Stagflation and Topsy-Turvy Capital Flows[*]

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Abstract

Financial openness is a cornerstone of the current international macroeconomic and financial architecture. Should we expect it to support stabilization policy in a context of heightened stagflation concerns? Using an open-economy model with nominal rigidities, we argue that, quite to the contrary, free capital mobility undermines monetary policy when the later faces an output-inflation trade-off. Capital inflows cause unwelcome upward pressure on domestic marginal costs in high-inflation countries, thus deteriorating the policy trade-off. Yet, market forces are likely to generate net inflows into these countries. A constrained efficient regime features net flows in the opposite direction, suggesting *topsy-turvy* capital flows following supply shocks.

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1 Introduction

One of the most striking and unexpected macroeconomic development of the ongoing recovery is the recent pick up in inflation. But despite the phenomenon affecting a wide range of jurisdictions, there appears to be significant cross-country heterogeneity in the extent to which latest inflation figures depart from levels seen in previous years. For instance, in February 2022, while CPI inflation in the United States sat at 7.9%, well above its average of the last decade, Japanese CPI inflation was 0.9%, comfortably close to its pre-pandemic mean. Such cross-country differences in inflationary pressures, if they prove persistent, are likely to lead to diverging monetary policy stances by the world's leading central banks going forward. A key issue for monetary theory and policy in this context is whether the current system of floating exchange rates and open capital accounts will foster a smooth macroeconomic adjustment out of the current juncture. Yet, perhaps because adverse supply shocks have not concerned us of a while, a formal analysis of this issue appears to be lacking. Our ambition with this paper is to fill this gap.

To this end, we formulate a tractable open-economy macro model featuring monopolistic competition and nominal rigidities in the New Open-Economy Macroeconomics tradition, whose main ingredients are at the core of larger scale dynamic stochastic general equilibrium (DSGE) models used by most central banks for policy analysis. To pinpoint whether free capital mobility across regions fosters or hampers the global economy's adjustment to an unanticipated cost-push shock, we analyze the constrained efficiency of external borrowing decisions in that context. That is, assuming that labor supply, expenditure allocation and price setting decisions are made by individual households and firms, we ask whether a planner would choose the same level of external saving or borrowing as private households.

We find that a regime of free capital mobility is constrained inefficient owing to two aggregate demand externalities associated with external borrowing in open-economy environments characterized by an output-inflation trade-off. The first externality reflects the fact that for given output gaps and terms of trade, a rise in the so-called demand gap (or relative consumption) raises wages and hence firms' marginal costs. If the domestic economy is experiencing a recession engineered by monetary policy to fight inflationary pressures, the rise in marginal cost deteriorates the policy trade-off. This externality accordingly leads to overborrowing in the high-inflation region. The second externality arises from the fact that, provided there is some home bias in consumption, a rise in the demand gap also causes a terms of trade appreciation. In turn, this terms of trade appreciation, may, depending on elasticities, either raise or lower firms' marginal costs.

For plausible parametrization of elasticities, the terms of trade appreciation raises marginal costs, contributing to further deteriorating the output-inflation trade-off. This second externality hence also causes overborrowoing in the high-inflation region.

The two externalities uncovered do not simply lead to inefficiencies at the margin. When both work in the same direction, they are so powerful that they actually reverse the direction of net capital flows in our model. Indeed, following a cost-push shock, while a free capital mobility regime is likely to feature net capital inflows into the high inflation region, a constrained efficient regime would require net outflows from that region. Our results hence suggest that ostensibly wrong price signals in international financial market lead to topsy-turvy capital flows in the basic two-country New Keynesian in the presence of an output-inflation trade-off.

Our paper relates to two main literature. First, it relates to the New Open-Economy Macroeconomics literature that developed following the seminal work of Obstfeld and Rogoff (1995). This literature has focused on studied optimal monetary policy in general equilibrium international macroeconomic models (see, e.g., Corsetti and Pesenti 2001, Benigno and Benigno 2003, Engel 2016, Egorov and Mukhin 2020). From a methodological standpoint, we build on this literature by adopting the key building blocks of monopolistic competition and sticky prices, and assuming that monetary policy is set cooperatively. But our focus is on studying the constrained efficiency of external borrowing decisions. Corsetti, Dedola and Leduc (2010) and Corsetti, Dedola and Leduc (2018) show that deviating from the classical complete markets assumption leads to a wedge in the international risk-sharing condition reflecting demand imbalances. In contrast, we assume that markets are complete and make this wedge a policy choice. A recent paper by Cho et al. (2021) compares welfare under free capital flows and closed capital accounts. We go beyond simply shutting down all financial flows brings important insights: free capital flows undermine the output inflation trade-off faced by policymakers and are destabilizing when economies face uneven inflationary pressures.

Second, our paper relates to the macro-finance literature on overborrowing. A subset of this literature shows that agents or countries may borrow excessively as a result of pecuniary externalities in incomplete markets environment (e.g., Caballero and Krishnamurthy 2001, Korinek 2007, Bianchi 2011). Another stream of this literature shows that overborrowing can also arise from aggregate demand externalities in economies with sticky prices or sticky wages (e.g., Farhi and Werning 2016). The bulk of this literature has focused on environments where monetary policy is constrained, such as by the zero lower bound (Korinek and Simsek 2016, Acharya and Bengui 2018, Fornaro and Romei

2019. Bianchi and Coulibaly 2021) or by a fixed exchange rate regime (Farhi and Werning (2012), Farhi and Werning 2017 and Schmitt-Grohe and Uribe 2016). In contrast, we study an environment where monetary policy is unconstrained, but faces non-trivial trade-offs due to inefficient cost-push shocks. A burgeoning literature featuring both pecuniary and aggregate demand externalities shows that capital controls can help monetary policy trade-off and is welfare-improving from the perspective of a small open-economy (Coulibaly 2020; Ottonello 2021; Matsumoto 2021). We contribute to this literature by analyzing the inefficient of the free capital flow regime at the world level. We show that the unwelcome upward pressure on marginal cost in high-inflation countries are destabilizing and compared to the efficient capital flow regime, capital tends to flow in the wrong direction under free capital mobility.

The remainder of the paper is organized as follows: Section 2 presents the model. Section 3 characterizes the optimal monetary policy and discusses macroeconomic adjustments under free capital flows. Section 4 characterizes the efficient capital flow regime. Section 5 concludes.

2 Model

The world is composed of two country of equal size, Home and Foreign. In each country, households consume goods and supply labor, while firms hire labor to produce output. Variables pertaining to Foreign are denoted with asterisks.

2.1 Households

In each country, there is a representative household. In the home country, the preferences of the representative household are represented by the utility functional:[1]

$$\int_0^{\infty} e^{-\rho t} \left[\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\phi}}{1+\phi} \right] dt,$$

where C_t is consumption, N_t is labor supply, ϕ is the inverse Frisch elasticity of labor supply, σ is the relative-risk-aversion coefficient, and ρ is the discount rate. The consumption

[1] Our model exposition focuses on households in Home, but households in Foreign are symmetric.

index C_t is defined as

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

In turn, $C_{H,t}$ and $C_{F,t}$ are CES aggregates over a continuum of goods produced respectively in Home and Foreign, with elasticity of substitution between varieties produced within a region equal to $\varepsilon > 1$. The elasticity of substitution between domestic and foreign goods is $\eta > 0$ and $\alpha \in (0, 0.5]$ is a home bias parameter capturing the degree of openness. When $\alpha = 0.5$, there is no home bias as households in the home country and the foreign country consume the same basket of goods. In contrast, when $\alpha < 0.5$, there is home bias in consumption as households value more highly domestic goods. In the limit where $\alpha \to 0$, the home bias is extreme and preferences converge to their closed-economy counterparts. We will interpret an absence of home bias as a manifestation of perfect trade integration, and accordingly, a home bias as indicator of imperfect trade integration.

In each country, an household can trade two types of bonds in credit markets: an international nominal bond B_t and a domestic nominal bond denoted D_t in Home and D_t^* in Foreign that can be traded only among domestic households. The international bond is (arbitrarily) denominated in the home currency, without loss of generality.

The household's budget constraint in the home country is given by:

$$\dot{D}_t + \dot{B}_t = i_t D_t + i_{B,t} B_t + W_t N_t + \Pi_t - \int_0^1 P_{H,t}(l)\, C_{H,t}(l) dl - \int_0^1 P_{F,t}(l) C_{F,t}(l) dl$$

where W_t is the nominal wage, Π_t is the payout of domestic firms, i_t denotes the return on Home bonds and $i_{B,t}$ denotes the return on the international claims held by Home households.

Foreign households are symmetric. Foreign households and Home households are similar as far as preferences toward consumption and leisure where as noted above Foreign variables are indexed by asterisks. We assume that the return on international claims held by home households and foreign households has two components: a component that is common across countries $\underline{i_t}$ and a country-specific component (τ_t for Home and τ_t^* for Foreign) that captures financial regulations imposed by a global financial regulator on international borrowing.We denote by ξ_t the wedge between the return on international bond faced by households in the two countries

$$\xi_t \equiv i_{B,t} - i_{B,t}^* = \tau_t - \tau_t^*. \tag{1}$$

With frictionless international asset market $\xi_t = 0$ for all $t \geq 0$. We assume that countries have symmetric net foreign asset positions (i.e., equal to 0) at time 0.

Standard expenditure minimization leads to consumer price indices (CPI) in Home and Foreign given by

$$P_t \equiv \left[(1-\alpha)\left(P_{H,t}\right)^{1-\eta} + \alpha\left(P_{F,t}\right)^{1-\eta}\right]^{1/(1-\eta)},$$
$$P_t^* \equiv \left[(1-\alpha)(P_{F,t}^*)^{1-\eta} + \alpha(P_{H,t}^*)^{1-\eta}\right]^{1/(1-\eta)},$$

$P_{H,t}$ (and $P^*_{F,t}$) being the Home's (and Foreign's) PPI and $P_{F,t}$ (and $P^*_{H,t}$) being Home's (and Foreign's) price index of imported goods. The terms of trade between the Home and the Foreign are defined as the ratio of PPIs, $S_t \equiv \frac{P_{F,t}}{P_{H,t}} = \frac{P^*_{F,t}}{P^*_{H,t}}$, while the real exchange rate is defined as the ratio of CPIs expressed in a common currency, $Q_t \equiv \frac{E_t P_t^*}{P_t}$, where E_t is the nominal exchange rate.

Households in each country choose consumption, labor supply and bond holdings to maximize utility. Their optimality conditions for labor supply and domestic bond holdings in log-linearized form are given by

$$w_t - p_t = \phi n_t + \sigma c_t, \tag{2a}$$
$$w_t^* - p_t^* = \phi n_t^* + \sigma c_t^*, \tag{2b}$$
$$\sigma \dot{c}_t = i_t - \pi_t - \rho, \tag{3a}$$
$$\sigma \dot{c}_t^* = i_t^* - \pi_t^* - \rho, \tag{3b}$$

where lower case letters denote logarithms of the respective capital letter variables, $\pi_t \equiv \dot{P}_t / P_t$ is the Home CPI inflation and $\pi_t^* \equiv \dot{P}_t^* / P_t^*$ is the Foreign CPI inflation. (2a) and (2b) are the optimality conditions for households choice of labor supply which equate the marginal disutility of work to the real wage. (3a) and (3b) are the Euler equation for domestic bonds. The remaining conditions are no arbitrage conditions between domestic bonds and international bonds, $i_t = i_{B,t}$ and $i_t^* = i_{B,t}^* - \dot{e}_t$ which combined leads to the following distorted interest parity condition,

$$i_t = i_t^* + \dot{e}_t + \xi_t.$$

International consumption smoothing. Combining the Home household's Euler equation with its Foreign household's counterpart for the international bonds gives an international consumption smoothing condition relating the ratio of marginal utility in both countries to the real exchange rate[2]

$$C_t = \Theta_t Q_t^{\frac{1}{\sigma}} C_t^*, \tag{4}$$

where $\Theta_t \equiv \Theta_0 \exp\left[\frac{1}{\sigma}\int_0^t \xi_s ds\right]$, with Θ_0 being a constant related to initial relative wealth positions. Given our assumption of symmetric initial positions, condition (4) indicates that the marginal utility of nominal wealth for Home and Foreign households are equalized when international bond markets are frictionless. By controlling for Θ_t, the global regulator indirectly controls for international demand imbalances and thus capital flows across countries. The global planner's policy instruments and objective are described in section 2.3. Taking logs on both sides of (4), and taking into account the (first-order accurate) relationship between the real exchange rate and the terms of trade, $q_t = (1-2\alpha)s_t$, we obtain the log-linearlized international consumption smoothing condition

$$\sigma(c_t - c_t^*) = \theta_t + (1-2\alpha)s_t. \tag{5}$$

2.2 Firms

Technology. Firms in Home and in Foreign produce differentiated goods $l \in [0,1]$ with a linear technology: $Y_t(l) = AN_t(l)$, resp. $Y_t^*(l) = A^*N_t^*(l)$, where A and A^* denote productivity parameters normalized to one for convenience. As in Engel (2016), here $N_t(l)$ and $N_t^*(l)$ are CES composite of individual household labor in Home and Foreign, where the elasticity of substitution among varieties of domestic labor in each country ε_t^w, resp. ε_t^{w*}, are stochastic and common to all firms within the country. The variation in wage markups, $\mu_t^w \equiv \frac{\varepsilon_t^w}{\varepsilon_t^w - 1}$ and $\mu_t^{w*} \equiv \frac{\varepsilon_t^{w*}}{\varepsilon_t^{w*}-1}$, are the sources of cost-push shocks that give rise to the well-known trade-off between achieving a zero output gap and stabilizing inflation (see e.g., Clarida, Gali and Gertler, 2002).

Price setting. Firms, which operate under monopolistic competition, engage in infrequent price setting à la Calvo (1983). Each firm has an opportunity to reset its prices when it receives a price-change signal, which itself follows a Poisson process with intensity $\rho_\delta \geq 0$. As a result, a fraction δ of firms receives a price-change signal per unit of time. These firms

[2]In models featuring uncertainty and complete markets, this condition is often labeled as an international risk sharing condition. Notice that (4) bears similarity to what is commonly referred to as the Backus-Smith condition (see Kollmann 1991 and Backus and Smith 1993) in which Θ_t would represent a Pareto weight in a planning problem.

reset their price, $P^r_{H,t}(j)$, to maximize the expected discounted profits

$$\int_t^\infty \rho_\delta e^{-\rho_\delta(k-t)} \frac{\lambda_k}{\lambda_t} \left[P^r_{H,t}(j) - P_{H,k}MC_k\right] Y_{k|t} dk,$$

subject to the demand for their own good, $Y_{k|t} = \left(P^r_{H,t}/P_{H,k}\right)^{-\varepsilon} Y_k$, taking as given the paths of output in the home country Y, the Home PPI P_H, and the real marginal cost MC. The real marginal cost is defined as $MC_k \equiv (1-\tau^N)W_k/(A_k P_{H,k})$, where τ^N is a time-invariant labor subsidy.[3] λ_k denotes Home household's time k marginal utility of consumption, so that the ratio λ_k/λ_t is the firm's relevant discount factor between time t and time k. The pricing environment is symmetric in the foreign country. In the limiting case of flexible prices (i.e. $\rho_\delta \to \infty$), firms are able to reset their prices continuously and optimal pricing setting reduces to $P_{H,t} = (1-\tau^N)\frac{\varepsilon}{\varepsilon-1}W_t$.

2.3 Policy

The global planner sets the cooperative monetary policy by choosing the nominal interest rates i_t and i^*_t on domestic bonds in both countries. She also controls the relative wealth $\{\Theta_t\}_{t\geq 0}$ by introducing distortionnary financial regulations in the international asset market, i.e. setting the path for $\{\xi_t\}_{t\geq 0}$, and determines the date 0 transfer $\mathcal{T}_0$ from Foreign to Home consistent with the chosen path for $\{\Theta_t\}_{t\geq 0}$,

$$\mathcal{T}_0 = \int_0^\infty e^{-\rho t} \left(C^*_t\right)^{1-\sigma} Q_t^{\frac{1}{\sigma}-1} \left[\Theta_t - \left(\frac{P_{H,t}}{P_t}\right)^{1-\eta} \left((1-\alpha)\Theta_t + \alpha Q_t^{\eta-1}\right)\right] dt,$$

to maximize global welfare. The global planner sets of policy instruments is $\{i_t, i^*_t, \Theta_t, \mathcal{T}_0\}$.

2.4 Equilibrium Dynamics

Given a specification of monetary and capital flow management policy, an equilibrium is a constellation where all households and firms optimize while markets clear.

[3] As is standard in the New Keynesian literature, we assume that this subsidy is set at the level that would be optimal in a steady state with flexible prices. This subsidy can thus be thought of as offsetting long-run distortions stemming from monopolistic competition.

Output determination. Market clearing for a good l produced in Home requires that the supply of the good equals the sum of the demand emanating from Home and Foreign:

$$Y_t(l) = \underbrace{(1-\alpha)\left(\frac{P_{H,t}(l)}{P_{H,t}}\right)^{-\varepsilon}\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t}_{C_{H,t}(l)\text{: Home demand for Home variety } l} + \underbrace{\alpha\left(\frac{P_{H,t}(l)}{P_{H,t}}\right)^{-\varepsilon}\left(\frac{P_{H,t}}{P_t^*}\right)^{-\eta} C_t^*}_{C_{H,t}^*(l)\text{: Foreign demand for Home variety } l} . \tag{6}$$

At the level of Home's aggregate output, market clearing requires

$$Y_t = \left(\frac{P_{H,t}}{P_t}\right)^{-\eta}\left[(1-\alpha)\,C_t + \alpha Q_t^{\eta} C_t^*\right].$$

A first order approximation of this condition around the symmetric steady state yields the following log-linear expression:

$$y_t = (1-\alpha)\left[c_t + \alpha\eta s_t\right] + \alpha\left[c_t^* + (1-\alpha)\eta s_t\right]. \tag{7a}$$

Similarly, the log-linearized Foreign goods market clearing condition is given by

$$y_t^* = (1-\alpha)\left[c_t^* - \alpha\eta s_t\right] + \alpha\left[c_t - (1-\alpha)\eta s_t\right]. \tag{7b}$$

These expressions indicate that output in each country depends on consumption in Home and Foreign, as well as on the terms of trade: a terms of trade improvement for Home (i.e., a decrease in s_t) raises output in Foreign at the expense of output in the core via the expenditure switching channel.

Combining the consumption smoothing relation (5) with the market clearing conditions (7a) and (7b) yields an expression for the equilibrium terms of trade:

$$\sigma(y_t - y_t^*) = \omega s_t + (1-2\alpha)\sigma\theta_t, \tag{8}$$

for $\omega \equiv \sigma\eta - (\sigma\eta - 1)(1-2\alpha)^2 > 0$.The expression indicates that output is relatively higher in the country which has less favorable terms of trade or, in the presence of home bias in consumption, in the country benefiting from a demand imbalance. In the absence of home bias (i.e., when $\alpha = 1/2$), since the composition of consumption is identical across the two countries, (consumption) demand imbalances do not translate into output differences. Combining the budget constraints of households, firms, as well as the condition relating the equilibrium terms of trade and the relative output (8), we arrive at the trade balance condition:

$$nx_t = \frac{\omega - 1}{2\sigma} s_t - \alpha\theta_t. \tag{9}$$

which says that the effects of an appreciated terms of trade on the trade balance depends on the relative importance of the elasticities of substitution across goods (η) and across time ($1/\sigma$). Furthermore, a positive demand imbalance ($\theta_t > 0$) is associated with capital inflows (i.e., negative net exports).

Denoting aggregate output in the Home as $Y_t \equiv \left[\int_0^1 Y_t(l)^{(\varepsilon-1)/\varepsilon} dl\right]^{\varepsilon/(\varepsilon-1)}$, aggregate employment relates to aggregate output according to $N_t \equiv \int_0^1 N_t(l)dl = Y_t Z_t$, where $Z_t \equiv \int_0^1 (P_t(l)/P_t)^{-\varepsilon} dl$. Since equilibrium variations in $z_t \equiv \ln Z_t$ around the steady state are of second order, up to a first order approximation, the relationships between aggregate employment and output is given by:

$$n_t = y_t, \quad \text{and} \quad n_t^* = y_t^*. \tag{10}$$

Inflation and marginal costs. Under our Calvo price setting assumption, up to a first-order approximation, the dynamics of PPI inflation in terms of the real marginal cost in each region are described by

$$\dot{\pi}_{H,t} = \rho\pi_{H,t} - \kappa\widehat{mc}_t, \tag{11a}$$

$$\dot{\pi}_{F,t}^* = \rho\pi_{F,t}^* - \kappa\widehat{mc}_t^*. \tag{11b}$$

where $\kappa \equiv \rho_\delta(\rho + \rho_\delta)$, and $\widehat{mc}_t$ (resp. $\widehat{mc}_t^*$) denotes the log deviation of the real marginal cost from its steady state value. Using the aggregate production functions (10) and the labor supply equations (2a), these are given by

$$\widehat{mc}_t = (\sigma + \phi)y_t - \frac{\omega - 1}{2} s_t + \alpha\sigma\theta_t + u_t, \tag{12a}$$

$$\widehat{mc}_t^* = (\sigma + \phi)y_t^* + \frac{\omega - 1}{2} s_t - \alpha\sigma\theta_t + u_t^*. \tag{12b}$$

Intuitively, the real marginal cost (measured in units of the domestic good) depends negatively on productivity, positively on the marginal rate of substitution between consumption and leisure and negatively on the terms of trade.[4] However, since the equilibrium marginal

[4] That is to say, an improvement in a country's terms of trade lowers its producers' marginal cost. A terms of trade improvement raises the price of the domestic good relative to that of the consumption basket. Noting that $p_t = p_{H,t} + \alpha s_t$, the labor supply equation (2a) implies that the real wage expressed in terms of the domestic good must be equal to $w_t - p_{H,t} = \phi n_t + \sigma c_t + \alpha s_t$, so that the real marginal cost is given by $\widehat{mc}_t = \phi n_t + \sigma c_t - a_t + \alpha s_t$.

rate of substitution itself depends ambiguously on the terms of trade (controlling for output and relative consumption), the relationship between the terms of trade and the marginal cost is a priori ambiguous. Finally, controlling for output and the terms of trade, higher relative consumption in a country raises its residents' marginal rate of substitution and thus increases the marginal cost.[5] The cost-push shocks, $u_t \equiv \mu_t^w - \mu^w$ and $u_t^* \equiv \mu_t^{w*} - \mu^w$, are deviations of wage markups from their steady state value.

2.5 World and Difference formulation

Before studying the optimal policy response to asymmetric cost-push shocks, it is convenient to rewrite the dynamics of output and inflation in both regions in "world" and "difference" format. For any variables ζ_t and ζ_t^*, we have defined "world" and "difference" values as: $\zeta_t^W = 0.5(\zeta_t + \zeta_t^*)$ and $\zeta_t^D = 0.5(\zeta_t - \zeta_t^*)$. Combining PPI inflation dynamics (11a)-(11b) in gaps yields both the world New-Keynesian Phillips curves and the New-Keynesian Phillips curves in difference

$$\dot{\pi}_t^W = \rho \pi_t^W - \kappa(\sigma + \phi) y_t^W - \kappa u_t^W, \tag{13}$$

$$\dot{\pi}_t^D = \rho \pi_t^D - \kappa \left[(\sigma + \phi) y_t^D - \frac{\omega - 1}{2} s_t + \alpha \sigma \theta_t \right] - \kappa u_t^D. \tag{14}$$

where y_t and y_t^* represents the output gap in Home and the Foreign. We also note that the equilibrium terms of trade expression (8) can be written as

$$2y_t^D = \frac{\omega}{\sigma} s_t + (1 - 2\alpha)\theta_t. \tag{15}$$

This relationship reveals that a more positive output gap in Home than in Foreign can arise for two reasons. On the one hand, an appreciated terms of trade $s_t < 0$ shifts demand away from Home goods towards Foreign goods, leading to a negative output gap differential. On the other hand, to the extent that there is some home bias in preferences ($\alpha < 0.5$), a positive demand gap raises demand more of the Home good than for the foreign good.

[5] Note that for Home, improved terms of trade correspond to a lower s_t while a higher relative consumption corresponds to a higher θ_t. In contrast, for Foreign, improved terms of trade correspond to a higher s_t while a higher relative consumption corresponds to a lower θ_t.

3 Capital flows, exchange rate and macro adjustment

Equipped with the model just presented, we now analyze to what extent trade imbalances and international relative prices movements foster the adjustment to an asymmetric cost-push shock. In order to focus on capital flows and currency misalignments unrelated to suboptimal monetary policy, we assume that monetary policy is set cooperatively under commitment. It turns out that even with the best monetary policy available, capital flows are constrained inefficient following an uneven inflationary shock. For plausible parameter values, capital flows amplify distortions associated with undesirable relative price movements and worsen the cross-country output-inflation trade-off.

Asymmetric cost-push shock scenario To dissect the stabilizing (or destabilizing) properties of capital flows and international relative price movements associated with uneven inflationary pressures, we focus on the adjustment to an unanticipated temporary asymmetric cost-push shock, starting from the symmetric steady state of the model. For concreteness, suppose that Home is subject to an inflationary cost-push shock such that $u_t = 2\bar{u} > 0$ for some $\bar{u} > 0$ for $t \in [0, T)$ and $u_t = 0$ for $t \geq T$, while Foreign is not hit by any shock (i.e., $u_t^* = 0$ for $t \geq 0$). In terms of the "world" and "difference" shocks appearing in (13) and (14), we therefore have

$$u_t^W = u_t^D = \begin{cases} \bar{u} > 0 & \text{for} \quad t \in [0, T) \\ 0 & \text{for} \quad t \geq T. \end{cases} \tag{16}$$

As is well known, monetary policy will not able to perfectly stabilize all variables under this scenario. Instead, it will trade off several distortions. The novelty of our analysis is to precisely nail down how capital flows come into play in the resolution of these trade-offs.

3.1 Welfare-based loss function

To capture the various trade-offs to be resolved by optimal monetary and (possibly also) by capital flow management policy, we use a standard welfare-based loss function. To obtain this loss function, we take a second-order approximation of a symmetrically weighted average of households' utilities in Home and Foreign (see Appendix A).[6] The instantaneous

[6] Given equal country sizes, our adoption of equal welfare weight can be interpreted as an implicit assumption of perfect insurance with respect to the risk of the cost-push shock scenario described above.

loss function is given by

$$\mathbb{L} = \left[(\sigma+\phi)(y_t^W)^2 + \frac{\varepsilon}{\kappa}(\pi_t^W)^2\right] + \left[(\sigma+\phi)(y_t^D)^2 + \frac{\varepsilon}{\kappa}(\pi_t^D)^2\right] \\ + \alpha(1-\alpha)(1-\sigma\eta)\eta(s_t)^2 + \sigma\alpha(1-\alpha)\left(\theta_t - (\sigma\eta-1)(1-2\alpha)\sigma^{-1}s_t\right)^2 \tag{17}$$

where the output gap and inflation are again expressed in "world" and "difference" forms. The first two terms in (17) featuring squared output gaps and inflation reflect sticky price distortions familiar from the closed economy literature. The third and fourth terms, reflecting distortions specific to the open economy context, captures welfare losses stemming from an inefficient cross-country distribution of consumption potentially caused by two factors: the demand imbalance θ_t and the terms of trade gap s_t. The later factor, however, disappears in an important special case where the intra-temporal elasticity is equal to the inter-temporal elasticity ($\eta = 1/\sigma$).

Normative research in new open-economy macroeconomics (e.g., Corsetti et al. 2010) has traditionally taken the demand imbalance term θ_t as exogenous – either equal to zero under complete markets or responding to shocks under incomplete markets – and studied how monetary policy should strike a balance between the remaining variables in (17). Our approach, in contrast, is to ask whether actively managing the demand imbalance θ_t may be desirable in a context where it could otherwise be left at zero. As a result, we will show that a free capital flow regime ($\theta_t = 0$ for all t) is not constrained efficient, as defined below.

Definition 1 (Constrained Efficiency)**.** Let $\{\pi_t^W, \pi_t^D, y_t^W, y_t^D, s_t\}_{t\geq 0}$, be the output gaps, inflations and terms of trade chosen by a global planner subject to $\theta_t = 0$ for all t which yields a loss $\widehat{\mathbb{L}}$. The free capital flow regime is constrained efficient if a global planner that chooses $\{\pi_t^W, \pi_t^D, y_t^W, y_t^D, s_t, \theta_t\}_{t\geq 0}$ cannot reduce the loss function below $\widehat{\mathbb{L}}$.

3.2 Optimal monetary policy

Following the asymmetric cost-push shock, monetary policy faces trade-offs: It optimally engineers a larger recession in Home than in Foreign, accompanied by a temporarily appreciated terms of trade.

The optimal monetary policy problem consists in choosing a path for the welfare relevant output gaps y_t^W, y_t^D, inflation π_t^W, π_t^D, and terms of trade s_t, to minimize the present value of the loss (17), subject to the NKPCs (13), (14), and the equilibrium terms of trade expression (15).[7] For a formal statement of the problem, see Appendix B.1.

The following proposition characterizes the optimal monetary policy.

Proposition 1 (Optimal monetary policy)**.** *Monetary policy is characterized by the following targeting rules:*

$$y_t^W + \varepsilon(p_t^W - p_0^W) = 0 \tag{18}$$
$$y_t^D + \varepsilon(p_t^D - p_0^D) = 0 \tag{19}$$

Proof. See Appendix B.1. □

Our characterization of optimal monetary policy is standard and analogous to that encountered for open-economy models in the literature. It strikes a balance between losses from inflation and losses from deviations of output and the terms of trade from their efficient level.

The two targeting rules (18) and (19) can be combined to deliver targeting rules for each country that only depend on the domestic output gap and inflation, i.e., $y_t + \varepsilon(p_t - p_0) = 0$ and $y_t^* + \varepsilon(p_t^* - p_0^*) = 0$, a feature referred to as *inward looking* monetary policy in the NOEM literature. As we shall see, under free capital mobility and assuming unitary elasticities ($\sigma = \eta = 1$), this feature will result in the Foreign output gap and inflation to be fully insulated from the Home cost-push shock, a feature sometimes referred to as *insularity* in the literature.

The targeting rules (18) and (19) lead us to one observation, summarized in the corollary below, which helps us narrow down the role played by capital flow in the macroeconomic adjustment.

Corollary 1 (Irrelevance of capital flow regime for world variables)**.** *The paths of world output gap y_t^W and world inflation π_t^W following the cost-push shock are independent of the capital flow regime (i.e., of the path of θ_t).*

Proof. See Appendix B.2 □

This observation follows directly from combining the "world" NKPC (13) with the "world" monetary policy targeting rule (18) and means that capital flows only matter for the determination of cross-country "difference" variables and the terms of trade.[8]

[7] Implicitly, in line with the literature, we assume that the policymaker has access to a date 0 transfer so the optimal policy problem reflects efficiency rather than a mix of efficiency and redistributive considerations.

[8] See Groll and Monacelli (2020) for a similar result regarding the irrelevance of the exchange rate regime.

Therefore, both from a positive and normative standpoint, an analysis of the role played by capital flows in the adjustment to the cost-push shock can legitimately center on the dynamics of cross-country difference variables y_t^D, π_t^D and external variables s_t and θ_t.

3.3 Macroeconomic adjustment under free capital flows

To develop intuition about the shortcomings of a free capital mobility regime, it is useful to go over the forces and trade-offs shaping the world economy's adjustment to the cost-push shock. Conveniently, our deterministic, continuous time formulation affords us a sharp graphical characterization of this adjustment.

In a free capital mobility regime, $\theta_t = 0\ \forall t \geq 0$. Accounting for this fact when substituting the equilibrium terms of trade expression (15) into the NKPC in difference (14) yields a dynamic equation for the cross-country difference in inflation as a function of itself and the difference in the output gap:

$$\dot{\pi}_t^D = \rho \pi_t^D - \kappa \left(\frac{\sigma}{\omega} + \phi \right) y_t^D - \kappa u_t^D. \tag{20}$$

Meanwhile, differentiating the targeting rule (19) with respect to time yields a dynamic equation for the cross-country difference in the output gap as a function of the cross-country difference in inflation:

$$\dot{y}_t^D = -\varepsilon \pi_t^D. \tag{21}$$

(20) and (21) form a dynamical system in π_t^D and y_t^D whose solution encapsulates the dynamics of the cross-country block of the model. π_t^D is a jump variable, and although y_t^D could in principle jump , under the optimal plan it is predetermined at $y_0^D = 0$.[9] The system is thus saddle-path stable and the solution can be conveniently represented with the help of a phase diagram. The $\dot{y}_t^D = 0$ locus is described by $\pi_t^D = 0$, while the $\dot{\pi}_t^D = 0$ locus is described by $\rho \pi_t^D = \kappa \left(\frac{\sigma}{\omega} + \phi \right) y_t^D + \kappa u_t^D$. Given our shock scenario, in the (y_t^D, π_t^D) space, the $\dot{y}_t^D = 0$ locus is therefore always a flat line at 0, while the $\dot{\pi}_t^D = 0$ is an upward sloping straight line with slope $\kappa \left(\frac{\sigma}{\omega} + \phi \right) / \rho$ and intercept $\kappa \bar{u} / \rho > 0$ in the short-run (i.e., for $t \in [0, T)$) and intercept 0 in the long-run (i.e., for $t \geq T$).

The loci are represented in Figure 1, where y_t^D rises (diminishes) south (north) of the $\dot{y}_t^D = 0$ locus and π_t^D rises (diminishes) west (east) of the $\dot{\pi}_t^D = 0$ locus. The fictional saddle-path associated with the system being permanently governed by the short-term loci

[9] The co-state variable φ_t^D is backward looking with an initial condition $\varphi_0^D = 0$, and both y_t^D and s_t are proportional to φ_t^D (see equations (A.20), (A.24) and (A.25) with $\theta_t = 0\ \forall t$).

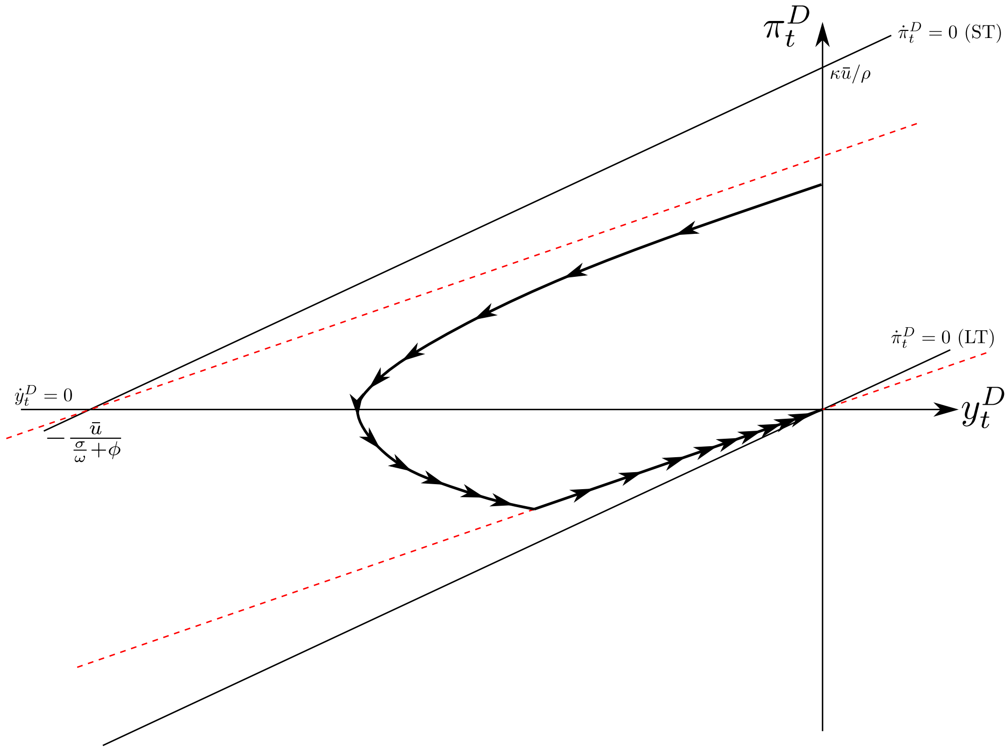

Figure 1: Macroeconomic adjustment under free capital flows.
Note: (ST) denotes short-term $\dot{\pi}_t^D = 0$ locus, (LT) denotes long-term $\dot{\pi}_t^D = 0$ locus.

is represented by the dotted upward sloping line, while that associated with the system being permanently governed by the long-term loci is represented by the dashed upward sloping line. The actual saddle path is represented by the thick curve with arrows.

The inflationary cost-push shock in Home naturally drives a cross-country difference in inflation up on impact. But the initial jump in the inflation difference is limited by monetary policy's commitment to generate a more negative output gap in Home than in Foreign in the future, with the difference in the output gap displaying a hump shape. To support this path for the output gap differential, the terms of trade gap needs to follow a similar hump shape, indicating persistently (misaligned and) appreciated terms of trade throughout the episode.

The terms of trade path depicted in Figure 1 maps into different patterns of capital flows depending on the value of the elasticities. From expression (9) with a zero demand imbalance, the trade balance is proportional to the terms of trade and given by

$$nx_t = 2\alpha\left(1-\alpha\right)\left(\sigma\eta - 1\right)s_t. \tag{22}$$

This leads us to the following proposition:

Proposition 2 (Capital flows under free capital mobility)**.** *Consider an inflationary cost-push shock in Home. Under free capital flows, if $\eta > 1/\sigma$ Home experiences capital inflows, and if $\eta < 1/\sigma$ Home experiences capital outflows. Finally, if $\eta = 1/\sigma$ there are no capital flows.*

The mechanism underlying these capital flow patterns are well understood.[10] When the intra-temporal elasticity is high (i.e. $\eta > 1/\sigma$), relative price movements are muted, and export revenues in consumption term drop following a terms of trade appreciation. When the intra-temporal elasticity is low, the opposite happens: relative price movements are strong and make export revenues rise in response to a terms of trade appreciation. Finally, when the intra-temporal elasticity equal to the inter-temporal one, export revenues are perfectly insulated from terms of trade movements.

The above characterization illustrates that unlike the terms of trade, which is necessarily excessively appreciated during the episode, capital might flow too much into Home, too much out of of Home, or be at the right level, relative to its efficient benchmark of zero. We next ask where capital flows stand, not relative to a hypothetical efficient allocation, but relative to a constrained efficient benchmark where labor supply, price setting and consumption allocation decisions are left to individual agents but a planner is in charge of saving/borrowing decisions.

4 Inefficiency of the free capital mobility regime

The regime of free capital mobility just described happens to generically be *constrained inefficient*. A constrained efficient capital account regime would account for two aggregate demand externalities associated with external borrowing: one operating via marginal costs and altering the central bank's output-inflation trade-off, and one influencing welfare losses from exchange rate misalignments.

To study constrained efficiency of the free capital mobility regime, we make the demand imbalance θ_t a choice variable of the optimizing policy maker and seek to understand under which circumstances θ_t is set to values different from zero. Hence, the optimal policy problem now consists in choosing a path for the welfare relevant output gaps y_t^W, y_t^D, inflation π_t^W, π_t^D, terms of trade s_t *and* demand imbalance θ_t to minimize the present discounted value of the loss (17), subject to the NKPCs (13), (14) and the equation relating the cross-country difference in the output gaps with the terms of trade (15).[11]

[10] See, for instance, Bianchi and Coulibaly (2021) who highlight the role of these two elasticities in driving the current account response to a monetary policy shock.

[11] See Appendix B.1 for a formal statement of the problem.

In addition to the targeting rules associated with monetary policy, (18) and (19), optimal policy now also pertains to an additional margin.

Proposition 3 (Optimal capital flow management)**.** *The optimal capital flow regime is characterized by the targeting rule*

$$\theta_t = \underbrace{\left[1 - \frac{1-2\alpha}{2(1-\alpha)\eta\sigma}\right]}_{\equiv\psi} 2y_t^D. \tag{23}$$

with the initial condition $\theta_0 = y_0^D = 0$.

Proof. See Appendix B.3 □

The coefficient ψ governing how the demand imbalance is optimally managed in response to movements in the cross-country difference in the output gap is a complex composite function of the model's deep parameters, suggesting that multiple forces are at play in the optimal capital account regime. Yet, the targeting rule (23) can be helpful to understand the pervasiveness of the inefficiencies plaguing the free capital mobility regime, and to associate these to two key externalities. We organize the discussion of these insights around the corollary below.

Corollary 2 (Constrained inefficiency of free capital flows)**.** *Except in knife-edge cases where*

$$\underbrace{2(1-\alpha)\eta}_{\text{Trade elasticity}} = \underbrace{(1-2\alpha)}_{\text{Home-Bias}} \times \underbrace{\frac{1}{\sigma}}_{\text{IES}} \tag{24}$$

the free capital mobility regime is not constrained efficient.

Since a persistently negative cross-country difference in the output gap y_t^D was shown in Section 3 to be a necessary feature of the world economy's adjustment to an asymmetric cost-push shock under free capital flows, (23) indicates that the free capital mobility regime can only be optimal if the composite parameter ψ is equal to zero.[12] While this condition holds for combinations of the model's deep parameters satisfying $2(1-\alpha)\eta = (1-2\alpha)/\sigma$, it does not hold generally, and neither does it hold for special cases commonly studied in the literature. In particular, it does not hold for a special parametrization popularized by

[12]Strictly speaking, the negativity of y_t^D following the shock was only established for the free capital mobility regime. However, an analogous argument applies for the constrained efficient capital account regime.

Cole and Obstfeld (1991) and known to deliver knife-edge results regarding capital flows and international spillovers in open-economy macroeconomic models, and neither does it hold in the absence of home bias. Indeed, in the Cole-Obstfeld case, $\psi = 1/[2(1-\alpha)] > 0$, while without home biais, $\psi = 1$. Furthermore, the fact that the condition only holds for knife-edge cases suggests multiple, potentially competing motives of inefficiency.

Another important implication of Proposition 3 is that even with the Cole-Obstfeld parametrization (unitary inter- and intra-temporal elasticities) where countries are insular to movements in terms-of-trade the free capital mobility regime is not constrained efficient. This result entails several novel insights. First, constrained inefficiency of the free capital mobility regime is unrelated to the notion insularity. In particular, insularity (i.e., absence of monetary policy spillovers on other countries' inflation and output) is not an indication that international capital markets promote a desirable allocation of resources. Second, international capital flows can be constrained inefficient even when they are efficient. Indeed, when $\sigma\eta = 1$ the trade balance is zero at all times under free capital mobility, as it is in the socially optimal allocation, but it is not zero in the constrained efficient allocation.

4.1 Constrained efficient capital flows

What do constrained efficient capital flows look like? Substituting the targeting rule (23) into the net exports expression (9), we obtain

$$nx_t = -\frac{\alpha}{\sigma} s_t. \tag{25}$$

Comparing this expression with (22) reveals that capital flows in a constrained efficient regime follow a drastically different pattern than their counterparts in a free capital mobility regime.

Proposition 4 (Capital flows under constrained efficient regime)**.** *Consider an inflationary cost-push shock in Home. Under the constrained efficient capital account regime, Home necessarily experiences capital outflows (i.e., $nx_t > 0 \; \forall t > 0$).*

This result follows from combining the trade balance expression (25) with the fact that the terms of trade gap is persistently negative following the cost-push shock in Home (i.e., the terms of trade is persistently appreciated). A comparison of the characterization of capital flows under the free capital mobility regime (provided in Proposition 2) with that under the constrained efficient regime given in Proposition 4 suggests dysfunctionalities in external borrowing that go well beyond inefficiencies at the margin. Indeed, in the empirically plausible case where $\eta > 1/\sigma$, Home experiences capital inflows under free capital mobility but capital outflows under the constrained efficient regime. In other words, capital flows are *topsy-turvy* under free capital mobility.

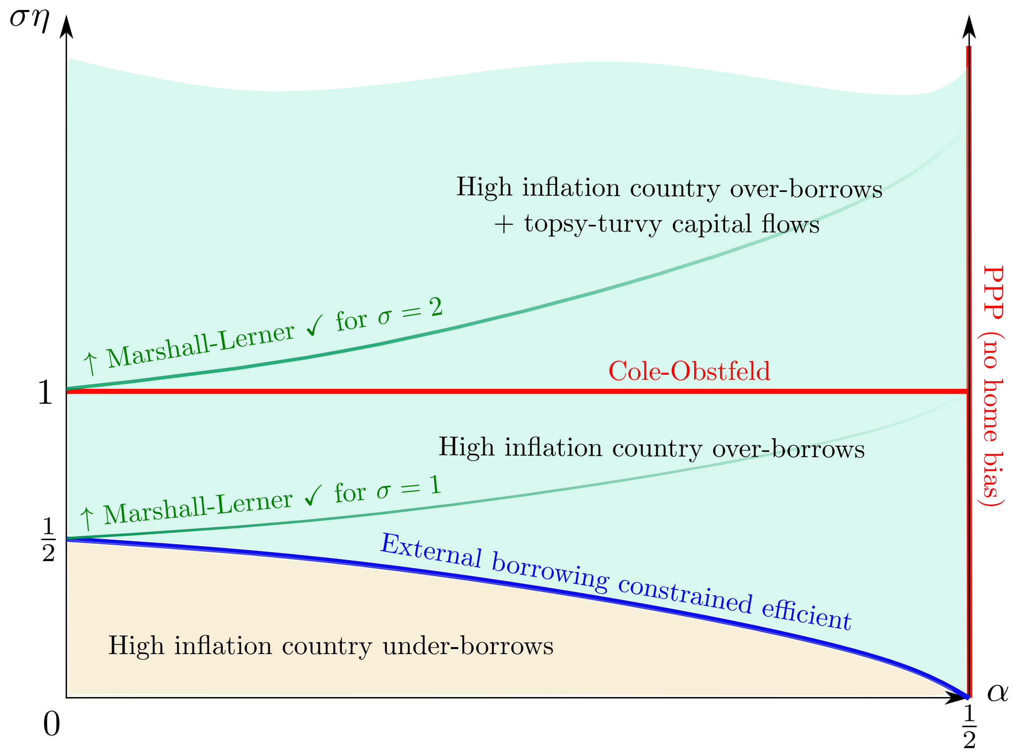

Figure 2: Characterization of capital flows in free capital mobility regime vs. optimal CFM

4.2 Decentralization with taxes on capital flows

So far we have drawn insights on optimal capital management policies based on a general notion of financial regulations captured by a wedge in the international risk-sharing condition. But as much as characterizing the optimal behavior of wedges can be enlightening, for some purposes it is equally useful to know how the planner can decentralize the desired outcome. In particular, characterizing the decentralization of the constrained efficient capital flow regime via taxes on capital flows allows us to relate the uncovered inefficiencies to the well established concepts of over- and under-borrowing and tie these with externalities.

Consider the global planner levies a tax τ_t on Home households' borrowing and a tax τ_t^* on Foreign households' borrowing. The effective interest rate on international borrowing faced by Home households is then given by $i_{B,t} = \underline{i}_t + \tau_t$ and the effective interest rate faced by Foreign households is $i^*_{B,t} = i_t + \tau^*_t$. By the consumption risk-sharing condition (4), the tax differential τ^D_t can be expressed as $2\tau^D_t = \sigma\dot{\theta}_t$. This implies that the optimal tax on capital flows can be derived directly from the targeting rule (23) and is given by

$$\tau^D_t = \Big[2(1-\alpha)\eta\sigma - (1-2\alpha)\Big]\pi^D_t. \tag{26}$$

Hence, the high inflation country over-borrows (i.e., $\mathrm{sign}(\tau^D_t) = \mathrm{sign}(\pi^D_t)$) when the trade elasticity, $2(1-\alpha)\eta$, is larger than the produce of the intertemporal elasticity of substitution and the home bias, $(1-2\alpha)/\sigma$. Conversely, the high inflation country under-borrows when the trade elasticity is larger than the intertemporal elasticity of substitution times the home bias. Finally, there is neither over- nor under-borrowing ($\tau^D_t = 0$) when (24) holds.

4.3 Insights from special cases

Two special cases allow us to trace back the constrained inefficiency of the free capital mobility regime to an aggregate demand externality operating through firms' margin costs. In the optimal capital flow management regime, this externality is internalized and the central bank faces an improved output-inflation trade-off thanks to a more favorable relative consumption profile.

Cole-Obstfeld parametrization ($\sigma\eta = 1$). This special case presents interest for several reasons. First, it has been widely studied. Second, because it has well known unique properties, it offers sharp insights into the causes of the constrained inefficiency of the free capital mobility regime. With $\sigma\eta = 1$, the terms of trade terms drop out of the loss function (17) and, leaving aside "world" terms (which are independent of the capital flow regime), the only terms remaining are

$$(\sigma+\phi)(y^D_t)^2 + \frac{\varepsilon}{\kappa}(\pi^D_t)^2 + \sigma\alpha(1-\alpha)\,(\theta_t)^2.$$

Meanwhile, the NKPC (14) is given by

$$\dot{\pi}^D_t = \rho\pi^D_t - \kappa\left[(\sigma+\phi)\,y^D_t + \alpha\sigma\theta_t\right] - \kappa u^D_t.$$

Given convex welfare losses, from a distortions management perspective, it optimal for policy to try to contain inflation through downward pressure on marginal costs via both the output gap y^D_t *and* the demand imbalance θ_t, rather than via the output gap alone. This requires distorting capital flows. According to the targeting rule (23), striking a balance

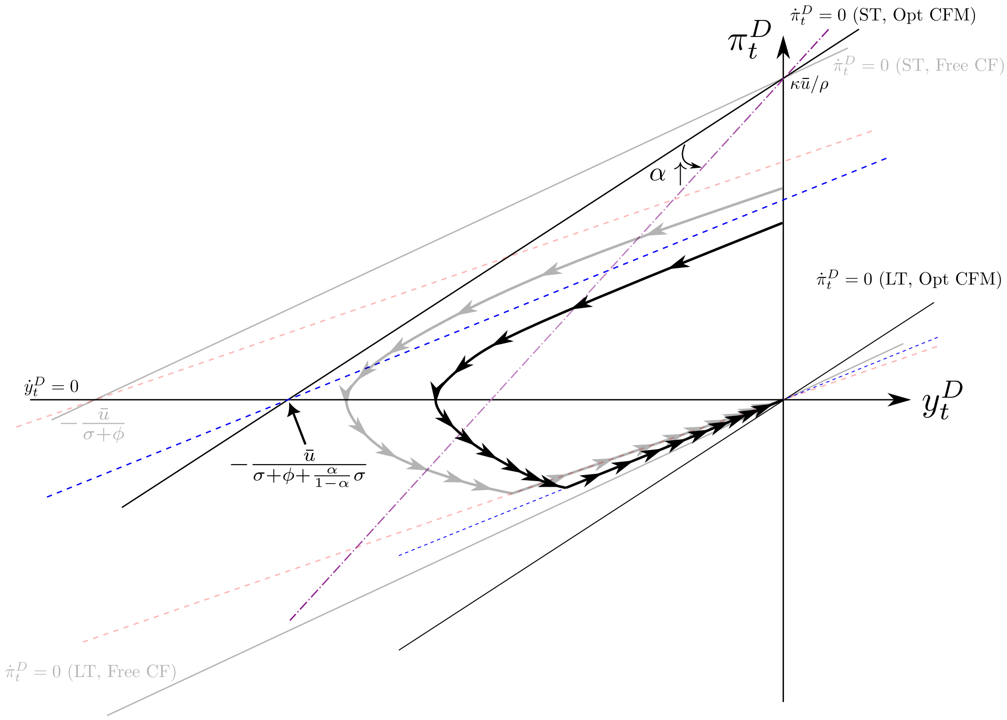

Figure 3: Macroeconomic adjustment under optimal CFM vs free capital flows for $\sigma\eta = 1$.
Note: (ST) denotes short-term $\dot{\pi}_t^D = 0$ locus, (LT) denotes long-term $\dot{\pi}_t^D = 0$ locus.

between distortions emanating from the output gap and the demand imbalance requires setting $\theta_t = y_t^D/(1-\alpha)$. Hence, the demand imbalance should take the same sign as the cross-country difference in the output gap at any instant. Meanwhile, from (26), the optimal tax differential is simply given by $\tau_t^D = \pi_t^D$, indicating over-borrowing by the high-inflation country. Using this targeting rule to substitute out θ_t, the NKPC becomes

$$\dot{\pi}_t^D = \rho\pi_t^D - \kappa\left(\sigma + \phi + \frac{\alpha}{1-\alpha}\sigma\right)y_t^D - \kappa u_t^D,$$

where the gray term reflects the contribution of the optimally managed demand imbalance term, which would be absent under free capital mobility. Figure 3 contrasts the adjustment process in the optimal capital flow management regime with that of the free capital mobility regime, again using with a phase diagram in the (y_t^D, π_t^D). In the figure, the $\dot{\pi}_t^D = 0$ loci are steeper when capital flows are managed optimally, indicating a more favorable output-inflation trade-off. Furthermore, this is more the case, the lower the degree of home bias (i.e., the higher α).

Two additional special features of this Cole-Obstfeld case present valuable insights. First, the fact that the optimal capital flow management regime entails flows even when the free capital mobility regime does not reveals that there is nothing wrong per se with capital flowing across countries in response to asymmetric cost-push shocks. Rather, it is suggestive that price signals conveyed in international financial markets do not reflect the social value of financial flows. Second, the fact that the free capital mobility regime is constrained inefficient in a constellation known for its absence of monetary policy spillovers on output and inflation clarifies that the inefficiency is unrelated to the correction or internalization of such spillover effects.

PPP or no home bias ($\alpha = 1/2$). This special case, on which the early NOEM literature almost exclusively focused (see, e.g., Corsetti and Pesenti 2001, Clarida et al. 2002 or Benigno and Benigno 2003), also deserves some interest. With $\alpha = 1/2$, the demand imbalance disappears from the equilibrium terms of trade expression (15) and the terms of trade is proportional to the cross-country difference in the output gap. Again leaving aside the "world" terms, the loss function (17) reduces to

$$\frac{\varepsilon}{\kappa}\left(\pi_t^D\right)^2 + \left(\phi + \frac{1}{\eta}\right)\left(y_t^D\right)^2 + \sigma\frac{1}{4}\left(\theta_t\right)^2,$$

and the NKPC (14) is given by

$$\dot{\pi}_t^D = \rho\pi_t^D - \kappa\left[\left(\phi + \frac{1}{\eta}\right)y_t^D + \alpha\sigma\theta_t\right] - \kappa u_t^D.$$

Similar to the Cole-Obstfeld case, spreading the burden of containing inflation through keeping marginal costs low via both the cross-country differential in the output gap and the demand imbalance is more attractive than doing so via the output gap alone. According to the targeting rule (23), this requires setting $\theta_t = 2y_t^D$, indicating that the demand imbalance is exactly set equal to cross-country difference the output gap in the optimal capital flow management regime. Furthermore, from (26), the optimal tax differential is given by $\tau_t^D = \eta\sigma\pi_t^D$, again indicating over-borrowing by the high-inflation region. Substituting out θ_t, the NKPC (14) becomes

$$\dot{\pi}_t^D = \rho\pi_t^D - \kappa\left(\phi + \frac{1}{\eta} + \sigma\right)y_t^D - \kappa u_t^D$$

where the gray term again reflects the contribution of the optimally managed demand imbalance term, which would simply be absent under free capital mobility. Figure 4 again contrasts the adjustment processes under the optimal vs free capital flow regimes. There, it is visible that the $\dot{\pi}_t^D = 0$ loci are steeper when capital flows are managed optimally, again

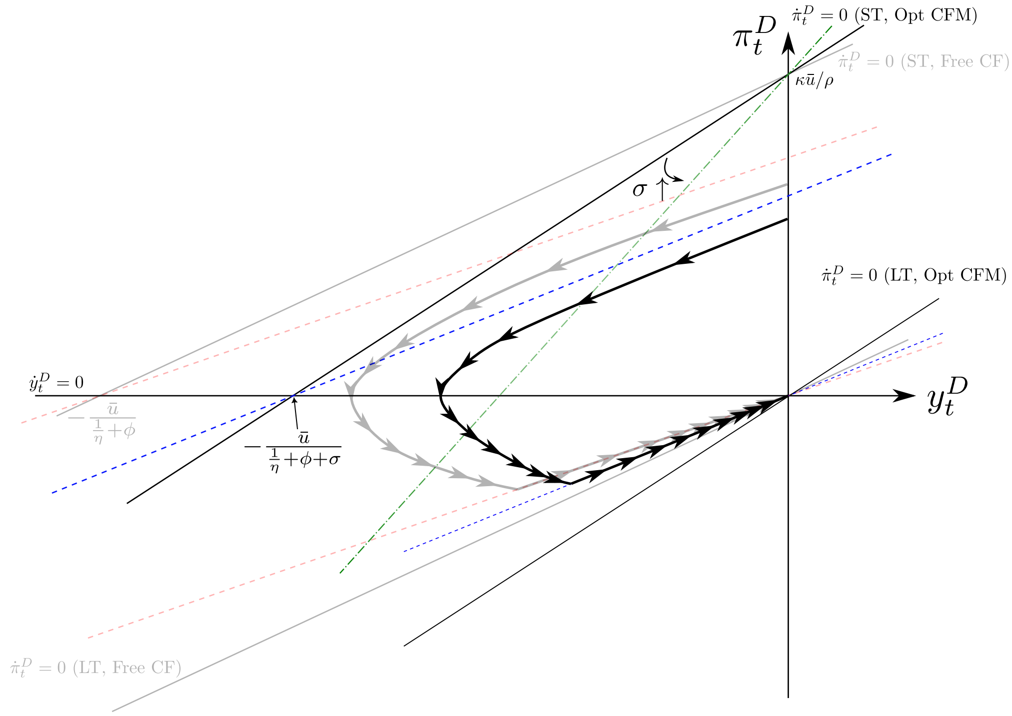

Figure 4: Macroeconomic adjustment under free capital flows for PPP case (for $\alpha = 1/2$).
Note: (ST) denotes short-term $\dot{\pi}_t^D = 0$ locus, (LT) denotes long-term $\dot{\pi}_t^D = 0$ locus.

suggesting an improved output-inflation trade-off under that regime.

4.4 Numerical illustration

We now turn to simulating the impulse response to an asymmetric cost-push shock to give more insights on how the macroeconomic adjustments plays out. We follow Farhi and Werning (2012) by setting $\rho = 0.04$, $\delta = 0.75$, $\varepsilon = 6$ and report results for an intermediate degree of openness $\alpha = 0.2$, somewhere between the degree of openness of Brazil where the ratio of imports to GDP is close to 15% and that of India where the ratio of imports to GDP is close to 30%. We consider the special case in which preferences are linear in leisure and set the Frisch elasticity of labor supply $\phi = 0$ to zero. As a benchmark, we set $\eta = 2.5$ which implies a trade elasticity of 4 in the range of the estimates by Simonovska and Waugh (2014).[13] We hit the economy with a 10 percent cost-push shock with a life of 2 years.

[13] Simonovska and Waugh (2014) found a range of the estimates for the trade elasticity between 2.69 and 4.47.

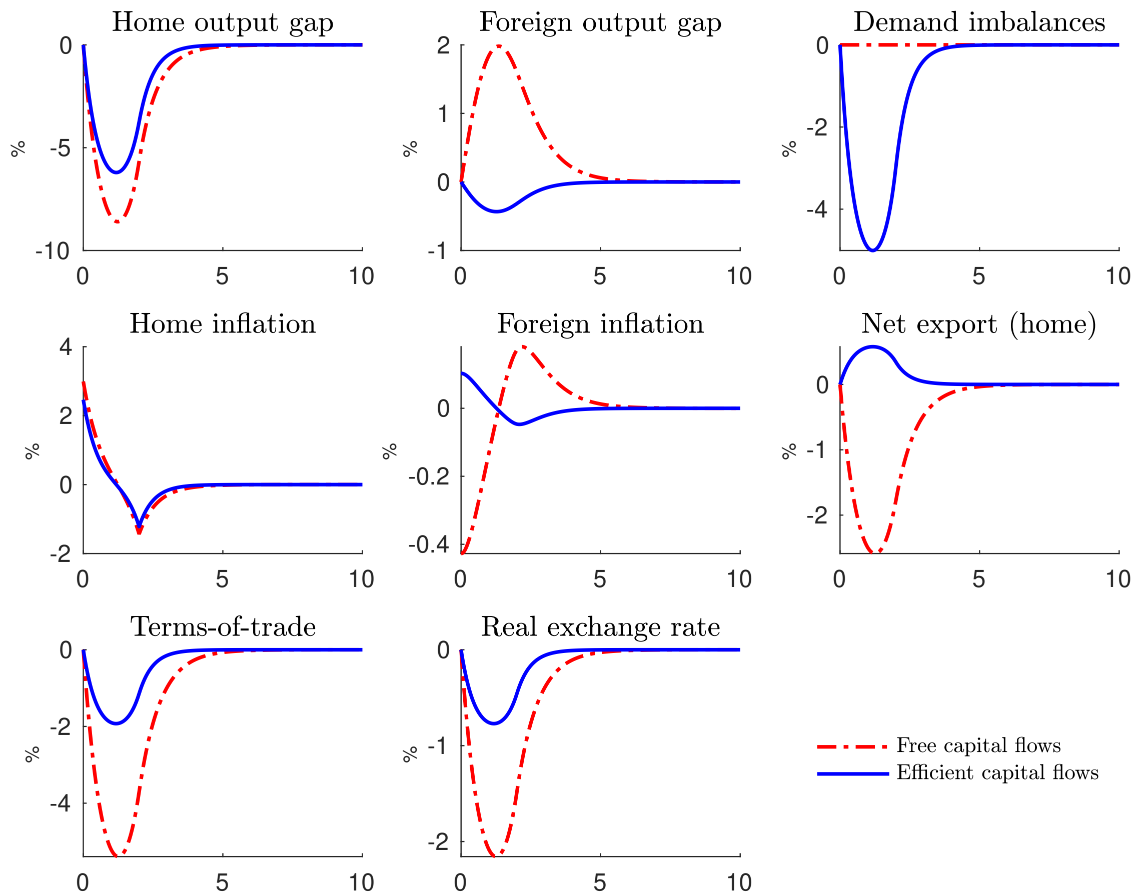

Figure 5: Impulse response.

Figure 5 illustrates the difference in the macroeconomic dynamics under free capital mobility compared to the efficient capital flow regime. It is well understood that under free capital mobility, the efficient allocation cannot be achieve under optimal monetary policy if there are cost-push shocks. In particular, an inward-looking optimal monetary policy does not allow for optimal terms-of-trade and real exchange rate response to shocks. As a result of the high PPI inflation on impact (2.5 percent) and the ensuing real exchange rate misalignment, at the end of the first year the Home country experiences a 3 percent decline in net exports associated with a deep recession (a negative output gap of more than 8 percent). The increase in the price of home goods leads to an increase in demand for foreign goods, leading Foreign PPI to fall by 0.4 percent and foreign output gap to increase by 2 percent.

Managing capital flows by creating a demand imbalances helps mitigate real exchange rate misalignment (only 2 percent below its efficient level in the first year vs. 6 percent under free capital flow) at the expense of distorting the international risk-sharing condition. The negative demand imbalance redirects demand toward the Home country (net exports improves by 1 percent). The increase in demand for home produced goods reduces the increase in home PPI inflation to 2 percent on impact and substantially alleviates the severity of the recession from 8 percent under free capital flow to 5 percent. As shown by Figure 5, this is not a zero sum game. Imposing restrictions on capital flows also reduces significantly the magnitude of both Foreign output gap (0.5 percent vs. 2 percent under free capital flow) and Foreign PPI inflation (0.05 percent vs. 0.4 percent under free capital mobility).

5 Conclusion

Using the canonical two-country New Keynesian model, we shed light on the role played by international financial markets and capital flows in the transmission of and adjustment to uneven inflationary pressures. Our analysis uncovers two aggregate demand externalities associated with external borrowing which affect policy trade-offs. First, external borrowing by the high inflation region exercises upward pressure on domestic marginal costs, thereby deteriorating the output-inflation trade-off. Second, external borrowing by the high inflation region amplifies currency misalignments, which may worsen or improve the (open-economy specific) policy trade-off between output and terms of trade distortions. As a result of these two externalities, a free capital mobility regime is generically constrained inefficient. For plausible parametrizations, the two externalities compound and the model features over-borrowing by the high inflation region. In addition, capital flows in the wrong direction: while a constrained efficient regime would require outflows from the high inflation region, a free capital mobility regime features capital inflows into this region.

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Appendix to "Uneven Inflationary Pressures and Topsy Turvy Capital Flows"

A Derivation of the loss function

The goal of the global planner is to maximize the average welfare function of Home and Foreign households. In this section, we rewrite the objective function in terms of the squared output gap, squared inflation and squared terms-of-trade and relative demand gap. Note that the period utility of the global planner is

$$v_t \equiv \frac{1}{2}\left[\frac{1}{1-\sigma}(C_t)^{1-\sigma} - \frac{1}{1+\phi}(N_t)^{1+\phi}\right] + \frac{1}{2}\left[\frac{1}{1-\sigma}(C_t^*)^{1-\sigma} - \frac{1}{1+\phi}(N_t^*)^{1+\phi}\right]$$

The loss relative to the efficient outcome is then $v_t - v_t^{max}$ where v^{max} is the maximized welfare that is welfare when C_t, C_t^*, N_t and N_t^* take on their efficient values. We start by describing the efficient allocation then turn to deriving the second order approximation of the loss function.

Efficient allocation. The socially optimal allocation solves the following static problem

$$\max_{C_{H,t}, C_{H,t}^*, C_{F,t}, C_{F,t}^*, N_t, N_t^*} \frac{1}{1-\sigma}\left[(1-\alpha)^{\frac{1}{\eta}}(C_{H,t})^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}}(C_{F,t})^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta(1-\sigma)}{\eta-1}} - \frac{1}{1+\phi}(N_t)^{1+\phi}$$

$$+ \frac{1}{1-\sigma}\left[(1-\alpha)^{\frac{1}{\eta}}(C_{F,t}^*)^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}}(C_{H,t}^*)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta(1-\sigma)}{\eta-1}} - \frac{(N_t^*)^{1+\phi}}{1+\phi}$$

subject to

$$C_{H,t} + C_{H,t}^* = N_t \tag{A.1}$$

$$C_{F,t} + C_{F,t}^* = N_t^* \tag{A.2}$$

Let $\vartheta_{H,t}$ and $\vartheta_{F,t}$ denote the multipliers on (A.1) and (A.2). The first order conditions are

$$[C_{H,t}] :: \quad \vartheta_{H,t} = (1-\alpha)^{\frac{1}{\eta}}(C_{H,t})^{-\frac{1}{\eta}}(C_t)^{\frac{1}{\eta}-\sigma} \tag{A.3a}$$

$$[C_{F,t}] :: \quad \vartheta_{F,t}^* = \alpha^{\frac{1}{\eta}}(C_{F,t})^{-\frac{1}{\eta}}(C_t)^{\frac{1}{\eta}-\sigma} \tag{A.3b}$$

$$[C_{H,t}^*] :: \quad \vartheta_{H,t} = \alpha^{\frac{1}{\eta}}(C_{H,t}^*)^{-\frac{1}{\eta}}(C_t^*)^{\frac{1}{\eta}-\sigma} \tag{A.4a}$$

$$[C_{F,t}^*] :: \quad \vartheta_{F,t}j = (1-\alpha)^{\frac{1}{\eta}}(C_{F,t}^*)^{-\frac{1}{\eta}}(C_t^*)^{\frac{1}{\eta}-\sigma} \tag{A.4b}$$

$$[N_t] :: \quad (N_t)^{\phi} = \vartheta_{H,t} \tag{A.5a}$$

$$[N_t^*] :: \quad (N_t^*)^{\phi} = \vartheta_{F,t}^* \tag{A.5b}$$

Combining (A.3a) and (A.3b) after multiplying the first equation by $C^{H,t} \cdot$ and the second $C^{F,t} \cdot$ and proceeding similar with (A.4a) and (A.4b), we arrive to

$$\vartheta_{H,t} C_{H,t} + \vartheta_{F,t}^* C_{F,t} = (C_t)^{1-\sigma} + (C_t^*)^{1-\sigma} \tag{A.6a}$$

$$\vartheta_{H,t} C_{H,t}^* + \vartheta_{F,t} C_{F,t}^* = (C_t)^{1-\sigma} + (C_t^*)^{1-\sigma} \tag{A.6b}$$

Substituting the resource constraint into (A.5a) and (A.5b) yields $(N_t)^{1+\phi} + (N_t^*)^{1+\phi} = \vartheta_{H,t}(C_{H,t} + C_{H,t}^*) + \vartheta_{F,t}^*(C_{F,t} + C_{F,t}^*)$ which combined with (A.6a) and (A.6b) leads to

$$(C_t)^{1-\sigma} + (C_t^*)^{1-\sigma} = (N_t)^{1+\phi} + (N_t^*)^{1+\phi} \tag{A.7}$$

From market clearing and symmetry $\bar{C}_t = \bar{C}_t^* = \bar{N}_t = \bar{N}_t^* = 1$ where variables with a *bar* denote efficient values. It is also It is straightforward to see that $\bar{C}_{H,t} = \bar{C}_{F,t}^* = 1 - \alpha$ and $\bar{C}_{F,t} = \bar{C}_{H,t}^* = \alpha$. In log-deviations, we get

$$\bar{c}_{H,t} = \bar{c}_{H,t}^* = \bar{c}_{F,t} = \bar{c}_{F,t}^* = 0 \quad \text{and} \quad \bar{n}_t = \bar{n}_t^* = 0. \tag{A.8}$$

Loss function. The second order approximation of the period utility around the efficient allocation (using $\bar{C}^{1-\sigma} = \bar{N}^{1+\phi}$ from (A.7) and symmetry) is given by

$$\begin{aligned} v_t = \frac{\sigma+\phi}{1+\phi}\frac{(\bar{C})^{1-\sigma}}{1-\sigma} + \frac{(\bar{C})^{1-\sigma}}{2}\Big[(c_t + c_t^*) + \frac{1-\sigma}{2}\left((c_t)^2 + (c_t^*)^2\right) \\ - (n_t + n_t^*) - \frac{1+\phi}{2}\left((n_t)^2 + (n_t^*)^2\right) + o\left(||u||^3\right)\Big] \end{aligned} \tag{A.9}$$

where $+o\left(||u||^3\right)$ indicate the 3^{rd} and higher order terms left out. Note from (A.8) and (A.9) that $v_t^{max} = \frac{\sigma+\phi}{1+\phi}\frac{(\bar{C})^{1-\sigma}}{1-\sigma}$. The period loss function loss function is then

$$\begin{aligned} v - v_t^{max} = \frac{1}{2}\Big[(c_t + c_t^*) + \frac{1-\sigma}{2}\left((c_t)^2 + (c_t^*)^2\right) \\ - (n_t + n_t^*) - \frac{1+\phi}{2}\left((n_t)^2 + (n_t^*)^2\right) + o\left(||u||^3\right)\Big] \end{aligned} \tag{A.10}$$

We now need to use the second order approximation of the aggregate demand equations and aggregate employment to replace for c_t and n_t. First note that after substituting for the international risk sharing condition (4), the aggregate demand for home goods can be rewritten as

$$Y_t = \left[(1-\alpha) + \alpha\,(S_t)^{1-\eta}\right]^{\frac{\eta}{1-\eta}} \left[(1-\alpha) + \alpha\Theta_t^{-1} Q_t^{\eta-\frac{1}{\sigma}}\right] C_t$$

Taking the second order approximation we get

$$\begin{aligned} y_t = c_t - \alpha\theta_t + \frac{\omega-(1-2\alpha)}{2\sigma} s_t + \frac{1}{2}\alpha(1-\alpha)(1-\eta)\eta(s_t)^2 \\ + \frac{1}{2}\alpha(1-\alpha)\left[\theta_t - (1-2\alpha)(\sigma\eta-1)\sigma^{-1}s_t\right]^2 + o(||u||^3) \end{aligned} \tag{A.11}$$

where $\omega = \sigma\eta + (\sigma\eta-1)(1-2\alpha)^2$. Similarly, demand for foreign good is given by

$$Y_t^* = \left[(1-\alpha) + \alpha\,(S_t)^{\eta-1}\right]^{\frac{\eta}{1-\eta}} \left[(1-\alpha) + \alpha\Theta_t Q_t^{\frac{1}{\sigma}-\eta}\right] C_t^*,$$

and the second order approximation is given by

$$\begin{aligned} y_t^* = c_t^* + \alpha\theta_t - \frac{\omega-(1-2\alpha)}{2\sigma} s_t + \frac{1}{2}\alpha(1-\alpha)(1-\eta)\eta(s_t)^2 \\ + \frac{1}{2}\alpha(1-\alpha)\left[\theta_t - (1-2\alpha)(\sigma\eta-1)\sigma^{-1}s_t\right]^2 + o(||u||^3) \end{aligned} \tag{A.12}$$

We then combine (A.11) and (A.12) to obtain

$$\begin{aligned} c_t + c_t^* = y_t + y_t^* + \alpha(1-\alpha)(1-\eta)\eta(s_t)^2 \\ + \alpha(1-\alpha)\left[\theta_t - (1-2\alpha)(\sigma\eta-1)\sigma^{-1}s_t\right]^2 + o(||u||^3) \end{aligned} \tag{A.13}$$

Using again (A.11) and (A.12) and after some algebraic manipulation we get

$$\begin{aligned} (c_t)^2 + (c_t^*)^2 = (y_t)^2 + (y_t^*)^2 - 2\alpha(1-\alpha)\,(\sigma\eta)^2\left(\sigma^{-1}s_t\right)^2 \\ + 2\alpha(1-\alpha)\left(\theta_t - (\sigma\eta-1)(1-2\alpha)\sigma^{-1}s_t\right)^2 + o(||u||^3) \end{aligned} \tag{A.14}$$

Aggregate employment is given $N_t = Y_t Z_t$ with $Z_t = \int_0^1 \left(P_{Ht(l)}/P_{Ht}\right)^{-\varepsilon} dl$. At the second order approximation $n_t = y_t + z_t + \frac{1}{2}y_t^2 + o(||u||^3)$ with $z_t = o + o(||u||^2)$. Thus, we have

$$n_t + n_t^* = y_t + y_t^* + \frac{1}{2}\left((y_t)^2 + (y_t^*)^2\right) + z_t + z_t^* + o(||u||^3) \tag{A.15}$$

$$(n_t)^2 + (n_t^*)^2 = (y_t)^2 + (y_t^*)^2 + o(||u||^3) \tag{A.16}$$

Plugging (A.13), (A.14), (A.15) and (A.16) into the (A.10) we obtain the following second order approximation of the period loss function

$$v - v_t^{max} = \frac{1}{2}\Big[z_t + z_t^* + (\sigma+\phi)(y_t)^2 + (\sigma+\phi)(y_t^*)^2 + 2\alpha(1-\alpha)(1-\eta\sigma)\eta(s_t)^2 \\ + 2\sigma\alpha(1-\alpha)\left(\theta_t - (\sigma\eta-1)(1-2\alpha)\sigma^{-1}s_t\right)^2\Big] + o(||u||^3)$$

The objective of the global planner is to minimize the loss function is $\mathbb{L} = \int_0^\infty e^{-\rho t}$. Using

$$\int_0^\infty e^{-\rho t} z_t dt = \int_0^\infty e^{-\rho t} \text{var}_l \left(P_{H,t}(l)\right) dt = \frac{1}{\kappa}\int_0^\infty e^{-\rho t}\left(\pi_{H,t}\right)^2 dt$$
$$\int_0^\infty e^{-\rho t} z_t^* dt = \int_0^\infty e^{-\rho t} \text{var}_l \left(P_{F,t}^*(l)\right) dt = \frac{1}{\kappa}\int_0^\infty e^{-\rho t}\left(\pi_{F,t}^*\right)^2 dt$$

and our definition of world and difference variables $(\pi_{H,t})^2 + (\pi_{F,t}^*)^2 = 2[(\pi_t^W)^2 + (\pi_t^D)^2]$ and $(y_t)^2 + (y_t^*)^2 = 2[(y_t^W)^2 + (y_t^D)^2]$ we arrive to

$$\mathbb{L} = \frac{1}{2}\int_0^\infty e^{-\rho t}\Big[2\frac{\varepsilon}{\kappa}\left((\pi_t^W)^2 + (\pi_t^D)^2\right)^2 + 2(\sigma+\phi)\left((y_t^W)^2 + (y_t^D)^2\right) \\ + 2\alpha(1-\alpha)(1-\eta\sigma)\eta(s_t)^2 + 2\sigma\alpha(1-\alpha)\left(\theta_t - (\sigma\eta-1)(1-2\alpha)\sigma^{-1}s_t\right)^2\Big] \tag{A.17}$$

which corresponds to (17).

B Optimal policy problem

We divide the loss (17) by a factor 2 since we can equivalently minimize a linear transformation of the objection function of the global planner. The optimal monetary policy problem is given by

$$\max_{\{\pi^W,\pi^D,x^W,y^D,s\}} \frac{1}{2}\int_0^\infty e^{-\rho t}\Big[\frac{\varepsilon}{\kappa}\left((\pi_t^W)^2 + (\pi_t^D)^2\right) + (\sigma+\phi)\left((y_t^W)^2 + (y_t^D)^2\right) \\ + \alpha(1-\alpha)(1-\sigma\eta)\eta(s_t)^2 + \sigma\alpha(1-\alpha)\left(\theta_t - (\sigma\eta-1)(1-2\alpha)\sigma^{-1}s_t\right)^2\Big]$$

subject to

$$\dot\pi_t^W = \rho\pi_t^W - \kappa(\sigma+\phi)y_t^W - \kappa u_t^W \tag{A.18}$$

$$\dot\pi_t^D = \rho\pi_t^D - \kappa(\sigma+\phi)y_t^D + \kappa\frac{\omega-1}{2}s_t - \kappa\alpha\sigma\theta_t - \kappa u_t^D \tag{A.19}$$

$$2y_t^D = \omega\sigma^{-1}s_t + (1-2\alpha)\theta_t \tag{A.20}$$

Letting φ_t^W, φ_t^D, be the co-state associated with (A.18), (A.19), the first order conditions are

$$\begin{aligned}
\left[\pi_t^W\right] &:: \quad \dot{\varphi}_t^W = -\frac{\varepsilon}{\kappa}\pi_t^W && \text{(A.21)}\\
\left[\pi_t^D\right] &:: \quad \dot{\varphi}_t^D = -\frac{\varepsilon}{\kappa}\pi_t^D && \text{(A.22)}\\
\left[y_t^W\right] &:: \quad 0 = -(\sigma+\phi)y_t^W + \kappa(\sigma+\phi)\varphi_t^W && \text{(A.23)}\\
\left[y_t^D\right] &:: \quad 0 = -(\sigma+\phi)y_t^D + \kappa(\sigma+\phi)\varphi_t^D - \Lambda_t && \text{(A.24)}\\
[s_t] &:: \quad 0 = -(\omega-1)y_t^D + \kappa(\omega-1)\varphi_t^D - \omega\sigma^{-1}\Lambda_t && \text{(A.25)}\\
[\theta_t] &:: \quad 0 = -\sigma\alpha(1-\alpha)\theta_t + \frac{\omega-1}{4}(1-2\alpha)s_t + \kappa\alpha\sigma\varphi_t^D + \frac{1}{2}(1-2\alpha)\Lambda_t && \text{(A.26)}
\end{aligned}$$

together with the initial conditions $\varphi_0^j = 0$ and transversality conditions $\lim_{t\to\infty} e^{-\rho t}\varphi_t^j = 0$ for $j \in \{W, D\}$ and where Λ_t is the Lagrange multiplier on (A.20).

B.1 Proof of Proposition 1

We start by deriving the targeting rules. Combining (A.24) and (A.25) we have

$$\Lambda_t = 0 \tag{A.27}$$

and substituting it back into (A.24) we get

$$y_t^D - \kappa\varphi_t^D = 0 \tag{A.28}$$

Differentiating (A.23) and (A.28) with respect to time and noting from (A.21) and (A.22) that $\kappa\dot{\varphi}_t^W = -\varepsilon\pi_t^W$ and $\kappa\dot{\varphi}_t^D = -\varepsilon\pi_t^D$ we get

$$\begin{aligned}
\dot{y}_t^W + \varepsilon\pi_t^W &= 0 \qquad \text{(A.29)}\\
\dot{y}_t^D + \varepsilon\pi_t^D &= 0
\end{aligned}$$

From (A.23), $y_t^W = \kappa\varphi_t^W$, and given that $\varphi_0^W = 0$, we have $y_0^W = 0$. From (A.28) and (A.20) we have $y_0^D = 0$ and $2y_0^D + \omega s_0 = 0$ which imply that $y_0^D = s_0 = 0$. Thus, integrating between 0 and t we arrive to

$$y_t^W + \varepsilon(p_t^W - p_0^W) = 0 \tag{A.30}$$
$$y_t^D + \varepsilon(p_t^D - p_0^D) = 0 \tag{A.31}$$

B.2 Proof of Corollary 1

We consider the targeting rule (A.29) for world variables and differentiate this rule to obtain $\ddot{y}_t^W + \varepsilon \dot{\pi}_t^W = 0$. We then use (A.18), $\dot{\pi}_t^W = \rho \pi_t^W - \kappa(\sigma + \phi) y_t^W - \kappa u_t^W$, to substitute for $\dot{\pi}_t^W$ and obtain

$$\ddot{y}_t^W - \rho \dot{y}_t^W - \varepsilon\kappa(1+\phi) y_t^W = \varepsilon\kappa u_t^W \tag{A.32}$$

The polynomial characteristic of this equation has one negative eigenvalue $z_1 < 0$ and one positive eigenvalue $z_2 > 0$ where

$$z_1 = \frac{1}{2}\left(\rho - \sqrt{\rho^2 + 4\kappa\varepsilon(1+\phi)}\right) < 0 \quad \text{and} \quad z_2 = \frac{1}{2}\left(\rho + \sqrt{\rho^2 + 4\kappa\varepsilon(1+\phi)}\right) > 0$$

The solution of this second order differential equation takes the form

$$y_t^W = \vartheta_0 e^{z_1 t} + \vartheta_1 \int_0^t e^{z_1(t-s)} u_s^W ds + \vartheta_2 \int_t^\infty e^{z_2(t-s)} u_s^W ds. \tag{A.33}$$

Differentiating (A.33) and relating each term to (A.32) we obtain

$$\vartheta_1 = \vartheta_2 = -\frac{\varepsilon\kappa}{z_2 - z_1}.$$

Next, from (A.33) for $t = 0$ we get

$$\vartheta_0 = y_0^W + \frac{\varepsilon\kappa}{z_2 - z_1} \int_0^\infty e^{-z_2 s} u_s^W ds$$

From the initial condition for the co-state variable $\varphi_0^W = 0$, the relation $y_t^W = \kappa \varphi_t^W$ implies that $y_t^W = 0$. The solution to the optimal monetary policy problem is thus

$$y_t^W = -\frac{\varepsilon\kappa}{z_2 - z_1}\left[e^{z_1 t} \int_0^t \left(e^{-z_1 s} - e^{-z_2 s}\right) u_s^W ds + \left(e^{z_2 t} - e^{z_1 t}\right) \int_t^\infty e^{-z_2 s} u_s^W ds\right]. \tag{A.34}$$

Using (A.29), the path for the world inflation under the optimal monetary policy satisfies

$$\pi_t^W = \frac{\kappa}{z_2 - z_1}\left[z_1 e^{z_1 t} \int_0^t \left(e^{-z_1 s} - e^{-z_2 s}\right) u_s^W ds + \left(z_2 e^{z_2 t} - z_1 e^{z_1 t}\right) \int_t^\infty e^{-z_2 s} u_s^W ds\right]. \tag{A.35}$$

From (A.34) and (A.35), it follows that the paths of the world variables y_t^W and π_t^W are independent of the path of θ_t.

B.3 Proof of Proposition 3

Using (A.27), that is $\Lambda_t = 0$, the optimality condition (A.26), becomes

$$\begin{aligned} 2\sigma\alpha(1-\alpha)\theta_t &= (1-2\alpha)\frac{\omega-1}{2}s_t + 2\kappa\sigma\alpha\varphi_t^D \\ &= (1-2\alpha)\frac{\omega-1}{2}s_t + 2\sigma\alpha y_t^D \end{aligned} \tag{A.36}$$

where the second equality uses (A.28). Substituting (A.20) into (A.36) we get

$$\begin{aligned} 2\sigma\alpha(1-\alpha)\theta_t &= (1-2\alpha)\frac{\omega-1}{2}s_t + \alpha\left[\omega s_t + (1-2\alpha)\sigma\theta_t\right] \\ \alpha\sigma\theta_t &= \left[\frac{\omega-1}{2} + \alpha\right] s_t \\ \sigma\theta_t &= \left[1 + \frac{\omega-1}{2\alpha}\right] s_t \end{aligned} \tag{A.37}$$

Finally, we use $s_t = \frac{\sigma}{\omega}[2y_t^D - (1-2\alpha)\theta_t]$ and rearrange the resulting expression to get

$$\begin{aligned} \theta_t &= \frac{\omega-(1-2\alpha)}{\omega-(1-2\alpha)^2}2y_t^D \\ &= \left[1 - \frac{1-2\alpha}{2(1-\alpha)\sigma\eta}\right] 2y_t^D. \end{aligned} \tag{A.38}$$

Optimal taxes on capital flow. Recall have $\tau_t^D = \sigma\dot{\theta}_t$. Differentiating (A.37) and using $\dot{s}_t = 2\pi_t^D$ we arrive to

$$\begin{aligned} \tau_t^D &= \left[1 + \frac{\omega-1}{2\alpha}\right]\frac{1}{2}\dot{s}_t \\ &= \left[2\left(1-\alpha\right)\sigma\eta - (1-2\alpha)\right] 2\pi_t^D \end{aligned} \tag{A.39}$$