Is Monetary Policy in an Open Economy Fundamentally Different?*

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Abstract

Openness *per se* requires optimal monetary policy to deviate from the canonical closed-economy principle of domestic price stability, even if domestic prices are the only ones to be sticky. I review this argument using a simple partial equilibrium analysis in an economy that trades in final consumption goods. I then extend the standard open economy New Keynesian model to include imported inputs of production. Production openness strengthens even further the incentive for the policymaker to deviate from strict domestic price stability. With both consumption and production openness, variations in the world price of food and in the world price of imported oil act as exogenous cost-push factors.

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1 Introduction

Is monetary policy in an open economy fundamentally different from its closed economy counterpart? This question has gained renewed interest in light of the dramatic rise in commodity prices over the last decade. Since many small open economies are either importers or exporters of energy, raw materials, and food, fluctuations in commodity prices play a central role in how monetary policy is conducted in these countries.

This paper makes two points. First, in a standard New Keynesian (NK henceforth) framework, openness *per se* alters the nature of optimal monetary policy relative to a closed economy setting. While strict domestic price (or, equivalently, markup) stabilization is generally optimal in a closed economy, the same result does not hold once the economy is open to trade (in goods and financial assets).[1] Second, the difference does not hinge on whether openness to trade is in final consumption goods (henceforth *consumption* openness) as opposed to imported production inputs (henceforth *production* openness).

The first result is important because it relates to the general nature of openness. If strict domestic price stabilization is not optimal, then some degree of exchange rate stabilization must be optimal. In other words, the so-called "fear of floating" (Calvo and Reinhart, 2002) can be interpreted as an equilibrium phenomenon. The second result implies that the issue of whether openness is relevant for monetary policy is essentially a quantitative one.

I begin by reviewing the classic "divine coincidence" result, which holds in a baseline closed economy NK model (Blanchard and Galí, 2007). When the equilibrium level of

[1] Our statement is referred to the baseline version of the closed economy NK model, and is meant to emphasize that the mere openness to trade, regardless of the underlying friction, will render inefficient to pursue a strict domestic price stability policy. This is not meant to imply that there cannot exist features, in a closed economy, that render optimal to deviate from domestic markup stabilization. The literature has identified several of these features, ranging from nominal wage stickiness (see, e.g., Erceg et al., 2000) to financial imperfections (Curdia and Woodford, 2009).

output under flexible prices and the efficient level of output coincide, stabilizing *domestic* markups (i.e., replicating the flexible price allocation) is (constrained) efficient. The intuition for that result is simple. In an economy with monopolistic competition, nominal price stickiness is the source of markup variability, and therefore of a time varying wedge between the marginal rate of substitution and the marginal rate of transformation. Hence (constrained) efficiency entails minimizing those variations (Goodfriend and King, 1997).

I then argue that, once the same baseline economy is open to trade in final consumption goods, the divine coincidence result breaks down**.** Via variations in international relative prices (terms of trade and/or real exchange rate) a planner can improve upon the flexible-price allocation. This depends on the mere possibility, in an open economy, to influence consumption for any given level of output (i.e., labor effort) via movements in the terms of trade. To clarify, openness makes deviating from price stability *desirable*, even in the absence of exogenous factors (such as so called "cost-push" shocks) that would make it unfeasible to simultaneously stabilize domestic prices and keep output at its flexible price level.

Finally, I show that the above result holds under both consumption and production openness. Hence, in our analysis, the two types of openness are *isomorphic.* This holds in two respects. First, in both cases, movements in the terms of trade are a critical margin that an optimizing policy maker may wish to exploit to improve upon the domestic markup stabilization prescription. Second, fluctuations in the world price of imported consumption goods (e.g., food) as well as of imported production inputs (e.g., oil and raw materials) can be sources of exogenous cost-push disturbances that render domestic price stability unfeasible. Those could be a dominant source of shocks that induce policymakers to engage in an active management of the terms of trade and, therefore, under price rigidity, of their nominal exchange rate. But in either case the basic principle, thereby deviating from domestic price stability is desirable, remains unaltered.

The analysis is divided in two parts. In the first part, I illustrate the main point of the paper using a partial equilibrium analysis. In the second part, I employ a more formal Ramsey-type analysis to characterize optimal monetary policy in a monopolistic competitive economy characterized by both consumption and production openness. The value added of the first part is to review in a compact way a series of basic principles of the recent optimal monetary policy literature in NK models (both in closed and open economies). The second part contains novel material on the analysis of optimal stabilization policy in a general small open economy model.

2 A simple illustration

In this section I compare the key elements that characterize optimal policy in a standard closed economy NK setting - such as the one popularized by the work of Woodford (2003), Clarida et al. (1999), Rotemberg and Woodford (1997), and Goodfriend and King (1997) - relative to its open economy extensions - as in the work, e.g., of Obstfeld and Rogoff (1996), Benigno and Benigno (2003), Corsetti and Pesenti (2003), Kollmann (2002), Devereux and Engel (2003), Clarida et al. (2002), Galí and Monacelli (2005), Sutherland (2005). Corsetti et al. (2011) features an extended review of the recent open economy monetary policy literature. It is important to notice, though, that virtually all models reviewed there are based on consumption openness.

2.1 Closed economy

Consider a standard closed economy with monopolistic competition in goods markets, nominal price stickiness, and constant elasticity of substitution among differentiated varieties. For the present purpose the underlying primitive model of price stickiness is irrelevant. Let the *nominal* marginal cost of production be W_t/MPN_t, where W_t is the nominal wage, and MPN_t is the marginal product of labor.

Markup pricing implies:

$$P_t = \mathcal{M}_{closed,t}^{-1} \frac{W_t}{MPN_t}, \tag{1}$$

where $\mathcal{M}_{closed,t}$ is the *real* marginal cost of production, or inverse of the price markup, in a closed economy.

Notice that the real marginal cost is *time-varying* precisely because prices are assumed to be sticky. In a frictionless economy, $\mathcal{M}_{closed,t} = 1$ holds for all t. In an economy with monopolistic competition, constant price elasticity of demand, and yet flexible prices, the real marginal cost is a constant, $\mathcal{M}_{closed,t} = \mathcal{M}_{closed}$ for all t.

Markup movements distort the equality between the real wage and the marginal product of labor. In fact, from markup pricing in (1), it holds:

$$\frac{W_t}{P_t} = \mathcal{M}_{closed,t} MPN_t.$$

A symmetric equilibrium of the sticky price economy in turn implies (under perfectly competitive labor markets):

$$MRS_t = \frac{W_t}{P_t} = \mathcal{M}_{closed,t} MPN_t, \tag{2}$$

where MRS_t is the marginal rate of substitution between consumption and leisure. Equation (2) shows that markup movements distort the equality between MPN_t and MRS_t, i.e., they act as a time varying wedge (Goodfriend and King, 1997). As a result, minimizing those variations is (constrained) efficient.[2]

[2] What monetary policy can achieve is *constrained* efficiency in the sense that it can aim at stabilizing completely the *cyclical* fluctuations in the markup. But it cannot eliminate the distortion associated with

A well-known literature, starting with Clarida et al. (1999), has typically "perturbed" equation (2) by introducing so-called cost-push factors. Typical examples of such cost-push factors are wage markup shocks, that distort the equality between MRS_t and W_t/P_t.

Notice that cost-push factors are *exogenous* forces that make it *unfeasible* to achieve the flexible price allocation (i.e., simultaneously stabilize domestic prices and keep output at its natural level). This does not alter the principle - rooted in price stickiness being the primitive source of distortion - thereby stabilizing the domestic (price) markup is *desirable*.[3]

This distinction is important because openness can typically be a source of cost-push shocks: for instance, due to variations in the world relative price of imported consumption goods (e.g., food) and/or variations in the world price of imported inputs (e.g., oil). But indeed these factors remain exogenous ones from the perspective of a small open economy. I shall argue below that openness may render optimal to deviate from the flexible price allocation even in the absence of any cost-push factor.

2.2 Consumption openness

Consider next a sticky price economy open to trade in final *consumption* goods. Denote by $P_{H,t}$ the consumption price of domestically produced goods, by $P_{F,t}$ the consumption price of imported goods (in units of domestic currency), and by $S_t = P_{F,t}/P_{H,t}$ the terms of trade (the relative price of imports). In this context the real marginal cost, $\mathcal{M}_{\alpha,t}$, is the ratio between the real *product* wage, $W_t/P_{H,t}$, and the marginal product of labor:

$$\mathcal{M}_{\alpha,t} = \frac{W_t/P_{H,t}}{MPN_t},$$

the *average* markup being greater than unity. That distortion can be corrected only via an appropriate use of taxes/subsidies. Adao et al. (2005) show that strict markup stabilization might not be constrained efficient if the standard closed economy NK model is extended to include accumulation of physical capital.

[3] As a result it has become customary in the literature to label cost-push shocks as *inefficient* shocks.

where the subscript α in $\mathcal{M}_{\alpha,t}$ denotes the presence of consumption openness (for notational reasons that will appear more clear below).

In turn, equilibrium implies:

$$\mathcal{M}_{\alpha,t} = \frac{W_t/P_{H,t}}{MPN_t} = \frac{(W_t/P_t)\,(P_t/P_{H,t})}{MPN_t} = \frac{MRS_t\ g(S_t)}{MPN_t} \tag{3}$$

where $P_t = \mathcal{P}(P_{H,t}, P_{F,t})$ is the consumption-based (CPI) price index, $\mathcal{P}(\cdot)$ is a homogeneous of degree one function,

$$g(S_t) = \frac{\mathcal{P}(P_{H,t}, P_{F,t})}{P_{H,t}},$$

and $g(\cdot)$ is an increasing function summarizing the dependence of the CPI-domestic price ratio on the terms of trade. Notice that in a closed economy the distinction between CPI and domestic goods prices is immaterial, hence $g(S_t) = 1$ for all t, and equation (3) coincides with (2).

Hence, in an open economy, there are two terms potentially driving a time-varying wedge between the MRS and the MPN: the inverse markup $\mathcal{M}_{\alpha,t}$ (due to price stickiness under monopolistic competition) and the openness-related relative price $g(S_t)$. Consider for simplicity the case of perfectly flexible domestic prices, i.e., of constant $\mathcal{M}_{\alpha,t}$. In that case, any shock hitting the domestic economy asymmetrically will require equilibrium movements in the terms of trade, therefore driving a wedge between the MRS and the MPN via the term $g(S_t)$. This is the first and main implication of openness.

Furthermore, under domestic price stickiness, constrained efficiency *may* require to strike an optimal balance between domestic markup volatility and terms of trade volatility. Assessing the extent to which a planner may want to resort to markup as opposed to terms of trade volatility, however, will require a full general equilibrium analysis, to which we will devote the sections below.[4]

Notice that, under complete exchange rate pass-through, it holds $P_{F,t} = E_t P^*_{F,t}$, where E_t is the nominal exchange rate (the price of one unit of foreign currency expressed in units of domestic currency), and $P^*_{F,t}$ is the foreign currency price of consumption imports (e.g., the world price of food). Hence shocks to the world price of imports, $P^*_{F,t}$, are akin to exogenous cost-push factors. As emphasized above, these exogenous factors eventually affect the feasibility of the flexible price allocation, yet not its desirability.

2.3 Production openness

Suppose next that the domestic economy trades also in an imported input of *production*, denoted by X_t. The production function of any given representative firm reads:

$$Y_t = A_t N_t^{1-\psi} X_t^{\psi} \tag{4}$$

where $\psi \in [0,1]$ denotes the share of imported inputs in production (energy, oil, raw materials), and A_t is aggregate total factor productivity (which evolves exogenously).

Define by $Z_t \equiv \mathcal{E}_t P^*_{X,t}/P_{H,t}$ the relative price of the production imports, where $P^*_{X,t}$ is the foreign currency price of the imported input. Under complete exchange rate pass-through on consumption imports, it is then straightforward to rewrite:

$$Z_t = \frac{\mathcal{E}_t P^*_{X,t}}{P_{H,t}} = \frac{\overbrace{\mathcal{E}_t P^*_{F,t}}^{=P_{F,t}}}{P_{H,t}} \frac{P^*_{X,t}}{P^*_{F,t}} = S_t \frac{P^*_{X,t}}{P^*_{F,t}} \tag{5}$$

Equation (5) suggests that the relative price of the imported input, Z_t, is proportional to the terms of trade and to the ratio of two exogenous prices, both expressed in units

[4] It should be previewed that the generality of this result will hinge on the assumed specification of preferences (Galí and Monacelli, 2005, Benigno and Benigno, 2005). Under CRRA utility, when the product of (the inverse of) the coefficient of relative risk aversion with the elasticity of substitution between domestic and imported goods is unitary, the optimality of domestic markup stabilization is restored. The intuition, in that case, is that income and substitution effects of terms of trade movements exactly offset each other.

of foreign currency: the foreign price of imported inputs, $P^*_{X,t}$, and the foreign price of imported consumption goods, $P^*_{F,t}$. In principle, fluctuations in both prices can constitute a sizeable source of shocks for small open economies. Fluctuations in $P^*_{X,t}$ capture, for instance, shocks to the world price of energy and raw materials, whereas fluctuations in $P^*_{F,t}$ capture shocks to the world price of food.

With both consumption and production openness the real marginal cost of production, denoted in this case by $\mathcal{M}_t$, can be written:[5]

$$\mathcal{M}_t = \frac{(W_t/P_{H,t})^{1-\psi} Z_t^{\psi}}{\Psi A_t},$$

where $\Psi \equiv (1-\psi)^{1-\psi}\psi^{\psi}$.

Multiplying and dividing by P_t, and using (5), one can write:

$$\begin{aligned} \mathcal{M}_t &= \frac{\left[\left(\frac{W_t}{P_t}\right)\left(\frac{P_t}{P_{H,t}}\right)\right]^{1-\psi} Z_t^{\psi}}{\Psi A_t} \\ &= \frac{\left[MRS_t \; g(S_t)\right]^{1-\psi} S_t^{\psi} \; \left(\frac{P^*_{X,t}}{P^*_{F,t}}\right)^{\psi}}{\Psi A_t}. \end{aligned} \tag{6}$$

A few observations on (6) are in order.

- First, (6) nests (3) when the economy is closed on the production side ($\psi = 0$), and it nests (2) in the case of both $\psi = 0$ and closed economy on the consumption side ($g(S_t) = 1$).

- Second, when the economy features *both* consumption and production openness, movements in the terms of trade, via the composite factor $g(S_t)^{1-\psi} S_t^{\psi}$, continue to generate a wedge between MRS_t and A_t (the marginal product of labor), even

[5] See the general equilibrium model below on how to derive this expression as an equilibrium condition.

under flexible prices (constant $\mathcal{M}_t$). In this vein, production openness is *isomorphic* to consumption openness.

- Third, under production openness (and in this case only), the "foreign currency price ratio", $P^*_{X,t}/P^*_{F,t}$, plays the role of a cost-push factor, genuinely related to openness. Being such factor exogenous to the small economy, it represents a source of wedge between MRS_t and A_t of completely different nature from the movements in the terms of trade, which are endogenous.

3 A general equilibrium model

In this section I extend the analysis to a full general equilibrium setup. I sketch a baseline open economy NK model with monopolistic competition and nominal price rigidity. The model is based on Faia and Monacelli (FM, 2008), which is a consumption openness model, extended to include the case of production openness.[6] Recent papers analyzing optimal monetary policy in small open economy models with an explicit emphasis on the role of commodity prices are Hueva and Nicolini (2012) and Catao and Chang (2010). The framework of both papers is nested within the one proposed here.[7]

The present analysis is based on three building blocks: (i) consumption openness; (ii) international risk sharing; (iii) production openness.

[6] Most of the papers in the NK open economy tradition rely on consumption openness. See for instance Obsteld and Rogoff (1996), Benigno and Benigno (2003), Corsetti and Pesenti (2001, 2003), Kollman (2002), Devereux and Engel (2003), Clarida, Galí, and Gertler (2002), Pappa (2004), Galí and Monacelli (2005), Sutherland (2005). An early exception featuring production openness (but not analyzing optimal monetary policy) is McCallum and Nelson (2000).

[7] Catao and Chang (2010), in fact, employ exactly the same consumption openness model with perfect pass-through of Galí and Monacelli (2005, GM). Different from GM, who assume that the foreign currency price of consumption imports is exogenous and constant, they assume that the same price is exogenous but time-varying. As explained above, this assumption is isomorphic to introducing an exogenous cost-push shock.

Consumption openness Let the consumption basket in the Home small economy be

$$C_t \equiv [(1-\alpha)^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} \ + \ \alpha^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}}]^{\frac{\eta}{\eta-1}}, \tag{7}$$

where $C_{H,t}$ is a bundle of domestically produced goods, $C_{F,t}$ is a bundle of imported goods[8], $\alpha \geq 0$ is the share of foreign consumption imports in the aggregate consumption bundle (i.e., the degree of consumption openness), and $\eta > 0$ is the elasticity of substitution between domestic and imported goods.

Under consumption openness the following aggregate market clearing condition for domestic goods holds:[9]

$$Y_t = (1-\alpha) g(S_t)^{\eta} C_t \ + \ \alpha S_t^{\eta} C_t^* \tag{8}$$

where Y_t is aggregate output of domestic goods, and C_t^* is aggregate foreign consumption (which evolves exogenously). Notice that in the case of a closed economy ($\alpha = 0$ and $g(S_t) = 1$) expression (8) reduces to the standard feasibility condition $Y_t = C_t$.

Risk sharing Let $Q_t = \mathcal{E}_t P_t^* / P_t$ be the CPI real exchange rate. In all models featuring complete international financial markets the following risk-sharing equilibrium condition holds:

$$\frac{U_{c,t}^*}{U_{c,t}} = Q_t = q(S_t) \tag{9}$$

where $U_{c,t}$ and $U_{c,t}^*$ denote the marginal utility of consumption in Home and Foreign respectively, and $q(\cdot)$ is an increasing function linking the terms of trade to the real

[8] In turn each consumption bundle $C_{H,t}$ and $C_{F,t}$ is composed of imperfectly substitutable varieties.

[9] The details can be found in Faia and Monacelli (2008).

exchange rate. The function $q(\cdot)$ can be derived from the definition of the CPI real exchange rate as follows:

$$\begin{aligned} Q_t &= \frac{\mathcal{E}_t P_t^*}{P_t} \\ &= S_t \frac{P_t^*}{P_{F,t}^*} \left(\frac{P_t}{P_{H,t}} \right)^{-1} \\ &= \frac{S_t}{g(S_t)} \equiv q(S_t) \end{aligned} \tag{10}$$

Notice that the last equality in (10) hinges on the assumption that Foreign is an approximately closed economy, so that $P_t^* = P_{F,t}^*$.

3.1 Production openness and price setting

Each monopolistic firm i in Home produces a homogenous good according to the constant return to scale technology:

$$\begin{aligned} Y_t(i) &= A_t F(N_t(i), X_t(i)) \\ &= A_t N_t(i)^{1-\psi} X_t(i)^{\psi} \end{aligned} \tag{11}$$

where the factor A_t describes (exogenous) total factor productivity.

Prices of domestically produced goods are determined one period in advance. There is no international price discrimination. Each producer i chooses $P_{H,t}(i)$, $N_t(i)$, $X_t(i)$ to maximize

$$\mathbb{E}_{t-1} \left\{ \nu_{t-1,t} \; \left[P_{H,t}(i) Y_t(i) - W_t N_t(i) - P_{X,t} X_t(i) \right] \right\},$$

where $\nu_{t-1,t}$ is the stochastic discount factor between time $t-1$ and t, subject to

$$\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\varepsilon} Y_t \leq A_t N_t(i)^{1-\psi} X_t(i)^{\psi}. \tag{12}$$

The left hand side of (12) denotes total demand for the domestic variety i (including the one from the foreign economy), and ε is the elasticity of substitution across differentiated domestically produced varieties.

Let $\mathcal{M}_t$ denote the Lagrange multiplier on constraint (12). The first order conditions on $P_{H,t}(i), N_t(i)$ and $X_t(i)$ read:

$$\frac{\beta P_{t-1}}{U_{c,t-1}}\mathbb{E}_{t-1}\left\{\frac{U_{c,t}\ Y_t}{P_t}\left[\frac{P_{H,t}(i)}{P_{H,t}}\ -\ \mathcal{M}_t\left(\frac{\varepsilon}{\varepsilon-1}\right)\right]\right\}=0 \tag{13}$$

$$\frac{W_t}{P_{H,t}} = \mathcal{M}_t MPN_t(i) \tag{14}$$

$$Z_t = \frac{P_{X,t}}{P_{H,t}} = \mathcal{M}_t MPX_t(i) \tag{15}$$

where $MPN_t(i) \equiv A_t(1-\psi)\left(X_t(i)/N_t(i)\right)^{\psi}$ is the marginal product of labor and $MPX_t(i) \equiv A_t\psi\left(X_t(i)/N_t(i)\right)^{-(1-\psi)}$ is the marginal product of the imported production input.

Equation (13) is the condition for optimal price setting, whereas (14) and (15) are the efficiency conditions for the choice of the labor and the imported input respectively.

By combining (14) and (15), re-writing the real product wage as $W_t/P_{H,t} = (W_t/P_t)\, g(S_t)$, and using (5), the multiplier $\mathcal{M}_t$ can be interpreted as the equilibrium real marginal cost of production, and be written:

$$\mathcal{M}_t = \frac{\left(\frac{W_t}{P_{H,t}}\right)^{1-\psi} Z_t^{\psi}}{\Psi A_t} = \frac{\left(\frac{W_t}{P_t}g(S_t)\right)^{1-\psi} S_t^{\psi}\ p_{X,t}^{*\psi}}{MPN_t(i)^{1-\psi}MPX_t(i)^{\psi}} \tag{16}$$

where $p^*_{X,t} \equiv P^*_{X,t}/P^*_{F,t}$.[10]

Openness and the relation between marginal costs Notice that, from (16), the real marginal cost can be written

$$\mathcal{M}_t = \mathcal{M}_{\alpha,t}^{1-\psi}\Gamma_t^{\psi} \tag{17}$$

where $\mathcal{M}_{\alpha,t} \equiv (-U_{n,t}/U_{c,t})g(S_t)/A_t$ is the equilibrium expression for the real marginal cost when only consumption openness is present ($\psi = 0$), and $\Gamma_t \equiv S_t p^*_{X,t}/A_t$ is a time-varying wedge between the two measures of open economy marginal cost.

Hence the marginal cost in the general economy (featuring both types of openness) is a *weighted average* of $\mathcal{M}_{\alpha,t}$, the marginal cost under consumption openness, and the wedge term Γ_t, which depends on three factors: the terms of trade, the world relative price of the imported input, $p^*_{X,t}$, and total factor productivity, A_t.

Flexible prices Under flexible prices, after using equilibrium condition (16), equation (13) becomes

$$\mathcal{M}_t \equiv \frac{\left(-\frac{U_{n,t}}{U_{c,t}}g(S_t)\right)^{1-\psi} S_t^{\psi}\ \widetilde{p}^{*\psi}_{X,t}}{\Psi A_t} = \mu^{-1},$$

where $\mu \equiv \varepsilon/(\varepsilon - 1)$ is the constant desired markup. Hence, under flexible prices, due to the primitive assumption of constant elasticity of substitution across varieties ε, each firm would optimally choose to keep its markup constant. This is a well-known insight of the NK literature that we reformulate here in the case of an economy with both consumption and production openness.

[10] Hence (16) derives (6) as an equilibrium condition.

Symmetric equilibrium and price setting In a symmetric equilibrium, using (16), the price setting condition (13) can be rewritten as:

$$\mathbb{E}_{t-1}\left\{\frac{U_{c,t}\ A_t F(N_t, X_t)}{g(S_t)} + \Psi^{-1}\mu\ U_{n,t}\ F(N_t, X_t)\ \Theta_t^{\psi}\right\} = 0, \tag{18}$$

where $\Theta_t \equiv \Theta\left(C, N, S, p^*_{X,t}\right) = (U_{c,t}/U_{n,t})\, q(S_t) p^*_{X,t}$, and the real wage has been replaced with the standard household's consumption/leisure condition $W_t/P_t = -U_{n,t}/U_{c,t}$.

Two elements typical of the presence of production openness affect condition (18). First, the presence of the imported input X_t in the production function $F(\cdot)$. Second, the presence of the term Θ_t, which in turn depends on the real exchange rate, $q(S_t)$, and on the world relative price of the imported input, $p^*_{X,t}$. Notice that in the absence of production openness ($\psi = 0$) the price setting condition (18) nests the one obtained in the baseline model with consumption openness.[11]

4 Optimal monetary policy: constrained efficiency

In this section we characterize optimal monetary policy as the constrained-efficient (Ramsey) allocation under pre-set prices. In the following, we assume a standard isoelastic utility

$$U(C, N) = \frac{C^{1-\sigma}}{1-\sigma} - \frac{N^{1+\zeta}}{1+\zeta},$$

which implies $-U_{cc,t}C_t/U_{c,t} = \sigma$ and $U_{nn,t}N_t/U_{n,t} = \zeta$, where ζ and σ are both constant. We use these assumptions to rewrite constraints (9) and (8) accordingly.

Let $\left\{\varphi_p, \varphi_{f,t}, \varphi_{r,t}\right\}$ denote Lagrange multipliers on constraints (18), (8) and (9) respectively. The constrained efficient problem for the Ramsey planner of the small economy can be written:

[11] See Faia and Monacelli (2007).

$$
\begin{aligned}
&Max_{\{C_t,\, S_t,\, N_t\}}\ \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\zeta}}{1+\zeta} \right\} \\
&+\mathbb{E}_{-1} \sum_{t=0}^{\infty} \beta^t \varphi_p \ \left\{ \frac{C_t^{-\sigma}\ A_t F(N_t, X_t)}{g(S_t)} \ - \Psi^{-1}\mu\ N_t^{\zeta}\ F(N_t, X_t)\ \Theta_t^{\psi} \right\} \\
&+\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \varphi_{f,t}\ \left\{ A_t F(N_t, X_t) - (1-\alpha) g(S_t)^{\eta} C_t \ -\ \alpha S_t^{\eta} C_t^{*} \right\} \\
&+\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \varphi_{r,t}\ \left(C_t - q(S_t)^{\frac{1}{\sigma}} C_t^{*} \right)
\end{aligned}
$$

Notice that the multiplier on the price setting constraint, φ_p, is constant across time and states.[12]

After substituting C_t from (9), the first order conditions with respect to S_t and N_t can be conveniently combined in such a way that the real marginal cost under constrained efficiency, $\overline{\mathcal{M}}_t$, can be written, after some algebra[13]

$$
\overline{\mathcal{M}}_t = \Gamma_t^{\psi} \cdot \left[\frac{\Sigma(S_t) + \left(\frac{\psi}{1-\psi}\right)^{1-\psi} \varphi_p \mu H_t}{q(S_t)^{-\frac{1}{\sigma}} \frac{D(S_t)}{g(S_t)} \left\{ 1 + \frac{\varphi_p \mu}{\Psi} \left[F_{n,t} + F(\cdot) \left(\frac{\zeta}{N_t} + \psi \frac{\Theta_{n,t}}{\Theta_t} \right) \right] \right\}} \right]^{1-\psi}, \tag{19}
$$

where $H_t = H(N_t, C_t, X_t, \Theta_t) \equiv N_t^{\zeta} F(\cdot) \Theta_t^{\psi-1} \Theta_{s,t} C_t^{\sigma-1}$, Γ_t is the time varying wedge between the production openness and the consumption openness marginal cost as from (17), and $\Sigma(S_t)$ and $D(S_t)$ are composite terms which are functions of the terms of trade only, and whose expressions are derived in the Appendix.[14]

Equation (19) displays the condition that the real marginal cost $\overline{\mathcal{M}}_t$ must satisfy under constrained efficiency. The purpose of our analysis is to verify whether (or not)

[12] Notice also that the version of the Ramsey problem is a restricted one, that does not include the choice of variable X_t. After determining S_t and N_t, in fact, the allocation for X_t consistent with constrained efficiency can be derived uniquely from (15).

[13] More details concerning the derivation of the first order conditions can be found in the Appendix.

[14] In equation (19) $F_{n,t} \equiv \partial F(\cdot)/\partial N_t$, $\Theta_{n,t} \equiv \partial \Theta_t / \partial N_t$, $\Theta_{s,t} \equiv \partial \Theta_t / \partial N_t$.

constrained efficiency requires, under *both* consumption and production openness, $\overline{\mathcal{M}}_t$ to be time and state invariant.

It is particularly instructive to derive expression (19) under the special case of $\psi = 0$, which corresponds to a baseline economy with consumption openness only:

$$\overline{\mathcal{M}}_t = \overline{\mathcal{M}}_{\alpha,t} = \frac{\Sigma(S_t) q(S_t)^{\frac{1}{\sigma}} g(S_t)}{D(S_t)} \overline{\mathcal{M}}^{closed} \tag{20}$$

where

$$\overline{\mathcal{M}}^{closed} \equiv \left[1 + \varphi_p \mu (1 + \zeta)\right]$$

is the real marginal cost under constrained efficiency in the particular case of a closed economy.

Three aspects of (20) are worth emphasizing.

- First, constrained efficiency in an open economy with only consumption openness requires the real marginal cost, $\overline{\mathcal{M}}_{\alpha,t}$, to be *time varying*.
- Second, the source of *optimal* fluctuations in the marginal cost is entirely due to movements in the composite term $\Sigma(S_t) q(S_t)^{\frac{1}{\sigma}} g(S_t)/D(S_t)$, which, in turn, is a function of the terms of trade only. This result is consistent with the partial equilibrium intuition derived from equation (3).
- Third, in the special case of a *closed* economy ($\alpha = \psi = 0$) constrained efficiency requires the real marginal cost to be *constant*, and equal to $\overline{\mathcal{M}}^{closed}$. Put differently, and consistent with our intuition from equation (2), constrained efficiency requires to replicate the same allocation that would result under flexible prices. This result is a central one that emerges from the recent New Keynesian optimal monetary policy literature.[15]

[15] Woodford (2003), Galí (2008).

I then turn back to an interpretation of equation (19) in the more general case of both consumption and production openness. There are two key insights:

- All terms on the right hand side of equation (19) are time varying. Hence also in a more general model of openness constrained efficiency requires a deviation from the constant real marginal cost allocation.

- Second, under both production and consumption openness, it is not only movements in the terms of trade that contribute to the desired variations in the real marginal cost (as it is the case under consumption openness only). Those additional factors depend on the endogenous variations in consumption and labor in a more convoluted way, due to the indirect effect of terms of trade movements (and in turn of the foreign currency price ratio) on both marginal factors of production. Yet the same principle derived in the simpler case of consumption openness remains: due to mere open economy factors, and *regardless of the presence of cost-push factors*, optimal monetary policy requires a deviation from the allocation that prescribes to replicate a constant domestic real marginal cost.

5 Conclusions

I have shown, using both partial and general equilibrium insights, that optimal policy prescriptions in a small open economy differ substantially from its closed economy counterpart. In an open economy, and even if domestic prices remain the only source of nominal rigidity, it is not optimal to aim at replicating the flexible price allocation, which is the normative centerpiece of the recent NK closed economy monetary policy literature. Efficiency in an open economy (in a second best sense) requires a certain degree of volatility in both the real marginal cost and the terms of trade. Under price rigidity this entails an optimal, yet not full, degree of nominal exchange rate volatility.

A key, and novel, insight of our analysis is that the above result holds regardless of whether an economy is open to trade on the consumption or on the production side. Moreover, this result does not hinge on whether or not open economy cost-push factors (such as time-varying world food or energy prices) are present. The latter only affect the feasibility, yet not the desirability, of the domestic constant markup allocation.

These insights suggest that consumption and production openness are isomorphic, and in fact reinforce each other to make domestic price stability even less desirable in a small open economy. Assessing the quantitative significance of the desired deviation from price stability in an economy with both types of openness remains an interesting topic for future research, especially in light of the multiple sources of international price shocks typically faced by small open economies.

We have focused here only on the role of consumption and production openness as possible causes of "fear of floating". But openness, in general, can feature multiple sources of such phenomenon, ranging from local currency pricing to imperfections in international financial markets (see for instance Engel 2010 and Corsetti et al. 2011). Measuring the combined quantitative effect of all these ingredients in making optimal monetary policy in an open economy fundamentally different still remains an explored endeavor.

Appendix

Preliminarily, it is useful to define the function $K(S_t)$, which combines (9) and (8), and reads:

$$K(S_t) \equiv \frac{A_t F(\cdot)}{g(S_t) C_t} = (1-\alpha) g(S_t)^{\eta-1} + \alpha {S_t}^{\eta} q(S_t)^{-1/\sigma}$$

Notice that $K(S_t)$ is a function of the terms of trade only, and is equal to 1 in the particular case of a closed economy, where $\alpha = 0$ and $g(S_t) = q(S_t) = S_t = 1$.

The first order conditions of the Ramsey problem with respect to S_t and N_t read respectively:

$$\Sigma(S_t) = \underbrace{-\left(\frac{\psi}{1-\psi}\right)^{1-\psi} \varphi_p \mu \frac{N_t^{\zeta} F(\cdot)}{C_t^{1-\sigma}} \Theta_t^{\psi-1} \Theta_{s,t}}_{=0 \text{ if } \psi=0} + \varphi_{f,t} C_t^{\sigma} q_t^{-\frac{1}{\sigma}} D(S_t) \tag{21}$$

$$\varphi_{f,t} A_t F_{n,t} = N_t^{\zeta} - \varphi_p \left\{ \frac{C_t^{-\sigma} A_t F_{n,t}}{g(S_t)} - \frac{\mu}{\Psi} N_t^{\zeta} \Theta_t^{\psi} \left(\frac{\zeta F(\cdot)}{N_t} + F_{n,t} + \psi F(\cdot) \frac{\Theta_{n,t}}{\Theta_t} \right) \right\} \tag{22}$$

where

$$\Sigma(S_t) \equiv \sigma^{-1} \left(\frac{q_{s,t}}{q_t} \right) - \varphi_p K(S_t)$$

and

$$D(S_t) \equiv (1-\alpha) \left\{ \left(\eta - \frac{1}{\sigma} \right) g(S_t)^{\eta - \frac{1}{\sigma} - 1} + \sigma^{-1} S_t^{\frac{1}{\sigma} - 1} g(S_t)^{\eta - \frac{1}{\sigma}} \right\} + \alpha \eta S_t^{\eta - 1}$$

Combining (21) and (22) one can derive (19) in the main text.

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