. The PEG rule is better than the DPI rule for higher values of Frisch labor supply elasticity and intratemporal elasticity of substitution. This implies that the CPI and PEG rules are more successful in reducing the disutility of excess labor hours than the DPI rule, as long as there is room for households to substitute their labor hours and consumption, i.e., ν^{-1} and η are high. This contrasts to the findings of De Paoli (2009b) who showed that the DPI rule is best in both a financial autarky and a complete market.

Tables 3 to 5 also show that in addition to the degree of habit persistence, both the Frisch labor supply elasticity of substitution and the intratemporal elasticity of substitution between domestic goods and foreign goods affect the welfare ranking of alternative monetary policy rules.

Table 3: Welfare Cost Relative to the DPI Rule: Financial Autarky with Perfect Pass-Through (η=2)

Degree of Habit	v=1/2	v=1	v=3
External Habit			
CPI			
0	0.0013	0.0014	0.0015
0.5	5.7201×10^{-4}	6.9368×10^{-4}	9.9667×10^{-4}
0.7	-1.1975×10^{-4}	-2.9849×10^{-4}	2.8972×10^{-4}
PEG			
0	0.0046	0.0052	0.0066
0.5	0.0031	0.0037	0.0052
0.7	0.0013	0.0019	0.0034
Internal Habit			
CPI			
0	0.0013	0.0014	0.0015
0.5	3.5976×10^{-4}	4.6371×10^{-4}	7.5742×10^{-4}
0.7	1.1335×10^{-4}	1.7285×10^{-4}	3.4147×10^{-4}
PEG			
0	0.0046	0.0052	0.0066
0.5	0.0014	0.0019	0.0035
0.7	4.7026×10^{-4}	6.9368×10^{-4}	0.0016

CPI = consumer price index inflation targeting rule; PEG= exchange rate pegging rule

Note: Entries are % units of steady state consumption.

Table 4: Welfare Cost Relative to the DPI Rule: Financial Autarky with Perfect Pass-Through (η=4)

Degree of Habit	v=1/2	v=1	v=3
External Habit			
CPI			
0	4.1221×10^{-4}	4.1168×10^{-4}	4.0640×10^{-4}
0.5	7.3485×10^{-4}	1.0403×10^{-4}	1.8398×10^{-4}
0.7	-2.0458×10^{-4}	-1.9669×10^{-4}	-1.3078×10^{-4}
PEG			
0	0.0016	0.0017	0.0020
0.5	7.3636×10^{-4}	8.9465×10^{-4}	0.0013
0.7	-7.1752×10^{-4}	3.4513×10^{-4}	4.1341×10^{-4}
Internal Habit			
CPI			
0	4.1221×10^{-4}	4.1168×10^{-4}	4.0640×10^{-4}
0.5	1.1179×10^{-4}	1.4197×10^{-4}	2.1738×10^{-4}
0.7	3.4957×10^{-4}	4.9709×10^{-5}	1.0200×10^{-4}
PEG			
0	0.0016	0.0017	0.0020
0.5	4.1429×10^{-4}	5.4828×10^{-4}	9.4497×10^{-4}
0.7	1.2346×10^{-4}	1.8192×10^{-4}	4.0554×10^{-4}

CPI = consumer price index inflation targeting rule; PEG= exchange rate pegging rule

Note: Entries are % units of steady state consumption.

Table 5: Welfare Cost Relative to the DPI Rule: Financial Autarky with Perfect Pass-Through (η=6)

Degree of Habit	v=1/2	v=1	v=3
External Habit			
CPI			
0	2.0403×10^{-4}	1.9825×10^{-4}	1.8577×10^{-4}
0.5	1.3097×10^{-6}	1.5096×10^{-5}	1.4241×10^{-5}
0.7	-1.6327×10^{-4}	-1.6522×10^{-4}	-1.4091×10^{-4}
PEG			
0	8.6708×10^{-4}	9.0053×10^{-4}	9.6081×10^{-4}
0.5	2.7921×10^{-4}	3.5234×10^{-4}	5.3954×10^{-5}
0.7	-2.0870×10^{-4}	-1.7341×10^{-4}	-1.2521×10^{-5}
Internal Habit			
CPI			
0	2.0403×10^{-4}	1.9825×10^{-4}	1.8577×10^{-4}
0.5	6.2079×10^{-5}	7.7946×10^{-5}	1.1403×10^{-5}
0.7	1.9508×10^{-5}	2.7952×10^{-5}	5.6333×10^{-5}
PEG			
0	8.6708×10^{-4}	9.0053×10^{-4}	9.6081×10^{-4}
0.5	2.1536×10^{-4}	2.8148×10^{-5}	4.6567×10^{-5}
0.7	6.4044×10^{-5}	9.3809×10^{-5}	2.0409×10^{-5}

CPI = consumer price index inflation targeting rule; PEG= exchange rate pegging rule

Note: Entries are % units of steady state consumption.

We now consider the case of internal habit, where a household's current consumption is a determinant of future utility. With internal habit, there is no inefficiency or externality in production or labor hours; the findings of De Paoli (2009b) therefore hold in this case, i.e., the DPI rule is better than the PEG at high values of intratemporal elasticity of substitution (See Tables 3–5).

3.3.2 Welfare Ranking of Alternative Monetary Policy Rules in Complete Markets

Domestic consumption is not closely linked to domestic production in a complete market. First, consider the case of external habit. In a complete market, the coefficient of the expected real exchange rate in the welfare equation (39) always negative, i.e. $\mathcal{C} < 0.$ Therefore, the lower value of $E_0[q(t)]$ improves welfare for any η>1. The substitution effect dominates the wealth effect for a higher intratemporal elasticity of substitution, thereby making the PEG rule better than the DPI rule. If the Frisch labor supply elasticity is high (i.e., if households are more willing to intratemporally substitute their labor supply when wage changes due to an external shock), then the policy of maintaining a stable exchange rate is welfare improving. The effect of a real exchange rate appreciation on welfare increases if there is more room for households to decrease their labor supply and households have a higher degree of external habit in consumption, as shown in Tables 6–8.

Table 6: Welfare Cost Relative to the DPI Rule: Complete Market with Perfect Pass-Through (η=2)

Degree of Habit	v=1/2	v=1	v=3
External Habit			
CPI			
0	7.4100×10^{-4}	9.8887×10^{-4}	0.0013
0.5	-6.9462×10^{-4}	1.5713×10^{-4}	9.8329×10^{-4}
0.7	-0.0025	-0.0012	3.9062×10^{-4}
PEG			
0	0.0029	0.0039	0.0057
0.5	-0.0015	7.3848×10^{-4}	0.0044
0.7	-0.0073	-0.0035	0.0022
Internal Habit			
CPI			
0	7.4100×10^{-4}	9.8887×10^{-4}	0.0013
0.5	6.4518×10^{-4}	9.5654×10^{-4}	0.0015
0.7	5.8338×10^{-4}	9.4104×10^{-4}	0.0016
PEG			
0	0.0029	0.0039	0.0057
0.5	0.0028	0.0039	0.0061
0.7	0.0028	0.0039	0.0065

CPI = consumer price index inflation targeting rule; PEG= exchange rate pegging rule

Note: Entries are % units of steady state consumption.

Table 7: Welfare Cost Relative to the DPI Rule: Complete Market with Perfect Pass-Through (η=4)

Degree of Habit	v=1/2	v=1	v=3
External Habit			
CPI			
0	-0.0011	-3.7181×10^{-4}	1.2084×10^{-4}
0.5	-0.0034	-0.0016	-2.7925×10^{-4}
0.7	-0.0063	-0.0031	-8.1613×10^{-4}
PEG			
0	-0.0033	-0.0011	6.4186×10^{-4}
0.5	-0.0107	-0.0052	-9.1388×10^{-4}
0.7	-0.0204	-0.0108	-0.0031
Internal Habit			
CPI			
0	-0.0011	-3.7181×10^{-4}	1.2084×10^{-4}
0.5	-0.0012	-4.2349×10^{-4}	1.1906×10^{-4}
0.7	-0.00112	-4.6324×10^{-4}	1.1576×10^{-4}
PEG			
0	-0.0033	-0.0011	6.4186×10^{-4}
0.5	-0.0035	-0.0012	6.5809×10^{-4}
0.7	-0.0037	-0.0013	6.6345×10^{-4}

CPI = consumer price index inflation targeting rule; PEG= exchange rate pegging rule

Note: Entries are % units of steady state consumption.

Table 8: Welfare Cost Relative to the DPI Rule: Complete Market with Perfect Pass-Through (η=6)

Degree of Habit	v=1/2	N=1	v=3
External Habit			
CPI			
0	-0.0015	-5.6342×10^{-4}	-4.8212×10^{-5}
0.5	-0.0038	-0.0016	-3.2427×10^{-4}
0.7	-0.0067	-0.0029	-6.8352×10^{-4}
PEG			
0	-0.0050	-0.0020	-1.4884×10^{-4}
0.5	-0.0124	-0.0058	-0.0013
0.7	-0.0224	-0.0104	-0.0028
Internal Habit			
CPI			
0	-0.0015	-5.6342×10^{-4}	-4.8212×10^{-5}
0.5	-0.0016	-6.0584×10^{-4}	-5.7227×10^{-5}
0.7	-00016	-6.3703×10^{-4}	-6.3539×10^{-5}
PEG			
0	-0.0050	-0.0020	-1.4884×10^{-4}
0.5	-0.0051	-0.0021	-1.7097×10^{-4}
0.7	-0.0053	-0.0022	-1.9145×10^{-4}

CPI = consumer price index inflation targeting rule; PEG= exchange rate pegging rule

Note: Entries are % units of steady state consumption.

If households have a substantial degree of external habit, a higher Frisch labor supply elasticity could overturn the welfare ranking of alternative monetary policy rules, even if the intratemporal elasticity of substitution is low. For example, the welfare gain from the PEG rule relative to the DPI rule is approximately 0.007% of the steady state consumption for $\nu = 0.5,\ b = 0.7,$ and $\eta = 2,$ while there occurs a welfare loss from the PEG rule relative to the DPI rule for $\nu = 0.5,\ \ b = 0,$ and $\eta = 2.$ That is, as long as domestic and foreign consumption goods are not close complements, any monetary policy that diverts some domestic production toward the foreign country can be welfare improving in the economy with external habit . Maintaining the nominal exchange rate reduces the volatility of the real exchange rate by causing the real exchange rate to appreciate, thereby reducing the disutility of domestic production and increasing the consumption of foreign goods.

However, the Frisch labor supply elasticity plays a relatively minor role in the welfare ranking of alternative monetary policy rules in the internal habit case. The effect of the real exchange rate appreciation on welfare depends on the degree of intratemporal elasticity of substitution more than the Frisch labor supply elasticity when households fully take into account their current consumption decision on future utility.

3.3.3 Welfare Ranking of Alternative Monetary policy Rules in Incomplete Markets

We now consider the welfare ranking of alternative monetary policy rules in incomplete markets. In an incomplete market, the wealth effects are more tightly linked to domestic production than in a complete market.

Table 9: Welfare Cost Relative to the DPI Rule: Incomplete Market with Perfect Pass-Through (η=2)

Degree of Habit	v=1/2	v=1	v=3
External Habit			
CPI			
0	0.0016	0.0021	0.0025
0.5	0.0011	0.0023	0.0034
0.7	2.9072×10^{-4}	0.0024	0.0040
PEG			
0	0.0061	0.0081	0.0107
0.5	0.0047	0.0084	0.0131
0.7	0.0029	0.0084	0.0151
Internal Habit			
CPI			
0	0.0016	0.0021	0.0025
0.5	6.1360×10^{-4}	0.0017	0.0029
0.7	2.7127×10^{-4}	0.0014	0.0027
PEG			
0	0.0061	0.0081	0.0107
0.5	0.0023	0.0062	0.0114
0.7	0.0010	0.0051	0.0110

CPI = consumer price index inflation targeting rule; PEG= exchange rate pegging rule

Note: Entries are % units of steady state consumption.

Table 10: Welfare Cost Relative to the DPI Rule: Incomplete Market with Perfect Pass-Through (η=4)

Degree of Habit	v=1/2	v=1	v=3
External Habit			
CPI			
0	6.0460×10^{-4}	6.2767×10^{-4}	6.7059×10^{-4}
0.5	5.4332×10^{-4}	7.2777×10^{-4}	0.0010
0.7	2.9093×10^{-4}	6.7055×10^{-4}	0.0012
PEG			
0	0.0023	0.0025	0.0031
0.5	0.0021	0.0028	0.0043
0.7	0.0016	0.0027	0.0050
Internal Habit			
CPI			
0	6.0460×10^{-4}	6.2767×10^{-4}	6.7059×10^{-4}
0.5	4.0632×10^{-4}	5.5376×10^{-4}	8.5857×10^{-4}
0.7	2.7120×10^{-4}	3.9728×10^{-4}	7.7348×10^{-4}
PEG			
0	0.0023	0.0025	0.0031
0.5	0.0015	0.0020	0.0036
0.7	0.0011	0.0016	0.0034

CPI = consumer price index inflation targeting rule; PEG= exchange rate pegging rule

Note: Entries are % units of steady state consumption

Table 11: Welfare Cost Relative to the DPI Rule: Incomplete Market with Perfect Pass-Through (η=6)

Degree of Habit	v=1/2	v=1	v=3
External Habit			
CPI			
0	2.9433×10^{-4}	3.0264×10^{-4}	3.0943×10^{-4}
0.5	2.5562×10^{-4}	3.6622×10^{-4}	5.0384×10^{-4}
0.7	5.5915×10^{-5}	3.0349×10^{-4}	6.0712×10^{-4}
PEG			
0	0.0012	0.0013	0.0015
0.5	0.0011	0.0015	0.0023
0.7	7.1354×10^{-4}	0.0014	0.0027
Internal Habit			
CPI			
0	2.9433×10^{-4}	3.0264×10^{-4}	3.0943×10^{-4}
0.5	2.0539×10^{-4}	2.7478×10^{-4}	4.2087×10^{-4}
0.7	2.2190×10^{-4}	1.8842×10^{-4}	3.6586×10^{-4}
PEG			
0	0.0012	0.0013	0.0015
0.5	8.4552×10^{-4}	0.0011	0.0019
0.7	6.0655×10^{-4}	8.7722×10^{-4}	0.0018

CPI = consumer price index inflation targeting rule; PEG= exchange rate pegging rule

Note: Entries are % units of steady state consumption.

In this case, the effect of habit on the welfare ranking of alternative monetary policy rules is relatively limited irrespective of external or internal habit (Tables 9–11). If the degree of external habit is high, then external habit would have the same impact on welfare in an incomplete market as in a financial autarky. For example, if $\eta = 6,\ \nu = 0.5,$ and $b = 0.8,$ then the PEG rule and the CPI rule outperform the DPI rule for a country spread premium equal to 0.03, i.e., $\eta_B = 0.03$. The welfare gain from the PEG rule and the CPI rule relative to the DPI rule are approximately 0.0002% and 0.0003% of the steady state consumption, respectively.

3.4 Price Stability versus Exchange Rate Stability in Imperfect Pass-Through

The previous section demonstrated that, in the case of perfect exchange rate pass-through, the welfare ranking of alternative monetary policy rules depends on the degree of habit persistence and the Frisch labor supply elasticity, as well as asset market structure . The PEG rule outperforms the PPI rule in a small open economy with external habit and high intratemporal elasticity of substitution between home and foreign goods, irrespective of asset market structure. In this subsection, we examine the relative performance of simple monetary policy rules in the case of imperfect exchange rate pass-through.

3.4.1 Welfare Ranking of Alternative Monetary policy Rules in a Financial Autarky

In a financial autarky, where the wealth effects are completely linked to domestic production, the effect of an imperfect exchange rate pass-through (or the effect of the exchange rate misalignment) on welfare is marginal, as shown in Tables 12–14. The CPI rule performs best for a substantial degree of external habit, while the DPI rule performs better than the CPI

rule and PEG rule for a moderate degree of external habit, irrespective of the values of intratemporal elasticity of substitution for traded goods and habit.

We now consider the the case of internal habit. In this case, the inefficiency in the exchange rate arising from exchange rate misalignment is not enough to reverse the welfare ranking of alternative monetary policy rules. The findings of De Paoli (2009a) that the DPI rule is better than the PEG at high values of intratemporal elasticity of substitution also hold in this instance.

Table 12: Welfare Cost Relative to the DPI Rule: Financial Autarky with Imperfect Pass-Through (η=2)

Degree of Habit	v=1/2	v=1	v=3
External Habit			
CPI			
0	9.6938×10^{-4}	0.0010	0.0011
0.5	3.1490×10^{-4}	4.1187×10^{-4}	6.5240×10^{-4}
0.7	-2.8734×10^{-4}	-2.3071×10^{-4}	-8.7970×10^{-6}
PEG			
0	0.0059	0.0067	0.0088
0.5	0.0039	0.0047	0.0069
0.7	0.0017	0.0024	0.0045
Internal Habit			
CPI			
0	9.6938×10^{-4}	0.0010	0.0011
0.5	4.4197×10^{-4}	5.1248×10^{-4}	6.9679×10^{-4}
0.7	2.0186×10^{-4}	2.4705×10^{-4}	3.8398×10^{-4}
PEG			
0	0.0059	0.0067	0.0088
0.5	0.0039	0.0046	00066
0.7	0.0023	0.0028	0.0043

CPI = consumer price index inflation targeting rule; PEG= exchange rate pegging rule

Note: Entries are % units of steady state consumption.

Table 13: Welfare Cost Relative to the DPI Rule: Financial Autarky with Imperfect Pass-Through (η=4)

Degree of Habit	v=1/2	v=1	v=3
External Habit			
CPI			
0	2.6211×10^{-4}	2.5820×10^{-4}	2.4852×10^{-4}
0.5	5.8339×10^{-7}	2.0030×10^{-5}	7.2895×10^{-5}
0.7	-2.2961×10^{-4}	-2.3132×10^{-4}	-2.0008×10^{-4}
PEG			
0	0.0018	0.0019	0.0022
0.5	7.6726×10^{-4}	9.4577×10^{-4}	0.0014
0.7	-1.3770×10^{-4}	-3.1736×10^{-5}	3.6073×10^{-4}
Internal Habit			
CPI			
0	2.6211×10^{-4}	2.5820×10^{-4}	2.4852×10^{-4}
0.5	8.7737×10^{-5}	1.0054×10^{-4}	1.3392×10^{-4}
0.7	3.5014×10^{-5}	4.2755×10^{-5}	6.6731×10^{-5}
PEG			
0	0.0018	0.0019	0.0022
0.5	8.7373×10^{-4}	0.0010	0.0014
0.7	4.3191×10^{-4}	5.2075×10^{-4}	7.9091×10^{-4}

CPI = consumer price index inflation targeting rule; PEG= exchange rate pegging rule

Note: Entries are % units of steady state consumption.

Table 14: Welfare Cost Relative to the DPI Rule: Financial Autarky Market with Imperfect Pass-Through (η=6)

Degree of Habit	v=1/2	v=1	v=3
External Habit			
CPI			
0	1.2103×10^{-4}	1.1577×10^{-4}	1.0508×10^{-4}
0.5	-2.9760×10^{-5}	-2.1660×10^{-5}	3.1729×10^{-6}
0.7	-1.6691×10^{-4}	-1.7310×10^{-4}	-1.6574×10^{-4}
PEG			
0	8.8933×10^{-4}	9.2982×10^{-4}	0.0010
0.5	2.6340×10^{-4}	3.4010×10^{-5}	5.3861×10^{-4}
0.7	-2.7114×10^{-4}	-2.4375×10^{-4}	-9.8776×10^{-5}
Internal Habit			
CPI			
0	1.2103×10^{-4}	1.1577×10^{-4}	1.0508×10^{-4}
0.5	3.4725×10^{-5}	3.9744×10^{-5}	5.2868×10^{-4}
0.7	1.2103×10^{-4}	1.5703×10^{-5}	2.4854×10^{-5}
PEG			
0	8.8933×10^{-4}	9.2982×10^{-4}	0.0010
0.5	3.7331×10^{-4}	4.3153×10^{-4}	5.8706×10^{-4}
0.7	1.7308×10^{-4}	2.0859×10^{-4}	3.1669×10^{-4}

CPI = consumer price index inflation targeting rule; PEG= exchange rate pegging rule

Note: Entries are % units of steady state consumption.

3.4.2 Welfare Ranking of Alternative Monetary policy Rules in Complete Markets

Exchange rate misalignment plays a pivotal role in a small open economy with a complete market, irrespective of habit formation. Moreover, an imperfect exchange rate pass-through dominates all the other elements we have previously considered (i.e., habit persistence, intratemporal elasticity of substitution, and the Frisch labor supply elasticity), making the PEG rule the best among the considered simple rules. This reflects the fact that the real exchange rate gap arising from the exchange rate misalignment affects welfare more critically than the output gap arising from the habit.

Figures 1 and 2 show that the coefficient of the real exchange rate in the welfare equation is always negative, irrespective of the degree of habit and intratemporal elasticity of substitution. In this circumstance, monetary policy which causes the the real exchange rate to appreciate is more likely to be welfare-improving. With imperfect exchange rate pass-through, both domestically producing and importing firms reoptimize their prices infrequently. Hence, the composite general price also moves sluggishly, making the real exchange rate highly dependent on the nominal exchange rate. As such, the PEG rule causes the real exchange rate to appreciate more than any other simple monetary policy rule (Tables 15– 17).

Table 15: Welfare Cost Relative to the DPI Rule: Complete Market with Imperfect Pass-Through (η=2)

Degree of Habit	v=1/2	v=1	v=3
External Habit			
CPI			
0	-0.0014	-0.0012	-2.9529×10^{-4}
0.5	-0.0046	-0.0038	-0.0014
0.7	-0.0087	-0.0074	-0.0030
PEG			
0	-0.0051	-0.0043	
0.5	-0.0159	-0.0136	-0.0019
0.7	-0.0305	-0.0267	-0.0070
Internal Habit			-0.0143
CPI			
0	-0.0014	-0.0012	-2.9529×10^{-4}
0.5	-0.0028	-0.0016	-5.1648×10^{-4}
0.7	-0.0032	-0.0019	-6.5473×10^{-4}
PEG			
0	-0.0051	-0.0043	-0.0019
0.5	-0.0075	-0.0051	-0.0024
0.7	-0.0084	-0.0058	-0.0029

CPI = consumer price index inflation targeting rule; PEG= exchange rate pegging rule

Note: Entries are % units of steady state consumption.

Table 16: Welfare Cost Relative to the DPI Rule: Complete Market with Imperfect Pass-Through (η=4)

Degree of Habit	v=1/2	v=1	v=3
External Habit			
CPI			
0	-0.0057	-0.0025	-7.8295×10^{-4}
0.5	-0.0119	-0.0052	-0.0015
0.7	-0.0203	-0.0088	-0.0024
PEG			
0	-0.0146	-0.0076	-0.0029
0.5	-0.0317	-0.0164	-0.0060
0.7	-0.0553	-0.0285	-0.0103
Internal Habit			
CPI			
0	-0.0057	-0.0025	-7.8295×10^{-4}
0.5	-0.0063	-0.0028	-8.8286×10^{-4}
0.7	-0.0067	-0.0030	-9.5200×10^{-4}
PEG			
0	-0.0146	-0.0078	-0.0029
0.5	-0.0158	-0..0082	-0.0032
0.7	-0.0164	-0.0087	-0.0035

CPI = consumer price index inflation targeting rule; PEG= exchange rate pegging rule

Note: Entries are % units of steady state consumption.

Table 17: Welfare Cost Relative to the DPI Rule: Complete Market with Imperfect Pass-Through (η=6)

Degree of Habit	v=1/2	v=1	v=3
External Habit			
CPI			
0	-0.0066	-0.0026	-7.2727×10^{-4}
0.5	-0.0130	-0.0048	-0.0012
0.7	-0.0217	-0.0079	-0.0018
PEG			
0	-0.0171	-0.0077	-0.0026
0.5	-0.0348	-0.0152	-0.0047
0.7	-0.0589	-0.0255	-0.0076
Internal Habit			
CPI	-0.0066		
0	-0.0071	-0.0026	-7.2727×10^{-4}
0.5	-0.0074	-0.0028	-7.8107×10^{-4}
0.7		-0.0029	-8.2107×10^{-4}
PEG			
0	-0.0171	-0.0079	-0.0026
0.5	-0.0179	-0.0081	-0.0028
0.7	-0.0187	-0.0085	-0.0029

CPI = consumer price index inflation targeting rule; PEG= exchange rate pegging rule

Note: Entries are % units of steady state consumption.

3.4.3 Welfare Ranking of Alternative Monetary policy Rules in Incomplete Markets

Finally, we consider the welfare ranking of alternative monetary policy rules in incomplete markets. In an incomplete market with imperfect exchange rate pass-through, the effect of habit on the welfare ranking of alternative monetary policy rules is as limited as in a financial autarky, irrespective of external or internal habit.

We first consider the case of external habit. If the degree of external habit is high, then the impact of external habit on welfare is the same in incomplete markets as in financial autarkies. For example, consider the case of $\eta = 6,\ b = 0.7.$ The PEG rule and the CPI rule outperform the DPI rule for a country spread premium equal to 0.03, i.e. $\eta_B = 0.03.$ The welfare gain from the PEG rule and the CPI rule relative to the DPI rule are approximately 0.0003% and 0.0002% of the steady state consumption, respectively. This shows that the impact of external habit and the welfare ranking of alternative monetary policy rules is similar to that in a financial autarky.

In the case of internal habit, the welfare ranking of alternative simple monetary policy rules does not change at all in an incomplete market. The inefficiency in the exchange rate gap arising from exchange rate misalignment is not enough to reverse the welfare ranking of alternative monetary policy rules, as shown in Tables 18–20.

Table 18: Welfare Cost Relative to the DPI Rule: Incomplete Market with Imperfect Pass-Through (η=2)

Degree of Habit	v=1/2	v=1	v=3
External Habit			
CPI			
0	0.0010	0.0011	0.0012
0.5	0.0011	0.0013	0.0018
0.7	8.0286×10^{-4}	0.0014	0.0022
PEG			
0	0.0049	0.0056	0.0073
0.5	0.0048	0.0061	0.0094
0.7	0.0042	0.0062	0.0110
Internal Habit			
CPI		0.0011	0.0012
0	0.0010	0.0013	0.0017
0.5	0.0011	0.0013	0.0020
0.7	0.0010		
PEG			
0	0.0049	0.0056	0.0073
0.5	0.0049	0.0060	0.0092
0.7	0.0046	0.0061	0.0104

CPI = consumer price index inflation targeting rule; PEG= exchange rate pegging rule

Note: Entries are % units of steady state consumption.

Table 19: Welfare Cost Relative to the DPI Rule: Incomplete Market with Imperfect Pass-Through (η=4)

Degree of Habit	v=1/2	v=1	v=3
External Habit			
CPI			
0	4.1340×10^{-4}	3.9978×10^{-4}	3.8555×10^{-4}
0.5	4.1692×10^{-4}	5.3101×10^{-4}	6.6168×10^{-4}
0.7	1.7967×10^{-4}	4.7585×10^{-4}	8.0843×10^{-4}
PEG			
0	0.0021	0.0022	0.0026
0.5	0.0020	0.0025	0.0038
0.7	0.0014	0.0025	0.0046
Internal Habit			
CPI			
0	4.1340×10^{-4}	3.9978×10^{-4}	3.8555×10^{-4}
0.5	4.6875×10^{-4}	5.3485×10^{-4}	6.3932×10^{-4}
0.7	4.1856×10^{-4}	5.2934×10^{-4}	7.2850×10^{-4}
PEG			
0	0.0021	0.0022	0.0026
0.5	0.0021	0.0026	0.0038
0.7	0.0020	0.0027	0.0044

CPI = consumer price index inflation targeting rule; PEG= exchange rate pegging rule

Note: Entries are % units of steady state consumption.

Table 20: Welfare Cost Relative to the DPI Rule: Incomplete Market with Imperfect Pass-Through (η=6)

Degree of Habit	v=1/2	v=1	v=3
External Habit			
CPI			
0	2.1498×10^{-4}	7.2081×10^{-5}	1.8825×10^{-4}
0.5	2.1482×10^{-4}	2.0332×10^{-4}	3.3476×10^{-4}
0.7	-7.0319×10^{-6}	2.8391×10^{-4}	4.1707×10^{-4}
PEG			
0	0.0012	2.7477×10^{-4}	0.0014
0.5	0.0011	0.0013	0.0022
0.7	1.8789×10^{-4}	0.0015	0.0026
Internal Habit			
CPI			
0	2.1498×10^{-4}	7.2081×10^{-5}	1.8825×10^{-4}
0.5	2.5376×10^{-4}	2.8856×10^{-4}	3.3118×10^{-4}
0.7	2.1360×10^{-4}	2.7592×10^{-4}	3.7435×10^{-4}
PEG			
0	0.0012	2.7477×10^{-4}	0.0014
0.5	0.0013	0.0016	0.0022
0.7	0.0012	0.0016	0.0025

CPI = consumer price index inflation targeting rule; PEG= exchange rate pegging rule

Note: Entries are % units of steady state consumption.

4. CONCLUSION

In this paper, we explored the welfare implications of simple monetary policy rules such as the DPI rule, the CPI rule, and the PEG rule by introducing external and internal habit formation into a small open economy with nominal price rigidities under alternative asset market structures. We have shown that asset market structure is relevant for the welfare ranking of alternative monetary policy rules, even if both the intratemporal trade elasticity and the intertemporal elasticity of substitution in consumption are unitary.

The DPI rule can be inferior to the CPI rule in a sticky price model with a high degree of external habit in financial autarky, while the DPI rule is best among the considered simple rules in a complete asset market. This finding contrasts sharply to those of De Paoli (2009) and Faia and Monacelli (2008). More importantly, we have shown that the existence of external habit can reverse the welfare ranking of simple monetary policy rules in a complete market as well as in a financial autarky, for moderate values of intratemporal elasticity of substitution; with external habit, the PEG rule regime outperforms the DPI rule regime for high values of intratemporal elasticity of substitution between domestic and imported products when households are catching up with the Joneses, irrespective of asset market structure.

Finally, we have shown that the Frisch elasticity of labor supply as well as the intratemporal elasticity between home goods and imported goods plays a pivotal role in determining the welfare ranking of simple monetary rules in a small open economy with nominal rigidities.

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