Exchange Rate Pass-Through, Capital Flows, and Monetary Autonomy*

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In this paper, we propose incomplete exchange rate pass-through as a new channel through which balance sheet effects can constrain monetary policy. We consider a New Keynesian open economy with external debt in foreign currency. We first show that outstanding external debt imposes no constraint on monetary policy under complete exchange rate pass-through. If, however, pass-through is incomplete, then the expenditure switching benefits of an exchange rate depreciation are weakened, while the strength of debt deflation is unchanged. As a result, sudden stops are contractionary, and prior current account deficits are inefficiently high due to aggregate demand externalities. Optimal macroprudential policy makes the private sector internalize the social value of future exchange rate flexibility. Absent macroprudential tools, monetary policy would like to deter borrowing by promising a large, but time-inconsistent, exchange rate depreciation during crises.

Keywords: Capital flows, monetary and macroprudential policies, exchange rate pass-through

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1 Introduction

As shown during the 1997-1998 Asian financial crisis wave of sudden stops, the size and composition of private balance sheets can partially deprive a country of its monetary autonomy in spite of a flexible exchange rate regime. Exchange rate movements induce *balance sheet effects*: this term captures a wide range of mechanisms including bankruptcies due to domestic cross-holdings of nominal debt, valuation effects on the net foreign asset position, and financial constraints that make investment depend on firms' or banks' net worth. Balance sheet effects are thought to be especially relevant for monetary policy when the country faces volatile capital flows. Under the conventional "Mundell-Fleming view", a sharp exchange rate depreciation is the natural adjustment mechanism to a sudden stop, defined as an event when international capital stops flowing in and a current account surplus is quickly required. If domestic prices adjust slowly, this depreciation redirects consumption towards domestic goods and potentially stimulates exports. These expenditure switching effects alleviate the need for a domestic contraction, a well-known benefit of flexible exchange rates. But if there is a conflict between aggregate demand management and balance sheet effects, a domestic recession must necessarily accompany the rapid current account adjustment.

Safer forms of financing such as local currency debt (bank loans and corporate bonds) and equity funding have grown steadily in the aftermath of the Asian crisis, but so have gross external positions relative to GDP. Overall, the share of foreign currency debt remains high (Bénétrix, Lane and Shambaugh, 2015). Concerns about dollar debt in emerging markets have persisted, due to the deepening of bond markets which are mostly operating in U.S. dollars. Some emerging markets, for example Indonesia and Malaysia, have imposed heavy hedging regulations against foreign currency borrowing in the past decade. While others, such as Turkey and Argentina, have recently faced currency crises and concerns about financial contagion reminiscent of the Asian crisis.

In this paper, we propose a new channel through which balance sheet effects can constrain monetary policy when a country owes external debt in a foreign currency. A depreciation triggers two effects: an expenditure switching channel that boosts the production of domestic goods, by both reducing imports and stimulating exports, and a financial channel that revalues external debt denominated in foreign currency. We show that incomplete exchange rate pass-through to goods prices—that has been the focus of a large recent literature in international macroeconomics (Burstein and Gopinath,

2014)—leads to a new form of balance sheet effects. We then analyze optimal policy in the presence of this new channel to address a number of important policy questions. How should monetary policy react to a sudden stop, depending on the level of external debt? How should macroprudential policy be used to affect borrowing in booms, thereby relaxing potential constraints of debt on monetary autonomy in future busts? If macroprudential tools are lacking—which may be relevant in many emerging markets—what can monetary policy do by itself?

To tackle these questions, we develop a tractable New Keynesian model of a small open economy subject to the risk of a sudden external deleveraging. Markets are incomplete and households can save in local and foreign currency bonds. A crucial feature is the potential incomplete pass-through of exchange rates to consumer prices, which implies that the real burden of debt in terms of imports increases when the nominal exchange rate depreciates. We study optimal policy under different assumptions about available policy instruments.

During a sudden stop, monetary policy seeks to strike a balance between the beneficial expenditure switching effects of an exchange rate depreciation and the detrimental balance sheet effects due to the revaluation of external foreign currency debt. We first show that sudden stops do not lead to a domestic recession if there is full exchange rate pass-through to domestic goods prices. This neutrality arises because the expenditure switching effects of a depreciation compensate exactly the financial loss due to the revaluation of external debt.[1] Unlike much of the literature, we then depart from the complete pass-through assumption.[2]

Incomplete exchange rate pass-through weakens the expenditure switching channel, but the strength of balance sheet effects remains unchanged because foreign currency debt is nominal. As a result, debt imposes a constraint on how much monetary policy can depreciate. We show in this case that a sudden stop leads to a domestic recession, the depth of which increases with the amount of outstanding debt when the shock hits.[3] At low levels of debt, the exchange rate still depreciates, but as debt increases the depreciation is more limited; at sufficiently high levels of debt monetary policy can even find it optimal to appreciate the exchange rate.

[1] We extend the baseline representative agent model to show this neutrality result also holds with heterogeneous households who potentially differ in their debt portfolio positions.

[2] Incomplete pass-through is a widely documented phenomenon, see the recent handbook chapter by Burstein and Gopinath (2014).

[3] Auclert et al. (2021) show in a heterogeneous agent open economy model that exchange rate depreciation shocks can be contractionary due to the effect on households' real income.

Before the sudden stop, the country's external debt arises from agents' decentralized decisions under the anticipation of future exchange rates. The possibility of a future recession implies that there are aggregate demand externalities in financial markets, as described by Farhi and Werning (2016) and Korinek and Simsek (2016). These externalities imply that private current account deficits prior to the shock are excessive: individuals do not fully take into account how an aggregate increase in external debt will constrain monetary policy if a sudden stop occurs. Because the recession that accompanies a sudden stop is not imposed by an exogenous constraint on monetary policy, such as the zero lower bound or an exchange rate peg, a central bank with commitment can manage expectations about future exchange rates to induce the private sector to borrow less, thereby providing greater flexibility if the shock occurs. Importantly, this value of monetary policy credibility depends on the availability of macroprudential instruments.

We show that no monetary policy commitment is needed when macroprudential policy can be set optimally. The logic is that unconstrained macroprudential tools can perfectly decouple portfolio choices from the private sector's expectations about future policy, so discretionary monetary policy is optimal. However, the required portfolio taxes are large and state-dependent. In the absence of sufficiently powerful or flexible macroprudential tools, a role for commitment emerges. But the optimal monetary policy promise will always be time-inconsistent: once external debt is predetermined, monetary policy will still want to limit the exchange rate depreciation after a sudden stop shock.

The tension between macroeconomic stabilization and deleveraging speaks to a recent literature on the macroeconomic effects of household debt in New Keynesian models. In the seminal papers of Eggertsson and Krugman (2012) and Guerrieri and Lorenzoni (2011), a negative credit supply shock (the closed economy counterpart of a sudden stop) can cause a recession, but only by pushing the economy against the zero lower bound and thereby forcing monetary policy to be suboptimal. In an international context, fixed exchange rates put a similar exogenous constraint on monetary policy. However, Mian, Sufi and Verner (2017) show that growth in household debt to GDP (and in particular external debt) predicts recessions even in countries and periods where nominal rates are well above zero and with floating exchange rates. Our paper develops a theory of the currency denomination of debt as an endogenous constraint that prevents monetary policy from perfectly stabilizing the economy in response to external shocks. In this environment, expectations about future monetary policy feed back into how much households borrow ex-ante.

Related literature

Our paper lies at the intersection of several strands of the literature. Emerging markets crises spurred an extensive literature on balance sheet effects and currency crises due to financial frictions, for instance Krugman (1999), Céspedes, Chang and Velasco (2004) and Aghion, Bacchetta and Banerjee (2004). The mechanism does not rely on nominal rigidities and the focus is on the ex-post amplification mechanism instead of the ex-ante externalities. A notable exception is the analysis of dollarization as underinsurance due to a pecuniary externality in Caballero and Krishnamurthy (2004b). As in Section 4, this externality creates an insurance channel for monetary policy in Caballero and Krishnamurthy (2004a) in the absence of macroprudential instruments.

The innovation of this paper is to study the implications of incomplete exchange rate pass-through for balance sheet effects. We embed external adjustment concerns into New Keynesian models of optimal monetary policy in open economies featuring incomplete exchange rate pass-through, in the line of Corsetti and Pesenti (2005) and Devereux and Engel (2003). The early literature considered two polar cases: producer currency pricing (that implies full pass-through) and local currency pricing (that implies no pass-through). Recent work such as Gopinath (2016) and Gopinath et al. (2020) highlights a third paradigm, "dominant currency pricing".[4] Our framework nests all these cases and shows the implications of each configuration. Farhi and Maggiori (2018) and Gopinath and Stein (2018) show how the interaction between goods pricing and asset denomination can reinforce the dominance of a currency (namely the U.S. dollar). Egorov and Mukhin (2023) study optimal monetary policy and capital controls under dominant currency pricing.[5]

From a theoretical viewpoint, we build on the recent work on aggregate demand externalities pioneered by Farhi and Werning (2016), Korinek and Simsek (2016) and Schmitt-Grohé and Uribe (2016). The general theme is that frictions in goods and labor markets, in particular nominal rigidities, create inefficiencies in financial markets as well. Our paper is also related to the growing literature on the use of capital controls (in particular, following Farhi and Werning, 2014) and the interaction between monetary and macroprudential policies (see, e.g. Basu et al., 2025).[6]

[4] See Gopinath and Itskhoki (2022) for a recent review of the dominant currency literature.

[5] McLeay and Tenreyro (2026) examine dominant currency pricing, price stickiness and exchange rate pass-through for monetary policy.

[6] Bianchi and Coulibaly (2022) examine the use of monetary and macroprudential policies and the zero lower bound, which we abstract from given our focus on exchange rate pass-through.

As in Tirole (2003), there are dual and common agency problems. He describes the disciplining effect of foreign currency debt when policymakers can affect foreigners' returns, and focuses on the interaction with a credit rationing friction, while we interact the lack of commitment with the nominal rigidity friction. Restricting monetary policy policy to the exchange rate enables us to solve for optimal capital controls. Bohn (1990) also emphasizes how private external debt in local currency makes monetary policy time-inconsistent.

Finally, our analysis of the case of constrained macroprudential policy and lack of monetary policy commitment shares the equilibrium multiplicity present in many settings where there is a feedback between a state variable determined by the private sector's expectations and a discretionary government. The closest examples are Calvo (1988), Schneider and Tornell (2004), Albanesi, Chari and Christiano (2003) and Farhi and Tirole (2012). Jeanne and Korinek (2017) also study the interaction and optimal mix between ex-ante and ex-post policies in a model with pecuniary externalities.

The remainder of the paper is organized as follows. After presenting the model in Section 2, we study optimal monetary and macroprudential policy, and full commitment in Section 3. Section 4 turns to the case where perfect macroprudential tools are lacking, and compares the resulting optimal monetary policy under commitment and under discretion. Finally, Section 5 concludes.

2 Model

This section presents the environment. There are two countries, Home and Foreign, and two traded goods, H and F. Home is a small open economy (SOE) in the sense that Foreign prices and interest rates are taken as exogenous parameters of any equilibrium. Home borrows from Foreign until a Poisson sudden stop shock hits.

2.1 Environment

Time is infinite and discrete, denoted by $t = 0, 1, ...$

Households. In period t, the representative household values streams of Home good consumption $\{C_{H,t}\}$, Foreign good consumption $\{C_{F,t}\}$ and labor $\{N_t\}$ according to:

$$E\left[\sum_{j=0}^{\infty}\beta^t U(C_{H,t+j}, C_{F,t+j}, N_{t+j})\right]. \tag{2.1}$$

For tractability, we use the Cole and Obstfeld (1991) specification of unit elasticities of intra- and intertemporal substitution:

$$U(C_{H,t}, C_{F,t}, N_t) = \omega \log C_{H,t} + (1-\omega)\log C_{F,t} - \chi\frac{N_t^{1+\psi}}{1+\psi},$$

where ω is the weight on the home good, and $1/\psi$ is the Frisch elasticity of labor supply.

The domestic representative agent can save or borrow in one-period nominal bonds both domestically denominated in local currency (LC), and internationally denominated in foreign currency (FC). LC denominated debt in period t funding D_{t+1} in LC is repaid at the domestic nominal interest rate R_t at $t+1$. A FC denominated debt contract in period t specifies funding F_{t+1} in FC, and repayment of R^*F_{t+1} in FC at $t+1$.[7] The household budget constraint expressed in LC is given by:

$$P_{H,t}C_{H,t} + P_{F,t}C_{F,t} + R_{t-1}D_t + (1+\tau^F_{t-1})R^*\mathcal{E}_t F_t \leq W_t N_t + D_{t+1} + \mathcal{E}_t F_{t+1} + \Pi_t + T_t, \tag{2.2}$$

where $P_{H,t}$ is the LC price of Home goods, $P_{F,t}$ is the LC consumer price of imported Foreign goods, the nominal exchange rate $\mathcal{E}_t$ is the price of FC in LC (therefore, the exchange rate depreciates when $\mathcal{E}_t$ increases), W_t is the nominal wage in LC, Π_t denotes profits of domestic firms, T_t is a lump-sum transfer from the government, and τ^F_{t-1} is a macroprudential tax on FC capital inflows set at $t-1$.

FC borrowing is subject to a stochastic international borrowing constraint

$$F_{t+1} \leq B(s^t), \tag{2.3}$$

where $s^t = (s_0, \ldots, s_t)$ denotes the history of shocks (the probability distribution of histories

[7] Under incomplete pass-through, the distinction between contracts delivering goods or currency matters because real bonds would allow consumers to partially arbitrage away the price discrimination of Foreign exporters, for instance if their Foreign counterparties can repay them with Foreign goods bought abroad at lower prices.

is described below). We assume the household is relatively impatient

$$\beta R^* < 1.$$

Therefore, consistent with the empirical patterns in Mian, Sufi and Verner (2017), household debt expansion finances a consumption boom.

Firms. Representative domestic firms produce the Home tradable good from labor L_t using the linear technology:

$$Y_{H,t} = A_t L_t.$$

Firm profits in LC from domestic demand for Home goods $C_{H,t}$ and export demand for Home goods $C^*_{H,t}$ are given by

$$\Pi_t = P_{H,t} C_{H,t} + \mathcal{E}_t P^*_{H,t} C^*_{H,t} - W_t L_t,$$

where $P^*_{H,t}$ is the FC price of exported Home goods.

Nominal rigidities. The FC price of Foreign goods is taken as the numeraire $P^*_{F,t} \equiv 1$. We assume the LC price of Home goods $P_{H,t}$ is fixed and equal to $P_H \equiv 1$.[8] The nominal wage in LC W_t is assumed to be fully flexible. Exports revenue denominated in FC acts as a partial natural hedge against the financial effects of an exchange rate depreciation, and the strength of this hedge decreases with the short-run exchange rate pass-through of exports. We model this flexibly as follows:

Assumption 1. *The short-run exchange rate pass-through to consumer import prices is given by* $\lambda, \lambda^* \in [0, 1]$ *such that for all* t,

$$P_{F,t} = \mathcal{E}_t^{\lambda}, \tag{2.4}$$

$$P^*_{H,t} = \mathcal{E}_t^{-\lambda^*}. \tag{2.5}$$

This formulation nests the special cases of producer currency pricing (PCP) for

$$\lambda = \lambda^* = 1,$$

[8] These standard normalizations of $P^*_{F,t}$ and $P_{H,t}$ are without loss of generality.

when assuming the law of one price for both goods (e.g. Galí and Monacelli, 2005), local currency pricing (LCP) for

$$\lambda = \lambda^* = 0,$$

which eliminates pass-through from the exchange rate to consumer prices (e.g. Betts and Devereux, 2000), and dominant currency pricing (DCP) for

$$\lambda = 1, \ \lambda^* = 0,$$

when prices are set in the dominant currency (e.g. Gopinath et al., 2020).

One interpretation of Assumption 1 is that the final Foreign consumption good is a composite of a continuum $i \in [0,1]$ of intermediate Foreign goods such that

$$C_F = \exp \int_0^1 \log C_F(i) di.$$

If the set $[0,\lambda]$ of Foreign exporters i has fixed prices $\overline{P}^*(i)$ in FC while the set $[\lambda,1]$ has fixed prices $\overline{P}(i)$ in LC and the law of one price holds for each intermediate good, then the price index of Foreign goods is[9]

$$P_{F,t} = \exp\left(\int_0^\lambda \left[\log \mathcal{E}_t + \log \overline{P}^*(i) \right] di + \int_\lambda^1 \log \overline{P}(i) di \right) \propto \mathcal{E}_t^\lambda.$$

Government. The government sets monetary policy as the history-contingent path of nominal interest rates $\{R_t(s^t)\}_{t\geq 0}$ on LC denominated debt.

The government runs a balanced budget with lump-sum transfers financed by macroprudential policy as the history-contingent capital control tax $\{\tau^F_{t-1}(s^{t-1})\}_{t\geq 0}$ on foreign currency inflows at t:

$$\tau^F_{t-1} R^* \mathcal{E}_t F_t = T_t. \tag{2.6}$$

[9] Similarly, if the final Home consumption good is a composite of a continuum $i \in [0,1]$ of intermediate Home goods such that $C_H = \exp \int_0^1 \log C_H(i)\, di$. If the set $[0, 1-\lambda^*]$ of Home exporters i has fixed prices $\overline{P}^*(i)$ in FC while the set $[1-\lambda^*, 1]$ has fixed prices $\overline{P}(i)$ in LC and the law of one price holds for each intermediate good, then the foreign price index of Home goods is $P^*_{H,t} = \exp\left(\int_0^{1-\lambda^*} \log \overline{P}^*(i) di + \int_{1-\lambda^*}^1 \left[-\log \mathcal{E}_t + \log \overline{P}(i) \right] di \right) \propto \mathcal{E}_t^{-\lambda^*}$.

Rest of the world. The rest of the world exchanges Home and Foreign tradable goods and FC debt with the SOE and provides a perfectly elastic supply of FC denominated debt at the interest rate R^*. Foreign demand for exports of Home goods is given by:

$$C^*_{H,t} = \zeta \mathcal{E}_t^{\lambda^* \eta^*}$$

where $\zeta > 0$ is a Foreign demand shifter that can be interpreted as Foreign GDP adjusted for Foreign consumers' home bias, and $\eta^* \in [0, 1]$ is the Foreign price-elasticity of export demand.

Timing of shocks. The Markov structure of uncertainty features two states s, the normal state $\bar{s}$ and the sudden stop state ($\underline{s}$) associated with borrowing constraints $\overline{B} = \infty$ and $\underline{B} = 0$ respectively. At time 0, the economy starts in the normal state with inherited FC debt $F_0 \geq 0$. From the normal state there is a constant probability π of switching to the sudden stop. The sudden stop state is absorbing.

2.2 Equilibrium

Definition 1 (Equilibrium). *Given government policies* $\{R_t(s^t), \tau^F_{t-1}(s^{t-1})\}$*, a rigid-price equilibrium is given by allocations* $\{C_{H,t}(s^t), C_{F,t}(s^t), N_t(s^t), Y_{H,t}(s^t), L_t(s^t), D_t(s^t), F_t(s^t)\}$ *and prices* $\{P_{F,t}(s^t), W_t(s^t), \mathcal{E}_t(s^t)\}$ *such that after any history* s^t *households optimize* (2.1) *subject to budget constraints (2.2) and borrowing constraints* (2.3)*, the government balances its budget* (2.6)*, and markets clear:*

$$Y_{Ht} = C_{Ht} + \zeta \mathcal{E}_t^{\lambda^* \eta^*}, \tag{2.7}$$

$$L_t = N_t, \tag{2.8}$$

$$D_t = 0. \tag{2.9}$$

Equation (2.7) is the market-clearing condition for the Home good. Home output is demand-determined, which should be interpreted as monopolistically competitive domestic firms who accommodate the demand they face from domestic and foreign consumers, given the prices they have set before $t = 0$. Equations (2.8) and (2.9) are the market-clearing conditions for labor and LC debt.

The balance of payments condition (or external budget constraint in real terms, i.e.

units of Foreign good) is given by:

$$C_{F,t} \leq \frac{\mathcal{E}_t P^*_{H,t}}{P_{F,t}} C^*_{H,t} - \frac{\mathcal{E}_t}{P_{F,t}}(R^* F_t - F_{t+1}), \tag{2.10}$$

which under the pass-through Assumption 1:

$$C_{F,t} \leq \mathcal{E}_t^{1-\lambda^*-\lambda+\lambda^*\eta^*} \cdot \zeta - \mathcal{E}_t^{1-\lambda} \left(R^* F_t - F_{t+1}\right). \tag{2.11}$$

When the sudden stop shock hits at time t after the country has accumulated external debt F_t and cannot borrow, the country must suddenly run a current account surplus of $R^* F_t$ in FC. This can be done by raising FC exports revenue $P_H \mathcal{E}_t^{-\lambda^*} \cdot \zeta \mathcal{E}_t^{\lambda^*\eta^*}$, cutting on imports expenditure $P^*_{F,t} C_{F,t} / \mathcal{E}_t^{1-\lambda}$, or both.

We now characterize the equilibrium, which will serve as implementability conditions for the optimal policy problem. The households' first-order conditions give the relative expenditure on Home and Foreign goods:

$$U_{C_H,t} = \frac{U_{C_F,t}}{P_{F,t}} \tag{2.12}$$

$$\Leftrightarrow \quad C_{H,t} = \alpha \mathcal{E}_t^{\lambda} C_{F,t} \quad \text{where } \alpha = \frac{\omega}{1-\omega}, \tag{2.13}$$

the labor supply decision:

$$U_{C_H,t} = \frac{-U_{N,t}}{W_t}, \tag{2.14}$$

the LC bond Euler equation:

$$U_{C_H,t} = \beta R_t E_t \left[U_{C_H,t+1}\right], \tag{2.15}$$

and, in the normal state, the FC bond Euler equation:

$$U_{C_H,t} = \beta(1+\tau_t^F) R^* E_t \left[\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} U_{C_H,t+1}\right]. \tag{2.16}$$

Equations (2.15) and (2.16) give the domestic no-arbitrage condition in normal times:

$$E_t \left[U_{C_H,t+1} \left(R_t - (1+\tau_t^F) R^* \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}\right)\right] = 0. \tag{2.17}$$

2.3 Monetary policy.

In formulating the monetary policy problem we can think equivalently of setting the history-contingent path of nominal interest rates $\{R_t(s^t)\}_{t\geq 0}$ or nominal exchange rates $\{\mathcal{E}_t(s^t)\}_{t\geq 0}$, and we will use the latter formulation. Indeed, the usual interpretation of (2.17) for monetary policy in open economies with perfect capital mobility $\tau_t^F = 0$ is that given R^* and $\mathcal{E}_{t+1}$, setting the LC nominal interest rate R_t is equivalent to setting the current exchange rate $\mathcal{E}_t$. With unconstrained macroprudential taxes τ^F as an instrument, the interpretation is rather as follows: if the planner sets $C_{F,t}, C_{F,t+1}, \mathcal{E}_t, \mathcal{E}_{t+1}$, this pins down $C_{H,t}, C_{H,t+1}$ through (2.13), hence the domestic interest rate can be defined by (2.15) and the nominal wage adjusts to ensure labor market clearing.

Following Farhi and Werning (2016), we will analyze optimal policy in terms of two equilibrium objects, the instantaneous indirect utility V and the labor wedge τ. After replacing $C_{H,t}$ using (2.13) and

$$N_t = \frac{C_{H,t} + C^*_{H,t}}{A_t},$$

we can express households' instantaneous indirect utility V_t as a function of imports $C_{F,t}$ and the nominal exchange rate $\mathcal{E}_t$:

$$V(C_{F,t}, \mathcal{E}_t) = U\left(\alpha \mathcal{E}_t^{\lambda} C_{F,t}, C_{F,t}, \frac{\alpha \mathcal{E}_t^{\lambda} C_{F,t} + \zeta \mathcal{E}_t^{\lambda^* \eta^*}}{A_t}\right).$$

Definition 2. *The labor wedge τ_t of an equilibrium allocation is defined as*

$$\begin{aligned} \tau_t\left(C_{F,t}, \mathcal{E}_t\right) &= 1 + \frac{U_{N,t}}{A_t U_{C_{H,t}}} \\ &= 1 - \frac{\chi}{\omega A^{1+\psi}}\left[\alpha \mathcal{E}_t^{\lambda} C_{F,t} + \zeta \mathcal{E}_t^{\lambda^* \eta^*}\right]^{\psi} \alpha \mathcal{E}_t^{\lambda} C_{F,t}. \end{aligned} \tag{2.18}$$

Under flexible prices, the labor wedge would always be zero. Under nominal rigidities, a positive labor wedge can be interpreted as a domestic recession, because increasing equilibrium labor would reduce the labor wedge. Monetary policy is not constrained (we abstract from the zero lower bound) and can always set an exchange rate $\mathcal{E}_t$ that is optimal from a static viewpoint:

Definition 3. *The* myopic *monetary policy $\mathcal{E}^m(x)$ given net debt repayment $x = R^*F - F'$ (i.e. the current account surplus measured in FC) is the policy function of the static optimal*

monetary policy problem:

$$\mathcal{E}^m(x) = \arg\max_{\mathcal{E}} \quad V(C_F, \mathcal{E}) \tag{2.19}$$

$$s.t. \quad C_F = \mathcal{E}^{1-\lambda^*-\lambda+\lambda^*\eta^*}\zeta - \mathcal{E}^{1-\lambda}x \tag{2.20}$$

The partial derivatives of the indirect utility function V satisfy:

$$V_{C_F} = U_{C_F}(1+\alpha\tau) \tag{2.21}$$

$$V_{\mathcal{E}} = \frac{U_{C_F}}{\mathcal{E}}\left[\left(\lambda\alpha C_F + \zeta\lambda^*\eta^*\mathcal{E}^{\lambda^*\eta^*-\lambda}\right)\tau - \zeta\lambda^*\eta^*\mathcal{E}^{\lambda^*\eta^*-\lambda}\right]. \tag{2.22}$$

The interpretation of (2.21) is that an increase in imports C_F brings not only direct consumption value, but also the indirect benefit of stimulating a depressed domestic sector when $\tau > 0$. Equation (2.22) features the stimulative effects of expenditure switching (the term proportional to τ), as well as the labor costs of overheating the export sector. We can then solve for the optimal myopic monetary policy:

Proposition 1. *The myopic monetary policy satisfies*

$$\tau = \frac{(1-\lambda)\frac{x}{\zeta}\mathcal{E}^{1-\lambda^*\eta^*} - (1-\lambda-\lambda^*+\lambda^*\eta^*)\mathcal{E}^{1-\lambda^*} + \lambda^*\eta^*}{\alpha\left[(1-\lambda^*+\lambda^*\eta^*)\mathcal{E}^{1-\lambda^*} - \frac{x}{\zeta}\mathcal{E}^{1-\lambda^*\eta^*}\right] + \lambda^*\eta^*} \tag{2.23}$$

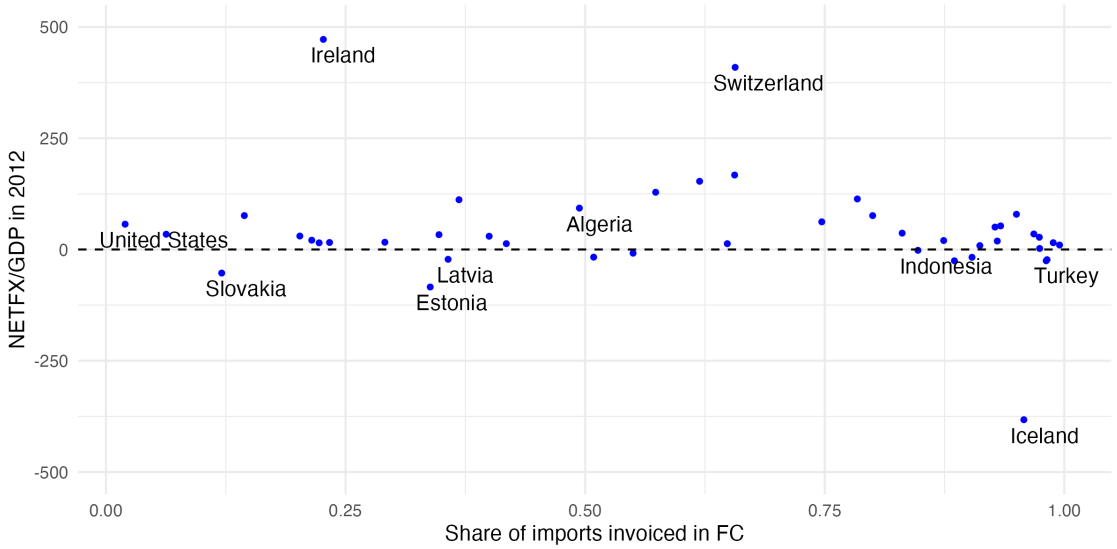
We include all proofs in Appendix A.1. In the numerator of (2.23), the term proportional to $1-\lambda-\lambda^*+\lambda^*\eta^*$ corresponds to a standard terms-of-trade manipulation motive of exchange rate policy: in the absence of any debt, that is with $x = 0$, the optimal myopic monetary policy simply balances the labor wedge distortion against the gains from maximizing export revenue. If $1-\lambda-\lambda^*+\lambda^*\eta^* > 0$ (as is the case under local currency pricing) then it is optimal to appreciate the currency relative to a flexible prices benchmark in order to extract more revenue.

Proposition 1 leads to the following neutrality result:

Corollary 1 (Neutrality under DCP)**.** *Under dominant currency pricing, $\lambda = 1$ and $\lambda^* = 0$, external debt x is neutral, in the sense that the optimal myopic monetary policy targets a zero labor wedge for any x.*

Corollary 1 states that external debt puts no constraint on aggregate demand manage-

Figure 1: Net foreign exchange exposure vs. imports share invoiced in foreign currency λ



Note: $NETFX/GDP$ is defined as in Lane and Shambaugh (2010). Data from Bénétrix et al. (2015) and Gopinath (2016).

ment in the DCP case. This neutrality arises because the expenditure switching effects of an exchange rate depreciation compensate exactly the financial loss due to the revaluation of external FC debt.

Remark 1. The same neutrality result as Corollary 1 would hold under complete exchange rate pass-through to local prices for the Foreign good $\lambda = 1$ and the Cole-Obstfeld condition $\eta^* = 1$ if Home exports were "commodities" produced by a domestic Lucas tree instead of domestic labor. In that case, a depreciation would not have the direct effect of increasing labor supply to produce exports, and the myopic monetary policy would be characterized by

$$\tau = \frac{(1-\lambda)\frac{x}{\zeta}\mathcal{E}^{1-\lambda^*\eta^*} - (1-\lambda-\lambda^*+\lambda^*\eta^*)\mathcal{E}^{1-\lambda^*}}{\alpha\left[(1-\lambda^*+\lambda^*\eta^*)\mathcal{E}^{1-\lambda^*} - \frac{x}{\zeta}\mathcal{E}^{1-\lambda^*\eta^*}\right]} \tag{2.24}$$

instead of (2.23).

2.4 Discussion

Empirical relevance. The model emphasizes the importance of the correlation between financial currency mismatch at the country-level and exchange rate pass-through. These

two objects are endogenous in the data, and part of the rest of the paper will be about explaining why countries may end up borrowing too much in foreign currency when they have a low exchange rate pass-through to import prices. How does the correlation look like in the data? Figure 1 shows a cross-country scatterplot of net foreign exposure, defined as in Lane and Shambaugh (2010), against the share of imports that is invoiced in foreign currency (λ in the model). See Appendix A.2 for further detail and figures. There are a limited set of countries for which both currency mismatch and invoicing data are available, so this may only give a partial picture.

A downward sloping pattern would indicate hedging: countries with low import pass-through taking positive net foreign exposure and thus avoiding the sudden stop risk that we describe. The data show no such negative correlation. Figures A.1-A.3 find a similar pattern using alternative measures of foreign exposure and the share of exports invoiced in foreign currency ($1-\lambda^*$). In Figure 1 examples of countries that are most exposed to the channels we point out are Slovakia and Estonia, which feature a floating exchange rate, a negative foreign exchange exposure, and a small share of imports invoiced in foreign currency.

Pass-through, debt deflation and terms of trade. To clarify the role of incomplete exchange rate pass-through and how it interacts with intertemporal trade, note that net *real* debt repayment measured in units of Foreign tradables

$$\frac{\mathcal{E}_t}{P_{F,t}}\left(R^* F_t - F_{t+1}\right) = \mathcal{E}_t^{1-\lambda}\left(R^* F_t - F_{t+1}\right),$$

is not affected by nominal exchange rate policy $\mathcal{E}_t$ when pass-through to import prices is complete. In that case, the only effect of $\mathcal{E}_t$ on the country's external budget constraint is through export revenue. With a trade elasticity η^* strictly greater than 1, a nominal depreciation increases the quantity of exports $C^*_{H,t}$ more than it deteriorates terms of trade $\frac{\mathcal{E}_t P^*_{H,t}}{P_{F,t}} = \frac{1}{\mathcal{E}_t}$, leading to an increase in real revenue as measured by units of foreign goods. Conversely, if the trade elasticity η^* is smaller than 1, a depreciation leads the country to sell more units of Home tradables but at a lower price, leading to an overall decrease in real revenue: this creates incentives for monetary policy to appreciate.

We assume incomplete pass-through for two reasons. First, we try to capture in a tractable way some of the balance sheet effects of a nominal depreciation. As mentioned in

the introduction, there are many more such effects, for instance those linked to "financial accelerator" amplification mechanisms, where net worth of firms or banks limits investment due to limited pledgeability. Adding those features would alter the trade-off between expenditure switching and balance sheet effects towards a higher "fear of floating". Second, incomplete exchange rate pass-through is a well-known empirical regularity and the focus of a large literature, both positive (reviewed in Burstein and Gopinath, 2014) and normative in the presence of nominal rigidities (Devereux and Engel, 2003). As this discussion shows, this incompleteness also has consequences for the real effects of a depreciation when debt is denominated in foreign currency. Typical estimates put the short-run exchange rate pass-through λ between 0.3 and 0.7. We do not claim that λ is a structural parameter robust to policy experiments; one can interpret λ as being state-dependent and perhaps larger for large devaluations. An important extension (even without debt) would be to investigate how microeconomic price-setting and currency invoicing decisions of Foreign exporters (that determine λ) are affected by *equilibrium* domestic monetary policy and vice-versa.

Incidence of exchange rate policy. Relatedly, we can decompose the incidence of a change in the nominal exchange rate on different groups, for instance a marginal appreciation (decrease in $\mathcal{E}_t$). The point of FC debt contracts is to insulate Foreign creditors's payoffs from exchange rate movements. However, there are other international transfers that still depend on the nominal exchange rate. In fact, the denomination of transactions between Home borrowers and Foreign lenders at time $t-1$ creates a contractual externality on Foreign consumers and exporters through the reaction of the Home central bank at time t. Tirole (2003) analyzes the consequences of this "dual and common agency" problem in a broad range of settings. Let us illustrate the transfers supposing that at time t no further borrowing occurs ($F_{t+1} = 0$). Home debtors repay R^*F_t FC to Foreign creditors. Home consumers pay $\frac{\zeta}{\mathcal{E}_t^{1-\lambda}} - R^*F_t$ in FC to Foreign exporters, whose FC profits given a linear technology $Y^* = A^*L^*$ and a FC wage W^* are

$$\Pi_t^* = \frac{\zeta}{\mathcal{E}_t^{1-\lambda}} + \frac{W^*}{A^*}\mathcal{E}_t^{1-\lambda}R^*F_t - \frac{W^*}{A^*}\zeta - R^*F_t.$$

Home exporters send ζ Home goods to Foreign consumers against $\mathcal{E}_t^{-\lambda^*}\zeta$ in FC. Thus a marginal appreciation has no effect on Foreign creditors, always hurts Foreign consumers,

and decreases the profits of Foreign exporters if and only if

$$\frac{W^*}{A^*}R^*F_t > \zeta \mathcal{E}_t^{-2(1-\lambda)}.$$

In a domestic (and static) context with a single good, monetary policy has no redistributive effects once financial contracts are made insensitive to the price level. This no longer holds in an international context with multiple goods and *relative* price stickiness.

2.5 Heterogeneous households

We now consider a more general setting of a SOE with heterogeneous households. The existing literature has introduced "balance sheet effects"—defined as recessionary effects of a depreciation in presence of foreign currency debt—by considering heterogeneous agents within the country or financial constraints. Recent examples include Aoki et al. (2017) and Bocola and Lorenzoni (2018) who focus on maturity mismatched banks, whose net worth determine the strength of domestic financial frictions.

We show that the neutrality results in Section 2.3 also hold in this case. There are a unit mass of households $i \in [0,1]$ with Pareto weights θ_i, where $\int \theta_i di = 1$. The government uses household-specific lump-sum transfers as in Farhi and Werning (2016). In this case:

Definition 4. *The* myopic *monetary policy problem with heterogeneous households given household i net debt repayment $x_i = R^*F_i - F_i'$ is:*

$$\max_{\{C_{Fi},N_i\}_{\forall i},\, \mathcal{E}} \quad \int \theta_i U(\alpha \mathcal{E}^{\lambda} C_{Fi}, C_{Fi}, N_i) di \tag{2.25}$$

$$s.t. \quad \int N_i di = \frac{\alpha \mathcal{E}^{\lambda} \int C_{Fi} di + \zeta \mathcal{E}^{\lambda^* \eta^*}}{A}, \tag{2.26}$$

$$\int C_{Fi} di = \mathcal{E}^{1-\lambda^*-\lambda+\lambda^*\eta^*}\zeta - \mathcal{E}^{1-\lambda} \int x_i di, \tag{2.27}$$

$$\frac{\chi N_{it}^{\psi}}{\omega / C_{Hit}} = \frac{\chi N_{jt}^{\psi}}{\omega / C_{Hjt}} \quad \forall i \neq j. \tag{2.28}$$

where (2.25) uses the household i expenditure switching condition for C_{Hi}, (2.26) is the labor market clearing condition, and (2.27) is the balance of payments condition. The final implementability condition (2.28) is from the optimal labor supply decision, which must be equalized across households given they face the same nominal wage.

The solution to this problem gives the following:

Proposition 2. *The myopic monetary policy with heterogeneous households satisfies*

$$\tau_i = \frac{(1-\lambda)\frac{\int x_i di}{\zeta}\mathcal{E}^{1-\lambda^*\eta^*} - (1-\lambda-\lambda^*+\lambda^*\eta^*)\mathcal{E}^{1-\lambda^*} + \lambda^*\eta^*}{\alpha\left[(1-\lambda^*+\lambda^*\eta^*)\mathcal{E}^{1-\lambda^*} - \frac{\int x_i di}{\zeta}\mathcal{E}^{1-\lambda^*\eta^*}\right] + \lambda^*\eta^*}, \tag{2.29}$$

where the individual household i labor wedge

$$\tau_{it}\left(C_{Fi,t}, \mathcal{E}_t\right) \equiv 1 + \frac{U_{Ni,t}}{A_t U_{C_{Hi,t}}} \tag{2.30}$$

is equalized for all households i.

Proposition 2 implies that Corollary 1 and Remark 1 extend to this case with heterogeneous households, and the optimal myopic monetary policy targets a zero labor wedge across all households. This shows that even with potential redistributive effects of monetary policy, balance sheet effects and external foreign currency debt act as a constraint only if exchange rate pass-through is incomplete.

3 Optimal policy with perfect instruments

In this section, we solve for the optimal joint monetary and macroprudential policies when arbitrary state-contingent macroprudential taxes are available.

Definition 5. *The Ramsey problem at time 0 solves for the Ramsey policy (path)* $\{\mathcal{E}_t(s^t), \tau_t^F(s^t)\}$ *such that no policy yields an equilibrium with a strictly higher welfare* (2.1).

Note that this definition assumes full commitment. For expository purposes, from now on we will make the following assumption to abstract from the terms-of-trade manipulation motive:

Assumption 2. $1-\lambda-\lambda^*(1-\eta^*) = 0$.

Without Assumption 2, all the results would go through up to a shift in labor wedges purely driven by the well-understood optimal tariff problem. Under Assumption 2, the

country budget constraint simplifies to

$$C_{F,t} \leq \zeta - \mathcal{E}_t^{1-\lambda} \left(R^* F_t - F_{t+1} \right). \tag{3.1}$$

It is useful to replace the planner's control variables $\{\tau_t^F(s^t)\}$ by $\{F_{t+1}(s^t)\}$ and express the Ramsey problem in terms of indirect utility:

Problem 1 (Ramsey)**.**

$$W(F_0, s_0) = \max_{\{\mathcal{E}_t, C_{F,t}, F_{t+1}\}_{t,s^t}} \quad E_0 \left[\sum_{t=0}^{\infty} \beta^t V(C_{F,t}, \mathcal{E}_t) \right] \tag{3.2}$$

$$s.t.\ \forall t \geq 0, s^t \quad C_{F,t}(s^t) \leq \zeta - \mathcal{E}_t(s^t)^{1-\lambda} \left[R^* F_t(s^{t-1}) - F_{t+1}(s^t) \right] \tag{3.3}$$

$$F_{t+1}(s^t) \leq B(s_t). \tag{3.4}$$

Given the optimal allocation we can then back out taxes as $\tau_t^F = \frac{U_{C_F,t}}{\beta R^* E_t \left[U_{C_F,t+1} \right]} - 1$. While expectations of future monetary policy are key determinants of private portfolios in any equilibrium, the Ramsey problem endows the planner with a wide enough set of instruments that no time-inconsistent exchange rate commitment arises in the Ramsey-optimal equilibrium:

Lemma 1 (Time consistency)**.**

- *The Ramsey policy is time-consistent: conditional on F_{t+1}, the time $t-$planner and the time $t+1-$planner share the same objective hence choose the same policies from $t+1$ onwards.*
- *Denote $\{F_{t+1}(s^t)\}_{t\geq 0}$ the Ramsey optimal path of debt. Then the Ramsey monetary policy $\{\mathcal{E}_t(s^t)\}_{t\geq 0}$ is myopic:*

$$\forall s^t, \mathcal{E}_t(s^t) = \mathcal{E}^m \left(R^* F_t(s^{t-1}) - F_{t+1}(s^t) \right).$$

Without restrictions on macroprudential policy, date-t financial decisions can be decoupled entirely from date-$(t+1)$ policies, because an appropriate macroprudential tax at time t can always undo the effect of exchange rate expectations and impose the date-t planner's desired borrowing. The more general argument is that time inconsistency of benevolent policymakers with time-consistent preferences can only arise due to differences in the

successive planners' implementability constraints. In Problem 1 this does not happen as the only such constraints are the country budget and borrowing constraints. Later sections in this paper will examine conditions that break the time-consistency of the planning problem.

Implementation. Problem 1 determines the optimal intertemporal wedges imposed on the private sector. These wedges can be seen as macroprudential taxes on debt τ^F, but an equally valid interpretation is that the country's capital account is completely closed and $-F_t$ denotes the central bank's official reserves at time t. In fact, once we allow for official sector borrowing and lending, there is a continuum of intermediate implementations where the official sector combines some reserves with macroprudential taxes that prevent the private sector from offsetting these gross positions.

Moreover, monetary policy should be taken in a broad sense, because we assumed that any exchange rate can be implemented at a negligible cost. In the simple model uncovered interest parity is sufficient, but in reality foreign exchange interventions might be part of the tools. However they must be used in combination with some kind of financial taxes, again to prevent the private sector from undoing completely the central bank's position.

3.1 Optimal policies after the sudden stop

Given time consistency, we start the analysis backwards by solving for $\underline{W}(F_T)$, the continuation utility when the economy enters state $\underline{s}$ at time T with debt R^*F_T and the planner reoptimizes. $\underline{W}$ will serve as boundary condition for the full stochastic Ramsey problem. Once the sudden stop hits at T there is no further uncertainty, so that $\underline{W}$ solves

$$\begin{aligned} \underline{W}(F_T) = \max_{\{\mathcal{E}_t, C_{F,t}\}_{t\geq T}} & \sum_{t=T}^{\infty} \beta^{t-T} V(C_{F,t}, \mathcal{E}_t) \\ \text{s.t.} \quad & C_{F,T} \leq \zeta - \mathcal{E}_T^{1-\lambda} R^* F_T \\ & C_{F,t} \leq \zeta \qquad\qquad \forall t \geq T+1. \end{aligned} \tag{3.5}$$

Proposition 3 (Optimal policy in the sudden stop)**.** *Suppose that $\lambda < 1$ and the sudden stop shock hits at time T when outstanding debt is $R^*F_T > 0$.*

- *At time T there is a recession $\tau_T > 0$ and it is increasing in R^*F_T: The higher the outstanding FC external debt R^*F_T, the deeper the recession when a sudden stop hits.*

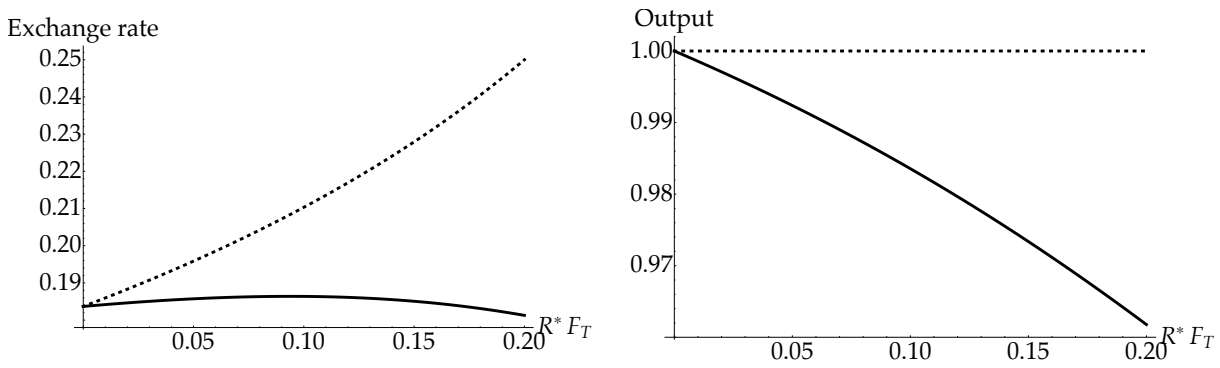


Figure 2: Solid line: optimal exchange rate $\mathcal{E}_T$ and domestic output $A_T L_T$ during the sudden stop as a function of outstanding debt $R^* F_T$. Dotted line: exchange rate when targeting $\tau = 0$, or equivalently stabilizing domestic output at the flexible price level.

- *There exists $\widehat{F} > 0$ such that the optimal exchange rate policy $\mathcal{E}_T$ is increasing in F_T for $F_T \leq \widehat{F}$ and decreasing in F_T for $F_T > \widehat{F}$.*

Figure 2 shows how the optimal policy during a sudden stop (solid line) is affected by foreign currency denominated external debt, and relative to policy which targets a zero labor wedge $\tau = 0$ and hence the flexible price level of output (dotted line). The optimal policy trades-off the expenditure switching effect with the balance sheet effects of debt revaluation (relative to the price of imports) and thus limits the depreciation, at the cost of allowing lower output and employment in the domestic sector. The expenditure switching motive dominates at low levels of debt and monetary policy depreciates. The second, financial, motive grows stronger as debt grows larger: once $R^* F_T$ reaches a sufficiently large level, a marginal increase in debt can even imply a marginal appreciation of the exchange rate (i.e. monetary tightening) in case of sudden stop.

Under the policy regime that only seeks to stabilize Home output (which would be the optimal policy if $\lambda = 1$), a larger exchange rate depreciation must take place. This is to achieve greater expenditure switching (increasing relative demand from Foreign imports to Home goods). The higher the outstanding debt in the sudden stop, the higher the required current account surplus, therefore the larger the needed depreciation.

Relation to liquidity traps. It is useful to contrast the balance sheet recession obtained here with the one described by Eggertsson and Krugman (2012). In both settings, there are two groups of agents, borrowers and savers, and an exogenous shock forces borrowers to

repay outstanding debt and cut on consumption. The debt repayment generates a transfer problem: the increase in savers' income does not fully translate into consumption because savers have a lower marginal propensity to consume out of transitory income (MPC) than borrowers. To keep aggregate consumption and thus output constant, the optimal response of monetary policy to such a shock is to lower the nominal interest rate, and therefore the real rate (assuming sticky prices), which induces savers to redirect consumption from future to present goods. If the real rate declines sufficiently, savers will fully pick up the slack; but the higher the debt repayment by borrowers, the larger the required drop in the real rate. If outstanding debt is high enough, the zero lower bound on nominal interest rates puts a lower bound on the real rate, and aggregate consumption must fall. In the model, savers are Foreigners whose preferences imply a *zero* marginal propensity to consume Home goods out of transitory income because the Home country is small. Therefore, under Assumption 2, a depreciation does not serve to redirect savers' consumption from future goods to present goods, but to redirect borrowers' consumption from foreign to domestic goods. There is no zero lower bound that would prevent monetary policy from achieving perfect aggregate demand management past a certain debt threshold. Nonetheless, any positive level of debt will imply a trade-off between aggregate demand management and cutting on imports consumption.

3.2 Optimal ex-ante policies

With the boundary condition $\underline{W}$ in hand, we turn to a characterization of optimal policies in normal times. The optimality conditions of the Ramsey problem imply that the Ramsey plan can be implemented by a macroprudential tax on FC borrowing τ_t^F given by:

$$1+\tau_t^F = E_t\left[\frac{1+\alpha\tau_{t+1}}{1+\alpha\tau_t}\right] + Cov_t\left[\frac{U_{C_F,t+1}}{E_t\left[U_{C_F,t+1}\right]}, \frac{1+\alpha\tau_{t+1}}{1+\alpha\tau_t}\right]. \tag{3.6}$$

The optimal Pigouvian corrective tax for endogenous aggregate demand externalities has the same form as in Farhi and Werning (2016). The first term is an intertemporal term designed to reallocate demand towards states with relatively larger labor wedges. The second term is a hedging term that augments the tax when the labor wedge depreciates in bad times (high marginal utility). The difference with Farhi and Werning (2016) is that the labor wedges and therefore macroprudential policy depend on exchange rate pass-through:

for instance, under DCP, $\tau_{t+1} = \tau_t = 0$ hence $\tau_t^F = 0$ for all t.

To study the dynamics of external debt during the credit boom, it is useful to remark that Problem 1 is a Bewley-Huggett-Aiyagari precautionary savings problem for an agent facing uninsurable sudden stop risk[10], with the extra feature that the ex-post cost of capital on external debt for domestic agents can be affected by exchange rate policy. Since the Ramsey optimal monetary policy is myopic, the analogy with the savings problem is straightforward: monetary policy plays the role of endogenous labor supply. Denote

$$C_F(x_t) = \zeta + \mathcal{E}^m(-x_t)^{1-\lambda}x_t,$$
$$\widetilde{U}(x_t) = V(C_F(x_t), \mathcal{E}^m(-x_t)).$$

Then (1) is equivalent, in recursive form, to the savings problem

$$W(F) = \max_{\{x,F'\}} \quad \widetilde{U}(x) + \beta\left[\pi\underline{W}(F') + (1-\pi)W(F')\right] \tag{3.7}$$
$$\text{s.t.} \quad x = F' - R^*F. \tag{3.8}$$

Since there is no growth and $\widetilde{U}' > 0$, $\widetilde{U}'' < 0$, the impatience condition implies that there is a target level of debt $F_\infty > 0$ such that for any initial debt F_0 the external debt of the country under the Ramsey plan converges monotonically to F_∞.

Figure 3 shows simulated paths of the economy for a sudden stop shock occurring at $t = 6$. The red line corresponds to the Ramsey plan. The blue dashed line ("laissez-faire") corresponds to an equilibrium with no macroprudential policy, $\tau_t^F = 0$ for all t, and myopic monetary policy. This is an interesting but somewhat unfair benchmark, because, as discussed in the next section, the optimal monetary policy when no macroprudential policy is available is no longer myopic. The laissez-faire path features a credit boom from 10% to 70% of GDP. Once the sudden stop hits, monetary policy's response given this large outstanding debt is to sharply appreciate the exchange rate, even though this contracts the domestic sector. By contrast, the optimal macroprudential tax starting at above 3% and reaching 4% largely tempers the credit boom, with debt only reaching 20% of GDP as the sudden stop hits. Although domestic output and imported consumption are lower during the boom, the benefit is that monetary policy is able to depreciate in reaction to the shock

[10]The connection between optimal taxation under incomplete markets and precautionary savings models has been made in a related context by Aiyagari, Marcet, Sargent and Seppälä (2002).

and output drops by much less.

4 Imperfect macroprudential instruments

Problem 1 allows for unrestricted exchange rate and macroprudential policies, and we have seen that the resulting optimal macroprudential tax on debt is state-dependent. In practice, countries subject to sudden stop risk might have difficulties implementing sophisticated macroprudential policy in the short run. As monetary policy remains the most flexible and well-understood instrument, how should it be conducted to stand in for a constrained macroprudential policy?

The first relevant observation is that the time consistency result of Lemma 1 need no longer hold once macroprudential policy is suboptimal. We illustrate this and compare the optimal monetary policies under commitment and discretion. To simplify, suppose in this section that the sudden stop is fully anticipated. The country enters time 0 with a (low) stock of debt $R^*F_0 \geq 0$ and agents borrow unconstrained. The sudden stop happens with certainty at time 1, and the economy is in financial autarky from time 2 on. Macroprudential policy is unavailable, hence the free capital mobility Euler equation

$$U_{C_F,0} = \beta R^* \left(\frac{\mathcal{E}_1}{\mathcal{E}_0}\right)^{1-\lambda} U_{C_F,1}, \tag{4.1}$$

must hold in any equilibrium. When debt is denominated in FC and pass-through is incomplete, monetary policy can affect borrowing both through wealth effects and a substitution effect.

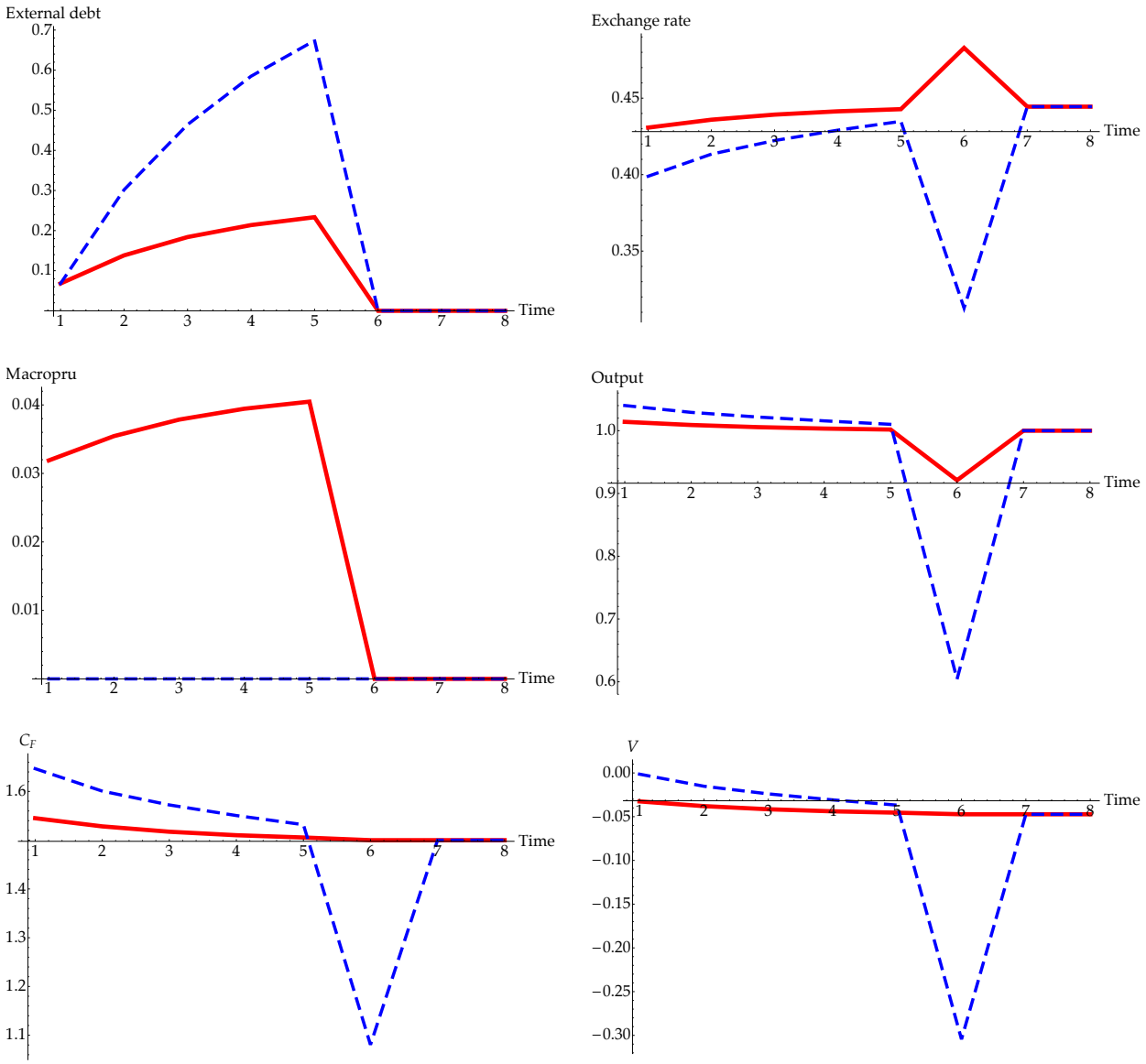


Figure 3: Simulated paths for sudden stop shock at $t = 6$. Solid red line: Ramsey policy. Blue dashed line: Myopic monetary policy without macroprudential policy.

4.1 Full commitment: the insurance channel of monetary policy

First suppose that monetary policy has full commitment power at time 0. The planning problem is Problem 1 to which we add (4.1) as an additional implementability condition:

$$\max_{\mathcal{E}_0,\mathcal{E}_1,C_{F,0},C_{F,1},F_1} \quad V(C_{F,0},\mathcal{E}_0)+\beta V(C_{F,1},\mathcal{E}_1) \tag{4.2}$$

$$\text{s.t.} \quad C_{F,0} \leq \zeta + \mathcal{E}_0^{1-\lambda}\left[F_1 - R^* F_0\right] \tag{4.3}$$

$$C_{F,1} \leq \zeta - \mathcal{E}_1^{1-\lambda} R^* F_1 \tag{4.4}$$

$$\frac{\mathcal{E}_0^{1-\lambda}}{C_{F,0}} = \beta R^* \frac{\mathcal{E}_1^{1-\lambda}}{C_{F,1}}. \tag{4.5}$$

The program is truncated at time 1 because the sudden stop breaks intertemporal linkages between periods 1 and 2, and dates following the sudden stop will just feature the natural allocation.

Proposition 4. *The equilibrium borrowing F_1 is above the Ramsey level (obtained with unconstrained macroprudential policy). The optimal monetary policy appreciates more at date-0 and depreciates more at date-1 than the myopic policies given equilibrium debt levels, hence the promised exchange rate $\mathcal{E}_1$ is time-inconsistent.*

This result connects to what Caballero and Krishnamurthy (2004a) call the "insurance channel" of monetary policy, in an alternative model based on pecuniary externalities. Absent macroprudential tools that would allow the planner to decouple borrowing incentives from monetary policy expectations, commitment becomes valuable. The central bank wishes to reduce the ex-ante current account deficit ($F_1 - R^* F_0$) by promising a costly depreciation for households leveraged in foreign currency, thereby increasing the real cost of capital. However, even if this succeeds in decreasing the amount of external debt outstanding at the time of the sudden stop, a reoptimizing monetary policy still wants to depreciate less than what it optimally committed to ex-ante. As in Klein, Krusell and Rios-Rull (2008), the time-inconsistency arises not due to differences in objectives between successive planners, as they share the same welfare function *conditional on* F_1, but to differences in the constraint sets: ex-ante, a marginal increase in $\mathcal{E}_1$ allows to relax the implementability constraint (4.5), while ex-post borrowing choices are sunk and the constraint is lifted.

Importantly, the policy experiment of this subsection has no counterpart in the liquidity

trap literature: for a similar deleveraging shock occurring at time 1, the optimal monetary policy during the resulting liquidity trap is to set the nominal interest rate i_1 at 0, both under commitment and discretion. There is also no relation to forward guidance, which can only apply to variables that remain under the control of monetary policy, i.e. interest rates that follow the exit from the liquidity trap. Time-inconsistently low future interest rates are aimed instead at stimulating consumption during the liquidity trap, while time-inconsistently high future interest rates cannot deter borrowing before the liquidity trap (again because the deleveraging shock breaks intertemporal incentives).

4.2 No commitment and preventive tightening

If monetary policy lacks credibility, it loses the ability to decrease debt F_1 (increase private hedging) through a time-inconsistent commitment to depreciate. The only available instrument is now the date-0 exchange rate. The finite horizon prevents reputational mechanisms of the kind in Chari and Kehoe (1990). To ease notation, we can solve the private portfolio problem in closed form. For given $\mathcal{E}_0 > 0$ and exchange rate expectation $\mathcal{E}_1 > 0$ denote

$$\phi_1\left(F_0, \mathcal{E}_0, \mathcal{E}_1\right) = \frac{1}{1+\beta}\left[\beta R^* F_0 + \zeta\left(\frac{1}{R^* \mathcal{E}_1^{1-\lambda}} - \frac{\beta}{\mathcal{E}_0^{1-\lambda}}\right)\right], \tag{4.6}$$

as the borrowing F_1 that solves the equilibrium Euler equation (4.5).

Definition 6. *A Markov perfect equilibrium (MPE) is an equilibrium*

$$\{\mathcal{E}_0, \mathcal{E}_1, F_1, C_{F,1}, C_{F,0}\}$$

such that:

- $\{\mathcal{E}_0, C_{F,0}, C_{F,1}, F_1\}$ *solve the date-0 central bank's problem*

$$\max_{\mathcal{E}_0, C_{F,0}, C_{F,1}, F_1} \quad V(C_{F,0}, \mathcal{E}_0) + \beta V(C_{F,1}, \mathcal{E}^m(R^* F_1)) \tag{4.7}$$

$$\text{s.t.} \quad C_{F,0} = \zeta + \mathcal{E}_0^{1-\lambda}\left[F_1 - R^* F_0\right] \tag{4.8}$$

$$C_{F,1} = \zeta - \mathcal{E}^m (R^* F_1)^{1-\lambda} R^* F_1 \tag{4.9}$$

$$F_1 = \phi_1\left(F_0, \mathcal{E}_0, \mathcal{E}^m(R^* F_1)\right) \tag{4.10}$$

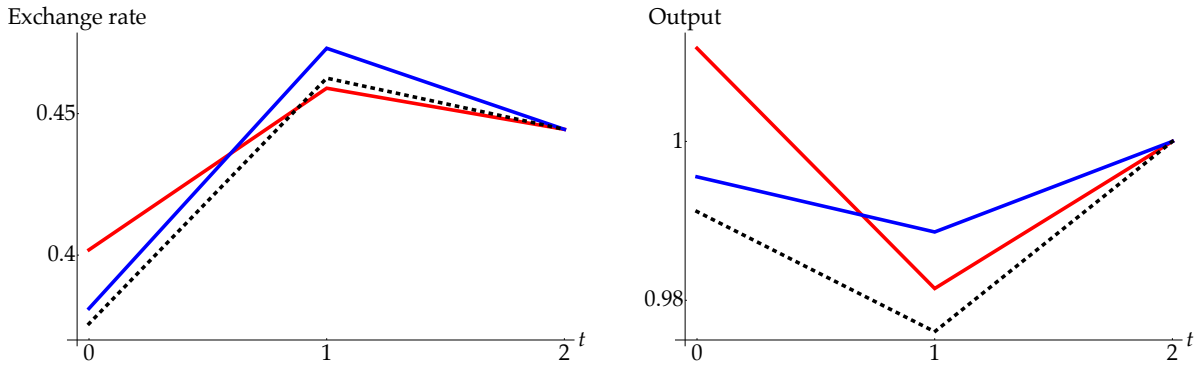


Figure 4: Red solid line: Ramsey. Blue solid line: No macroprudential policy, full monetary policy commitment. Black dotted line: No macroprudential policy, MPE.

- *The date-1 exchange rate is time consistent:* $\mathcal{E}_1 = \mathcal{E}^m(R^* F_1)$.

This definition of Markov perfect equilibrium assumes that the date-0 central bank is able to select its preferred households' expectations about $\mathcal{E}_1$ as long as they are consistent with the corresponding future reaction to the aggregate debt level.

Proposition 5. *Let* $\mathcal{E}_0^{MPE}$, $\mathcal{E}_0^c$ *and* $\mathcal{E}_0^R$ *denote the optimal MPE, commitment, and Ramsey date-0 exchange rate respectively. Then*

$$\mathcal{E}_0^{MPE} < \mathcal{E}_0^c < \mathcal{E}_0^R.$$

Figure 4 compares the dynamics of exchange rate and output for our different assumptions on policy instruments. The red solid line depicts the Ramsey plan. Under this scenario, external debt is limited at $F_1 = 0.1$ thanks to the macroprudential tax set according to formula (3.6) which gives $\tau_0^F = 7\%$. As a consequence, monetary policy is able to depreciate in period 1, and does not need to tighten in period 0. This benchmark contrasts with what happens when τ_0^F is restricted at zero. If monetary policy has full commitment (blue solid line), it promises a large depreciation $\mathcal{E}_1 = 0.5$, combined with some limited ex-ante tightening. This is time-inconsistent because at the induced private external debt $F_1 = 0.12$ (which is therefore much larger than the Ramsey level, as hinted by the large macroprudential tax that the Ramsey plan requires), the optimal discretionary exchange rate at time 1 would be around 0.47. If we impose time consistency and Markov perfect equilibrium (black dotted line), date-0 monetary policy tries to affect private sector borrowing F_1 without taking into account the effect of F_1 on future monetary policy incen-

tives. By tightening strongly at time 0, monetary policy is able to reduce F_1 to around 0.12, but this comes at the cost of a significant drop in $Y_{H,0}$ (to around 0.98).

5 Conclusion

In this paper, we have shown that the interaction between incomplete exchange rate pass-through and foreign currency debt can act as a constraint on monetary policy. When pass-through to import prices is complete, nominal exchange rate depreciations have no balance sheet effects because they are fully offset by strong expenditure switching effects. When pass-through is incomplete, however, expenditure switching is dampened while debt revaluation is still in full force. Therefore, monetary policy faces a trade-off following a shock, such as a sudden stop, that would normally call for a sharp depreciation, and the more outstanding foreign currency debt the country has, the less the central bank is able to depreciate. As a result, output contracts in spite of flexible exchange rates. We explored the consequences of this trade-off for macroprudential policy and monetary policy with commitment and under discretion.

To isolate the role of incomplete exchange rate pass-through, we focused on the case where all the external debt is in foreign currency. Local currency denominated debt introduces issues of central bank credibility, as in work on *sovereign* debt by Du et al. (2018) and Ottonello and Perez (2018). Fanelli and Wang (2018) combine the insights of this paper with *private* portfolio choices between several currencies, as in Fanelli (2018), to formalize the interactions between macroprudential and monetary policy as a dual and common agency game (Tirole, 2003) and derive capital control formulas on different types of assets, showing how they depend on—and affect—the credibility of monetary policy.

References

Aghion, Philippe, Philippe Bacchetta, and Abhijit Banerjee (2004), "A corporate balance-sheet approach to currency crises", *Journal of Economic theory*, Vol. 119, pp. 6–30.

Aiyagari, S Rao, Albert Marcet, Thomas J Sargent, and Juha Seppälä (2002), "Optimal Taxation without State-Contingent Debt", *Journal of Political Economy*, Vol. 110, pp. 1220–1254.

Albanesi, Stefania, Varadarajan V Chari, and Lawrence J Christiano (2003), "Expectation traps and monetary policy", *The Review of Economic Studies*, Vol. 70, pp. 715–741.

Aoki, Kosuke, Gianluca Benigno, and Nobuhiro Kiyotaki (2017), "Monetary and Financial Policies in Emerging Markets", working paper.

Auclert, Adrien, Matthew Rognlie, Martin Souchier, and Ludwig Straub (2021), "Exchange rates and monetary policy with heterogeneous agents: Sizing up the real income channel",Technical report, National Bureau of Economic Research.

Basu, Suman S, Emine Boz, Gita Gopinath, Francisco Roch, and D Filiz Unsal (2025), "Integrated monetary and financial policies for small open economies", *Econometrica*, Vol. 93, pp. 2201–2234.

Bénétrix, Agustín S, Philip R Lane, and Jay C Shambaugh (2015), "International currency exposures, valuation effects and the global financial crisis", *Journal of International Economics*, Vol. 96, pp. S98–S109.

Betts, Caroline and Michael B Devereux (2000), "Exchange rate dynamics in a model of pricing-to-market", *Journal of international Economics*, Vol. 50, pp. 215–244.

Bianchi, Javier and Louphou Coulibaly (2022), "Liquidity traps, prudential policies, and international spillovers",Technical report, National Bureau of Economic Research.

Bocola, Luigi and Guido Lorenzoni (2018), "Financial Crises, Dollarization, and Lending of Last Resort in Open Economies", working paper.

Bohn, Henning (1990), "A positive theory of foreign currency debt", *Journal of International Economics*, Vol. 29, pp. 273–292.

Burstein, Ariel and Gita Gopinath (2014), "International Prices and Exchange Rates", *Handbook of International Economics*, Vol. 4, pp. 391–451.

Caballero, Ricardo J and Arvind Krishnamurthy (2004a), "Inflation targeting and sudden stops", in *The Inflation-Targeting Debate*: University of Chicago Press, pp. 423–446.

——— (2004b), "Smoothing sudden stops", *Journal of Economic Theory*, Vol. 119, pp. 104–127.

Calvo, Guillermo A (1988), "Servicing the public debt: The role of expectations", *The American Economic Review*, pp. 647–661.

Céspedes, Luis Felipe, Roberto Chang, and Andrés Velasco (2004), "Balance Sheets and Exchange Rate Policy", *The American Economic Review*, Vol. 94, pp. 1183–1193.

Chari, Varadarajan V and Patrick J Kehoe (1990), "Sustainable plans", *Journal of Political Economy*, pp. 783–802.

Cole, Harold L and Maurice Obstfeld (1991), "Commodity trade and international risk sharing: How much do financial markets matter?", *Journal of Monetary Economics*, Vol. 28, pp. 3–24.

Corsetti, Giancarlo and Paolo Pesenti (2005), "International dimensions of optimal monetary policy", *Journal of Monetary economics*, Vol. 52, pp. 281–305.

Devereux, Michael B and Charles Engel (2003), "Monetary policy in the open economy revisited: Price setting and exchange-rate flexibility", *The Review of Economic Studies*, Vol. 70, pp. 765–783.

Du, Wenxin, Carolin Pflueger, and Jesse Schreger (2018), "Sovereign Debt Portfolios, Bond Risks, and the Credibility of Monetary Policy", working paper.

Eggertsson, Gauti B. and Paul Krugman (2012), "Debt, Deleveraging, and the Liquidity Trap: A Fisher-Minsky-Koo Approach*", *The Quarterly Journal of Economics*, Vol. 127, pp. 1469–1513.

Egorov, Konstantin and Dmitry Mukhin (2023), "Optimal policy under dollar pricing", *American Economic Review*, Vol. 113, pp. 1783–1824.

Fanelli, Sebastián (2018), "Monetary Policy, Capital Controls, and International Portfolios", working paper.

Fanelli, Sebastián and Olivier Wang (2018), "Monetary Policy Credibility and Private Portfolios", working paper.

Farhi, Emmanuel and Matteo Maggiori (2018), "A Model of the International Monetary System", *The Quarterly Journal of Economics*, Vol. 133, pp. 295–355.

Farhi, Emmanuel and Jean Tirole (2012), "Collective Moral Hazard, Maturity Mismatch, and Systemic Bailouts", *American Economic Review*, Vol. 102, pp. 60–93.

Farhi, Emmanuel and Iván Werning (2014), "Dilemma not Trilemma? Capital Controls and Exchange Rates with Volatile Capital Flows", *IMF Economic Review (Special Volume in Honor of Stanley Fischer)*, Vol. 62, pp. 569–605.

Farhi, Emmanuel and Iv'an Werning (2016), "A Theory of Macroprudential Policies in the Presence of Nominal Rigidities", *Econometrica*, Vol. 84, pp. 1645–1704.

Galí, Jordi and Tommaso Monacelli (2005), "Monetary Policy and Exchange Rate Volatility in a Small Open Economy", *The Review of Economic Studies*, Vol. 72, pp. 707–734.

Gopinath, Gita (2016), "The International Price System", *Jackson Hole Symposium Proceedings*.

Gopinath, Gita, Emine Boz, Camila Casas, Federico J. Díez, Pierre-Olivier Gourinchas, and Mikkel Plagborg-Møller (2020), "Dominant Currency Paradigm", *American Economic Review*, Vol. 110, p. 677?719.

Gopinath, Gita and Oleg Itskhoki (2022), "Dominant currency paradigm: A review", *Handbook of international economics*, Vol. 6, pp. 45–90.

Gopinath, Gita and Jeremy C. Stein (2018), "Banking, Trade and the Making of a Dominant Currency", working paper.

Guerrieri, Veronica and Guido Lorenzoni (2011), "Credit Crises, Precautionary Savings, and the Liquidity Trap", Working Paper 17583, National Bureau of Economic Research.

Jeanne, Olivier and Anton Korinek (2017), "Macroprudential Regulation Versus Mopping Up After the Crash", Working Paper 18675, National Bureau of Economic Research.

Klein, Paul, Per Krusell, and Jose-Victor Rios-Rull (2008), "Time-consistent public policy", *The Review of Economic Studies*, Vol. 75, pp. 789–808.

Korinek, Anton and Alp Simsek (2016), "Liquidity Trap and Excessive Leverage", *American Economic Review*, Vol. 106, pp. 699–738.

Krugman, Paul (1999), "Balance sheets, the transfer problem, and financial crises", in *International finance and financial crises*: Springer, pp. 31–55.

Lane, Philip R. and Jay C. Shambaugh (2010), "Financial Exchange Rates and International Currency Exposures", *American Economic Review*, Vol. 100, pp. 518–40.

McLeay, Michael and Silvana Tenreyro (2026), "Dollar dominance and the transmission of monetary policy", *The Quarterly Journal of Economics*, Vol. 141, pp. 605–666.

Mian, Atif, Amir Sufi, and Emil Verner (2017), "Household Debt and Business Cycles Worldwide*", *The Quarterly Journal of Economics*, Vol. 132, pp. 1755–1817.

Ottonello, Pablo and Diego Perez (2018), "The Currency Composition of Sovereign Debt", *American Economic Journal: Macroeconomics*.

Schmitt-Grohé, Stephanie and Martín Uribe (2016), "Downward Nominal Wage Rigidity, Currency Pegs, and Involuntary Unemployment", *Journal of Political Economy*, Vol. 124, pp. 1466–1514.

Schneider, Martin and Aaron Tornell (2004), "Balance sheet effects, bailout guarantees and financial crises", *The Review of Economic Studies*, Vol. 71, pp. 883–913.

Tirole, Jean (2003), "Inefficient foreign borrowing: A dual-and common-agency perspective", *The American Economic Review*, Vol. 93, pp. 1678–1702.

A Appendix

A.1 Theoretical Appendix

Proof of Proposition 1. Let μ be the multiplier on the balance of payments (2.20). The first-order conditions are

$$V_{C_F} = \mu \tag{A.1}$$

$$V_{\mathcal{E}} + \mu \left(\left(1 - \lambda^* - \lambda + \lambda^* \eta^*\right) \mathcal{E}^{-\lambda^* - \lambda + \lambda^* \eta^*} \zeta - (1 - \lambda) \mathcal{E}^{-\lambda} x \right) = 0 \tag{A.2}$$

Substituting for V_{C_F} and $V_{\mathcal{E}}$ from (2.21) and (2.22) and rearranging gives

$$\tau = \frac{(1-\lambda)\frac{x}{\zeta}\mathcal{E}^{1-\lambda^*\eta^*} - \left(1 - \lambda - \lambda^* + \lambda^*\eta^*\right)\mathcal{E}^{1-\lambda^*} + \lambda^*\eta^*}{\alpha\left[\left(1 - \lambda^* + \lambda^*\eta^*\right)\mathcal{E}^{1-\lambda^*} - \frac{x}{\zeta}\mathcal{E}^{1-\lambda^*\eta^*}\right] + \lambda^*\eta^*}$$

□

Proof of Proposition 2. We solve a relaxed version of the policy problem in Definition 4 dropping the final constraint (2.28), verify that in any solution (2.28) must be satisfied.

This relaxed problem is

$$\begin{aligned}
\max_{C_{Hi}, C_{Fi}, N_i, \mathcal{E}} \quad & = \int \theta_i \left[\omega \log C_{Hi} + (1-\omega) \log C_{Fi} - \chi \frac{N_i^{1+\psi}}{1+\psi} \right] di \\
s.t. \qquad C_{Hi} &= \alpha \mathcal{E}^{\lambda} C_{Fi} \\
\int N_i di &= \frac{\alpha \mathcal{E}^{\lambda} \int C_{Fi} di + \zeta \mathcal{E}^{\lambda^* \eta^*}}{A} \\
\int C_{Fi} di &= \mathcal{E}^{1-\lambda^*-\lambda+\lambda^*\eta^*}\zeta - \mathcal{E}^{1-\lambda} \int x_i di
\end{aligned}$$

The first-order condition w.r.t. C_{Hi} for households i and j gives

$$\frac{C_{Hi}}{C_{Hj}} = \frac{\theta_i}{\theta_j}, \tag{A.3}$$

and the first-order condition w.r.t. N_i

$$-\theta_i \chi N_i^{\psi} = -\theta_j \chi N_j^{\psi}. \tag{A.4}$$

Combining these verifies that

$$\frac{\chi N_{it}^{\psi}}{\omega/C_{Hit}} = \frac{\chi N_{jt}^{\psi}}{\omega/C_{Hjt}} \quad \forall i \neq j, \tag{A.5}$$

and the individual labor wedge τ_i must be equalized across households.

Let μ_{1i}, μ_2 and μ_3 denote the multipliers on the constraints of the relaxed problem above. The first-order conditions w.r.t. C_{Fi} and $\mathcal{E}$ are

$$\theta_i \frac{1-\omega}{C_{Fi}} + \mu_{1i}\alpha\mathcal{E}^{\lambda} + \mu_2 \frac{\alpha\mathcal{E}^{\lambda}}{A} = \mu_3, \tag{A.6}$$

$$\int \mu_{1i}\alpha\lambda\mathcal{E}^{\lambda-1}C_{Fi}di + \mu_2 \frac{\alpha\lambda\mathcal{E}^{\lambda-1}\int C_{Fi}di + \zeta\lambda^*\eta^*\mathcal{E}^{\lambda^*\eta^*-1}}{A}$$
$$+ \mu_3\left[(1-\lambda^*-\lambda+\lambda^*\eta^*)\mathcal{E}^{-\lambda^*-\lambda+\lambda^*\eta^*}\zeta - (1-\lambda)\mathcal{E}^{-\lambda}\int x_i di\right] = 0. \tag{A.7}$$

Combining these expressions, the conditions for C_{Hi} and N_i, substituting for τ_i from (2.30) and rearranging gives

$$\tau_i = \frac{(1-\lambda)\frac{\int x_i di}{\zeta}\mathcal{E}^{1-\lambda^*\eta^*} - (1-\lambda-\lambda^*+\lambda^*\eta^*)\mathcal{E}^{1-\lambda^*} + \lambda^*\eta^*}{\alpha\left[(1-\lambda^*+\lambda^*\eta^*)\mathcal{E}^{1-\lambda^*} - \frac{\int x_i di}{\zeta}\mathcal{E}^{1-\lambda^*\eta^*}\right] + \lambda^*\eta^*}. \tag{A.8}$$

□

Proof of Proposition 3. The necessary first-order condition at T is

$$\begin{aligned} &-(1-\lambda)\mathcal{E}_T^{-\lambda}R^*F_T V_{C_F,T} + V_{\mathcal{E},T} = 0 \\ \Leftrightarrow \quad &\tau_T = \frac{(1-\lambda)\mathcal{E}_T^{1-\lambda}R^*F_T + \zeta\lambda^*\eta^*\mathcal{E}_T^{\lambda^*\eta^*-\lambda}}{\lambda\alpha\zeta + \zeta\lambda^*\eta^*\mathcal{E}_T^{\lambda^*\eta^*-\lambda} - \alpha\mathcal{E}_T^{1-\lambda}R^*F_T} \end{aligned} \tag{A.9}$$

Since

$$\tau_T = 1 - \frac{\chi}{\omega A^{1+\psi}}\left[\alpha\mathcal{E}_T^{\lambda}(\zeta - \mathcal{E}_T^{1-\lambda}R^*F_T) + \zeta\mathcal{E}_T^{\lambda^*\eta^*}\right]^{\psi}\alpha\mathcal{E}_T^{\lambda}(\zeta - \mathcal{E}_T^{1-\lambda}R^*F_T)$$

an increase in F_T raises both sides of equality (A.9) hence τ_T.

The second-order condition requires that the denominator of the right-hand side of

(A.9) be positive. Let $X = R^* F_T$. Differentiating (A.9) yields

$$\frac{d\mathcal{E}_T}{dX} = \frac{(1-\lambda)\mathcal{E}_T^{-\lambda} V_{C_F} + (1-\lambda)\mathcal{E}_T^{1-2\lambda} X V_{C_F,C_F} + V_{C_F,\mathcal{E}}\left[(1-\lambda)\mathcal{E}_T^{-\lambda} X + \mathcal{E}_T^{1-\lambda}\right]}{(1-\lambda)\lambda\mathcal{E}_T^{-\lambda-1} X - (1-\lambda)\mathcal{E}_T^{-\lambda}[V_{C_F,\mathcal{E}} - (1-\lambda)\mathcal{E}_T^{-\lambda} X V_{C_F,C_F}] + V_{\mathcal{E},\mathcal{E}}} \tag{A.10}$$

hence

$$\frac{d\mathcal{E}_T}{dX}(0) = \frac{(1-\lambda)\mathcal{E}_T^{-\lambda} V_{C_F} + V_{C_F,\mathcal{E}}\mathcal{E}_T^{1-\lambda}}{V_{\mathcal{E},\mathcal{E}}} > 0 \Leftrightarrow \frac{-V_{C_F,\mathcal{E}}}{V_{C_F}}\mathcal{E}_T^{-\lambda} > 1-\lambda$$

□

Proof of Proposition 4. The Lagrangian is

$$\begin{aligned} L = {} & V(C_{F,0}, \mathcal{E}_0) + \beta V(C_{F,1}, \mathcal{E}_1) + \eta_0^*\left[\zeta + \mathcal{E}_0^{1-\lambda}\left[F_1 - R^* F_0\right] - C_{F,0}\right] \\ & + \eta_1^*\left[\zeta - \mathcal{E}_1^{1-\lambda} R^* F_1 - C_{F,1}\right] + \mu_0\left[\beta R^*\left(\frac{\mathcal{E}_1}{\mathcal{E}_0}\right)^{1-\lambda}\frac{1}{C_{F,1}} - \frac{1}{C_{F,0}}\right] \end{aligned} \tag{A.11}$$

and the first-order conditions are

$$V_{\mathcal{E},0} + \eta_0^*(1-\lambda)\mathcal{E}_0^{-\lambda}\left[F_1 - R^* F_0\right] - \mu_0(1-\lambda)\frac{\mathcal{E}_0^{-\lambda}}{C_{F,0}} = 0 \tag{A.12}$$

$$\beta V_{\mathcal{E},1} - \eta_1^*(1-\lambda)\mathcal{E}_1^{-\lambda} R^* F_1 + \mu_0(1-\lambda)\beta R^*\frac{\mathcal{E}_1^{-\lambda}}{C_{F,1}} = 0 \tag{A.13}$$

$$V_{C_F,0} - \eta_0^* + \mu_0\frac{\mathcal{E}_0^{1-\lambda}}{C_{F,0}^2} = 0 \tag{A.14}$$

$$\beta V_{C_F,1} - \eta_1^* - \mu_0\beta R^*\frac{\mathcal{E}_1^{1-\lambda}}{C_{F,1}^2} = 0 \tag{A.15}$$

$$\mathcal{E}_0^{1-\lambda}\eta_0^* - R^*\mathcal{E}_1^{1-\lambda}\eta_1^* = 0 \tag{A.16}$$

This proposition follows from the fact that the multiplier μ_0 is positive. To show this, divide (A.14) by (A.15) and use (A.16) and (4.5) to get

$$\frac{(1+\alpha\tau_0)\frac{1-\omega}{C_{F,0}} + \mu_0\frac{\mathcal{E}_0^{1-\lambda}}{C_{F,0}^2}}{\beta(1+\alpha\tau_1)\frac{1-\omega}{C_{F,1}} - \mu_0\frac{\beta R^*\mathcal{E}_1^{1-\lambda}}{C_{F,1}^2}} = \frac{\eta_0^*}{\eta_1^*} = R^*\left(\frac{\mathcal{E}_1}{\mathcal{E}_0}\right)^{1-\lambda} = \frac{C_{F,1}}{\beta C_{F,0}}$$

therefore

$$2\mu_0 \frac{\mathcal{E}_0^{1-\lambda}}{C_{F,0}} = \alpha\beta(1-\omega)(\tau_1 - \tau_0) = \frac{\beta}{\lambda}(V_{\mathcal{E},1}\mathcal{E}_1 - V_{\mathcal{E},0}\mathcal{E}_0)$$

From (A.12) and (A.13) we can replace $(V_{\mathcal{E},1}\mathcal{E}_1 - V_{\mathcal{E},0}\mathcal{E}_0)$, obtaining finally

$$\mu_0 = (1-\lambda)\frac{\eta_0^*}{R^*}\frac{C_{F,0}R^*F_1 + C_{F,1}\left[F_1 - R^*F_0\right]}{1+\lambda+\beta-\beta\lambda} > 0$$

□

A.2 Empirical Appendix

We explore the empirical relation between exposure to external foreign currency denominated debt and the degree of exchange rate pass-through.

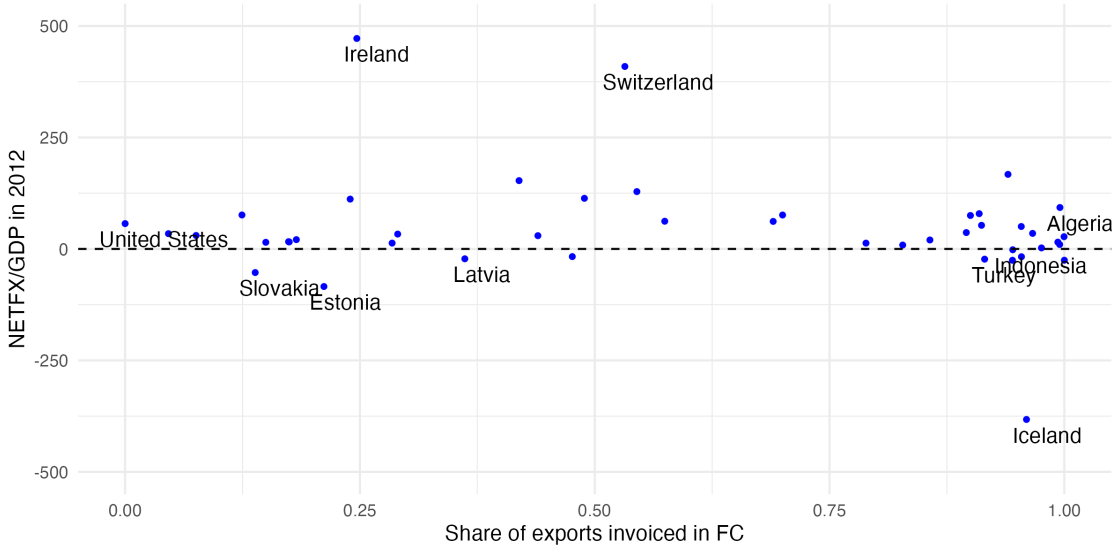
We use two variables for foreign exchange exposure following Lane and Shambaugh (2010) and Bénétrix et al. (2015).

NETFX is the difference between foreign assets denominated in foreign currency and foreign liabilities denominated in foreign currency, plotted as a percent of GDP.

FXAGG is *NETFX* as a share of the sum of foreign assets denominated in foreign currency and foreign liabilities denominated in foreign currency, plotted as a percent.

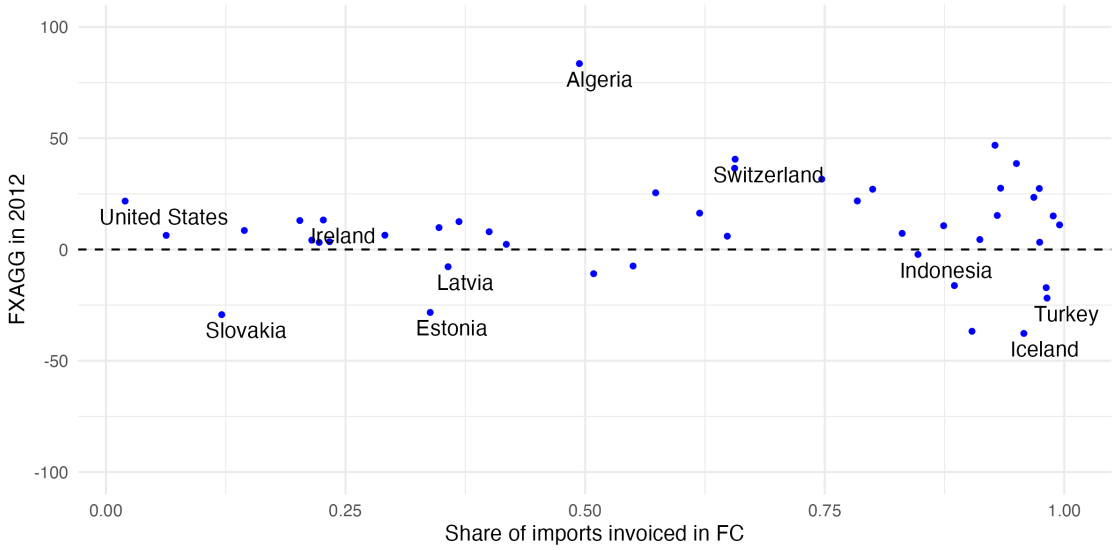
Gopinath (2016) measures the share of imports and exports invoiced in foreign currency. As shown in Section 2, the share of imports invoiced in foreign currency is a proxy for import pass-through λ, and the share of exports invoiced in foreign currency is a proxy for export pass-through $1-\lambda^*$ in the model.

Figure A.1: Net foreign exchange exposure vs. exports share invoiced in foreign currency $1 - \lambda^*$



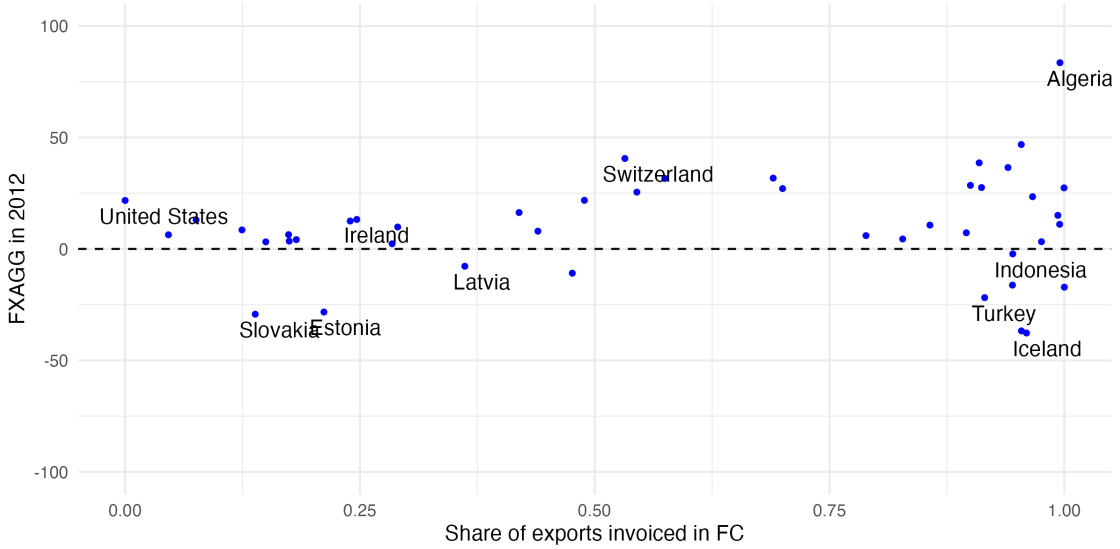
Note: *NETFX/GDP* is defined as in Lane and Shambaugh (2010). Data from Bénétrix et al. (2015) and Gopinath (2016).

Figure A.2: Net foreign exchange exposure vs. imports share invoiced in foreign currency λ



Note: *FXAGG* is defined as in Lane and Shambaugh (2010). Data from Bénétrix et al. (2015) and Gopinath (2016).

Figure A.3: Net foreign exchange exposure vs. exports share invoiced in foreign currency $1 - \lambda^*$



Note: *FXAGG* is defined as in Lane and Shambaugh (2010). Data from Bénétrix et al. (2015) and Gopinath (2016).