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Abstract

We provide a theory of financial fragmentation in monetary unions. Our key insight is that currency unions may experience endogenous breakings of symmetry: that is episodes in which identical countries react differently when exposed to the same shock. During these events part of the union suffers a capital flight, while the rest acts as a safe haven and receives capital inflows. The central bank then faces a difficult trade-off between containing unemployment in capital-flight countries, and inflationary pressures in safe-haven ones. By counteracting private capital flows with public ones, unconventional monetary interventions mitigate the impact of financial fragmentation on employment and inflation, thus helping the central bank to fulfill its price stability mandate.

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1 Introduction

The euro area recurrently experiences episodes of financial fragmentation, during which credit conditions and capital flows diverge across member countries. Fragmentation, as several ECB officials have argued, threatens price stability, because a single monetary policy is ill-suited to confront these inherently asymmetric scenarios (Lane, 2022; Panetta, 2022). Moreover, there is a concern that self-fulfilling market dynamics, which decouple macroeconomic conditions from fundamentals, may play an important role during these events. Against this background, the ECB has developed a host of unconventional monetary programs, on the premise that dealing with fragmentation requires more flexibility than what conventional monetary tools can provide.[1] In reaction, a heated debate has unfolded about the nature of financial fragmentation, and the appropriate design of monetary policy in currency unions.

We contribute to this debate by providing a theory of financial fragmentation in monetary unions. Our key insight is that currency unions may experience endogenous breakings of symmetry: that is episodes in which identical countries react differently when exposed to the same shock. During these events part of the union suffers a capital flight, while the rest acts as a safe haven and receives capital inflows. The central bank then faces a difficult trade-off between containing unemployment in capital-flight countries, and inflationary pressures in safe-haven ones. By counteracting private capital flows with public ones, unconventional monetary interventions mitigate the impact of financial fragmentation on employment and inflation, thus helping the central bank to fulfill its price stability mandate.

We formalize these insights with a two-country model of a monetary union. The two countries share the same fundamentals, i.e. the same parameter values, so any divergence between them is due to non-fundamental factors. Private agents invest in domestic capital and participate in international credit markets, subject to a borrowing limit. Capital is therefore imperfectly mobile inside the union, meaning that the return to investment may differ across the two countries.[2] Nominal wages are downwardly rigid, and therefore national Phillips curves are non-linear. Increases in aggregate demand thus have a limited impact on inflation in countries operating below full employment, while once full employment is reached further rises in demand generate strong inflationary pressures.

Fiscal policy plays an important role in our theory. In each country, the government has to finance some fixed government expenditure. To do so, it has access to taxes on labor income, which are non-distortionary in our model, and capital taxation, which is distortionary because it drives a wedge between the private and social return to investment. National governments seek

[1] These range from the Outright Monetary Transactions, introduced in 2012 in the aftermath of Mario Draghi's *whatever it takes* speech, to the Pandemic Emergency Purchase Programme deployed in response to the COVID-19 pandemic, and the Transmission Protection Instrument, announced at the beginning of the latest ECB tightening cycle. While each program has its own specificities, they all allow the ECB to purchase securities issued by the public sector of particular member countries undergoing a period of financial stress, without being restricted by capital keys.

[2] While we do not model explicitly the rest of the world, we are implicitly assuming that capital mobility is higher among members of the union, than between the union and the rest of the world. As in the theory developed by Fornaro (2022), this could be due to currency risk limiting international capital mobility. Beck et al. (2024) show empirically that the introduction of the euro triggered higher integration in the bond markets, but not in the equity ones. This evidence squares well with our model, in which bonds are traded internationally, while capital (i.e. equity) is not.

to minimize the use of distortionary taxation, so they tax capital only when public expenditure cannot be fully financed with non-distortionary taxes. We think of episodes in which governments resort to capital taxation as fiscal crises. Turning to monetary policy, we start by studying a cashless economy, in which a benevolent central bank sets average inflation across the union using conventional monetary tools.

At the union level, fundamentals determine the shape of the equilibrium. When fundamentals are good (low government expenditure, high return to investment, high private sector net worth,...), the union settles on a symmetric equilibrium. In this case, both countries avoid a fiscal crisis, the return to capital is equalized internationally, and conventional monetary tools are sufficient to maintain full employment and inflation on target.

When fundamentals deteriorate, so that public budgets cannot be balanced using exclusively non-distortionary taxes, the macroeconomic picture changes dramatically. First, symmetry between the two countries breaks down: one country suffers a capital flight, while the other acts as a safe haven. Second, expectations and animal spirits come into play. Indeed, fundamentals do not pin down which of the two countries experiences a capital flight. From the perspective of an individual country, therefore, a capital flight happens due to pessimistic animal spirits.

Animal spirits matter because of a self-reinforcing loop between capital flows, economic activity and fiscal policy. Imagine that agents expect that capital will fly out of a particular country. They then anticipate that capital outflows, by depressing economic activity and the tax base, will force the government to resort to distortionary capital taxation. In turn, expectations of high taxes depress the private return to investment. The result is a capital flight, which confirms the initial beliefs. For this reasoning to go through, the other country has to act as a safe haven and receive the inflows originating from the capital-flight country. This logic explains why this equilibrium is inherently asymmetric, capturing our notion of a fragmented monetary union.

Financial fragmentation acts as an endogenous asymmetric demand shock, because capital outflows depress demand in the capital-flight country, while inflows boost demand in the safe-haven one. Due to the non-linearities in the national Phillips curves, the monetary union effectively experiences a cost push shock, which worsens the inflation-employment trade-off faced by the central bank. Financial fragmentation thus leads to a combination of low employment (in the capital flight country) and inflation above target (in the safe-haven country). This is the sense in which fragmentation threatens price stability.

We then turn to unconventional monetary interventions, by introducing money, and so seignorage revenue, in the model. We think of unconventional policies as tools that give some flexibility to the central bank in allocating seignorage revenue among national governments. The basic principle behind the optimal unconventional policy is simple: the central bank should counteract private capital flows with public ones. Countries suffering capital flights thus receive net transfers from the central bank, financed with net public outflows from safe-haven countries.[3] This policy is appealing because it mitigates the asymmetric demand shock associated with financial fragmentation.

Importantly, public capital flows crowd in private ones. In fact, transfers from the central bank increase fiscal space and allow governments to reduce capital taxes. Lower taxes, in turn, attract

[3] We thus capture, albeit in a stylized way, the notion that purchases of public securities by the ECB, under programs such as the OMT, PEPP and TPI, serve to counter disorderly market dynamics, unjustified by fundamentals.

private capital inflows by increasing the private return to investment. This channel amplifies the effectiveness of unconventional monetary interventions in times of fragmentation.

Due to this crowding-in effect, the expectation that the central bank will deploy unconventional policies during self-fulfilling crises may be enough to stabilize the union on the symmetric equilibrium. This happens if the central bank has enough flexibility in the design of unconventional policies. Then, the central bank does not actually need to employ unconventional policies in equilibrium to fend off fragmentation. If instead flexibility is limited, perhaps because of lack of fiscal backing or political constraints, self-fulfilling fragmentation may occur. In this case, however, in-equilibrium unconventional monetary interventions mitigate the rise in inflation and unemployment caused by financial fragmentation. Hence, conventional and unconventional monetary tools complement each other in maintaining price stability within the monetary union.

We conclude by observing that international cooperation is crucial for a successful implementation of unconventional monetary policies. Ex-ante, that is before capital has been internationally allocated, all the countries of the union would benefit from the presence of unconventional monetary programs that combat fragmentation. But ex-post, if a self-fulfilling fragmentation event actually occurs, safe-haven countries are likely to oppose the use of unconventional policies by the central bank, because they represent a loss of income from their perspective. Our model thus suggests that financial fragmentation, at least of the kind described in this paper, is the outcome of lack of cooperation among member countries of the monetary union, which forces an unequal distribution of the fiscal adjustment during times of bad fundamentals.

Related literature. A long-standing literature argues that asymmetric shocks pose a challenge to monetary policy in currency unions, as in the classic contributions by Friedman (1953) and Mundell (1961).[4] How to design policies that mitigate this problem is very much an open question. In this respect, we are close to the notion that a successful currency union requires some form of countercyclical public capital flows among member countries. This idea was first fleshed out by Kenen (1969), while Gali and Monacelli (2008) and Farhi and Werning (2017) provide two modern formulations. Compared to these seminal contributions, our work features one key novelty. Typically, the literature considers exogenous asymmetric shocks, whose intensity does not depend on the policy regime. In contrast, in our theory the asymmetry among member countries arises endogenously, and is the result of a self-reinforcing loop between capital flows, economic activity and fiscal policy triggered by *symmetric* shocks. This difference is important, because it implies that public capital flows, by crowding in private ones, mitigate the source of asymmetry at the heart of our model. An extreme version of this insight is the result that enough flexibility in the design of unconventional monetary programs eliminates altogether the asymmetric dynamics that we emphasize.

Our paper is also connected to the literature on endogenous breaking of symmetry in open economies. This literature argues that, due to the presence of amplification effects, similar countries may end up experiencing very different outcomes. Some examples of this literature are Matsuyama (1996), Matsuyama (2004) and Acemoglu et al. (2017), which seek to explain differences in the long-run development pattern across countries. Buiter et al. (1998), which interprets the 1992-93 Exchange Rate Mechanism crisis as an example of symmetry breaking due to lack of cooperation,

[4] Benigno (2004) and Fornaro (2018) are two recent examples of works building on this insight.

is perhaps the work closest to ours. There are, however, several differences. First, we focus on a currency union with a single monetary authority, while Buiter et al. (1998) consider countries with independent monetary policy. Second, fiscal fragility plays a key role in our framework, while this is not the case in their work. Finally, we study the optimal design of unconventional monetary policies in currency unions, a topic not addressed by Buiter et al. (1998).

The euro area crisis of 2009-2012 has inspired a large literature studying the interactions between fiscal crises and economic activity. Some prominent examples are Broner et al. (2014), Gennaioli et al. (2014), Bocola (2016), Engler and Grosse-Steffen (2016) and Bocola and Dovis (2019). We are particularly close to the strand of this literature that focuses on self-fulfilling fiscal crises and monetary policy (Calvo, 1988; Aguiar et al., 2015; Corsetti and Dedola, 2016; Bacchetta et al., 2018; Bianchi and Mondragon, 2022; Fornaro, 2022). Compared to these works, we show that in monetary unions fiscal fragility can endogenously generate financial fragmentation and asymmetric demand conditions, jeopardizing price stability. Unconventional monetary interventions offer a potential solution to this problem.

Finally, the paper relates to the literature on unconventional monetary interventions. Gertler and Karadi (2011), Curdia and Woodford (2011), Gertler et al. (2020) and Amador and Bianchi (ming) are some important contributions to this literature, studying the use of unconventional policies in closed economies. Dedola et al. (2013) and Gourinchas et al. (2022), instead, focus on the international spillovers triggered by unconventional policies. Different from these papers, we study unconventional monetary policies in a currency union subject to the risk of endogenous fragmentation.

The rest of the paper is composed of five sections. Section 2 presents the baseline model. Section 3 describes how a self-reinforcing loop between capital flows, economic activity and fiscal policy may give rise to financial fragmentation. Section 4 derives the implications for conventional monetary policy. Section 5 turns to unconventional monetary interventions. Section 6 concludes. The Appendix contains all the proofs and derivations not included in the main text.

2 Model

There are two countries making part of a monetary union, home h and foreign f, and a single period. The two countries share the same fundamentals, i.e. the same parameter values. Since our results do not hinge on the presence of risk, we focus on a perfect-foresight economy.

2.1 Households

Each country is inhabited by a measure one of identical households. The utility of the representative household in country i is

$$\omega \log C_i^T + (1-\omega) \log C_i^N - \chi(P_i),$$

where C_i^T and C_i^N denote consumption respectively of a tradable and a non-tradable good, while $0 < \omega < 1$ is the share of tradable goods in the consumption basket.

Households experience disutility from inflation. Let P_i denote the price of a unit of the consumption basket, defined as

$$P_i = \left(P^T\right)^{\omega} \left(P_i^N\right)^{1-\omega}, \tag{1}$$

where P^T and P_i^N stand respectively for the price of a unit of tradable and non-tradable goods in terms of currency. Since both countries belong to a monetary union, they share the same price of the tradable good. We normalize the past price level in both countries to 1, so that the (gross) inflation rate is equal to P_i. The convex function $\chi(P_i)$ captures some utility cost that households experience whenever inflation deviates from its target value. We assume that $\chi(1) = \chi'(1) = 0$, which amounts to normalizing the inflation target to zero.

Each household starts the period with $\bar{K}$ units of investment goods. There are two assets in which households can invest, both of which yield returns at the end of the period. First, households can invest in a domestic technology, we refer to it as capital, that transforms one unit of investment into z units of the tradable good. Let K_i denote investment in home-country capital. In addition, households have access to an intra-period real bond denominated in units of the tradable good. Denote by D_i the level of debt assumed by domestic households at the start of the period, and R the interest rate on intra-period loans. The bond is traded internationally, and R is common across the two countries.

The start-of-period budget constraint faced by the households is then

$$K_i = \bar{K} + D_i. \tag{2}$$

Moreover, each household faces the borrowing limit

$$D_i \leq \phi K_i,$$

so that at most a fraction ϕ of the investment project can be financed with outside funds.[5]

The end-of-period budget constraint is

$$P^T C_i^T + P_i^N C_i^N = (1-\tau_i^k) P^T z K_i + (1-\tau_i^l) W_i L_i - P^T R D_i,$$

where W_i denotes the nominal wage, L_i employment, and τ_i^k and τ_i^l denote the tax rate levied by the domestic government respectively on capital and labor income. Each household is endowed with $\bar{L}$ units of labor, and there is no disutility from working. However, due to presence of wage rigidities that will be described later, households may end up working $L_i \leq \bar{L}$ units of labor.

Households have two decisions to take. First, they need to allocate their investment goods among the two asset. The optimal investment strategy is

$$K_i = \begin{cases} \frac{\bar{K}}{1-\phi} & \text{if } z(1-\tau_i^k) > R \\ \left[0, \frac{\bar{K}}{1-\phi}\right] & \text{if } z(1-\tau_i^k) = R \\ 0 & \text{if } z(1-\tau_i^k) < R. \end{cases} \tag{3}$$

[5] Therefore, in our model bond markets are (imperfectly) integrated. Equity markets, instead, are subject to an extreme form of home bias, since agents cannot directly invest in foreign capital. This asymmetry is in line with the evidence provided by Beck et al. (2024), who show that in the euro area equity markets integration is extremely limited, and far lower than bond markets integration.

Intuitively, if $z(1-\tau_i^k) > R$ households maximize investment in domestic capital by borrowing up to their limit. Instead, if $z(1-\tau_i^k) < R$ investment in domestic capital is unprofitable, and households lend all their net worth on the credit markets. Finally, if $z(1-\tau_i^k) = R$ households are indifferent between investing in domestic capital and lending. Note that the households' investment decision depends on the private, that is after tax, return on domestic investment. As long as $\tau_i^k > 0$, this is lower than the social return z.

Second, the optimal allocation of consumption expenditure among the two goods implies

$$C_i^N = \frac{1-\omega}{\omega}\frac{P^T}{P_i^N}C_i^T. \tag{4}$$

Demand for the non-traded good is thus decreasing in its relative price, and increasing in the consumption of the traded good.

2.2 Non-tradable production and nominal wage rigidities

Non-traded output Y_i^N is produced by a large number of competitive firms. Labor is the only factor of production, and the production function is $Y_i^N = L_i$. Profits are given by $P_i^N Y_i^N - W_i L_i$, and the zero profit condition implies that in equilibrium

$$P_i^N = W_i. \tag{5}$$

We introduce nominal rigidities by assuming, in the spirit of Akerlof et al. (1996), that nominal wages are subject to the downward rigidity constraint

$$W_i \geq \bar{W},$$

where $\bar{W} > 0$. This formulation captures in a simple way the presence of frictions to the downward adjustment of nominal wages, which might prevent the labor market from clearing.[6] In fact, equilibrium on the labor market is captured by the condition

$$L_i \leq \bar{L}, \quad W_i \geq \bar{W} \quad \text{with complementary slackness.} \tag{6}$$

This condition implies that unemployment arises only if the constraint on wage adjustment binds.

2.3 Fiscal policy

In each country, the domestic government has to finance an expenditure equal to G units of tradables at the end of the period. The fixed cost G could capture expenditures that governments incur to ensure that the economy functions smoothly. It could also encapsulate costs arising from previous debt obligations. In any case, we assume that it is infinitely costly to default on this expenditure.

[6] Several empirical works have shown, using micro-level data, that nominal wages are indeed downwardly rigid. Two recent examples of this literature are Grigsby et al. (2021) and Hazell and Taska (2020).

The budget constraint of the domestic government is then

$$P^T G = \tau_i^k P^T z K_i + \tau_i^l W_i L_i.$$

Both tax rates have upper bounds, respectively denoted by $\bar{\tau}^k$ and $\bar{\tau}^l$, that capture limits on the government's ability to extract income from the private sector. These upper bounds are generous enough so that governments can always raise enough funds to pay G.

How does the government set taxes? First, note that in our simple economy capital taxation is distortionary, because it drives a wedge between the private and social return to investment. Labor taxation, instead, does not entail any distortion. A government that can commit to a tax policy ex-ante, that is before investment has taken place, will thus resort to capital taxation only after exhausting its ability to tax labor.[7] If instead taxes are set ex-post, i.e. after capital has been installed, the government will be indifferent between any combination of τ_i^k and τ_i^l that balances the budget without violating the upper bounds $\bar{\tau}^k$, $\bar{\tau}^l$.

In what follows, we assume that governments minimize the use of distortionary taxation, so that

$$\tau_i^k = \max\left(0, \frac{P^T G - \bar{\tau}^l W_i L_i}{P^T z K_i}\right).$$

As we will see, capital is taxed in scenarios characterized by capital flights and weak economic activity. Intuitively, these exceptional circumstances force the government to resort to extraordinary distortionary taxation to balance the budget. We thus refer to episodes of $\tau_i^k > 0$ as fiscal crises.

The fiscal crisis that occurred in Italy in 1992 is perhaps the best example of what we have in mind. Facing capital flights and a deep recession that strained public finances, the government increased sharply the corporate statutory tax rate, introduced a special levy on firms' net assets that lasted until 1997, as well as a one-off levy on bank deposits (Balassone et al., 2002). All these measures depressed the private return on domestic investment.

Before moving on, a remark is in order. An important friction here is that the bulk of taxation falls on domestic sources of income, because the government has a limited ability to tax revenues earned abroad by its citizens. Eaton (1987), Velasco (1996) and Fornaro (2022) are examples of theories that build on this friction. Again the Italian fiscal crisis of 1992 is a good example, since most of the increase in public revenue came from taxes on domestic income.

2.4 Monetary policy

At the end of the period, the union's central bank sets monetary policy to maximize welfare. More precisely, in its objective function the central bank attaches equal weight to the welfare of every citizen of the union. For now, we frame conventional monetary policy in terms of a choice of P^T. Later on, in Section 5, we will elaborate on how the central bank can attain its desired monetary stance by adjusting the money supply, and add to the analysis unconventional monetary interventions.

[7] To be more precise, this is true if a country's utility is increasing in its consumption of tradable goods, even after taking into account the impact of higher consumption on inflation. We assume that this is the case throughout the paper.

2.5 Market clearing

Market clearing for the non-tradable consumption good requires that domestic consumption is equal to domestic production

$$C_i^N = Y_i^N = L_i. \tag{7}$$

Market clearing for the traded good ensures that tradable consumption is equal to domestic production, less government expenditure and payments to foreign creditors

$$C_i^T = zK_i - G - RD_i. \tag{8}$$

Finally, global investment in capital is equal to the initial endowment of investment goods

$$K_h + K_f = 2\bar{K}, \tag{9}$$

which guarantees that global credit markets clear.

Using the market clearing conditions we can rewrite the fiscal policy rule as

$$\tau_i^k = \max\left(0, \frac{G - \bar{\tau}^l \frac{1-\omega}{\omega} C_i^T}{zK_i}\right). \tag{10}$$

A country is thus more likely to experience a fiscal crisis when its tradable consumption C_i^T is low. The reason is that low tradable consumption depresses demand for non-traded goods and households' labor income, making it more likely that the government will have to turn to capital taxation to balance the budget.

We are ready to define a competitive equilibrium.

Definition 1 *A competitive equilibrium is a set of real allocations* $\{C_i^T, C_i^N, L_i, K_i, D_i\}$*, prices* $\{P_i$*,* P_i^N*,* $W_i\}$*, capital taxes* $\{\tau_i^k\}$ *and interest rate* R*, satisfying* (1) – (10)*, given* P^T *set by monetary policy.*

3 Capital flows and financial fragmentation

We now study how capital is allocated across the monetary union, by deriving the equilibrium on the tradable goods market.[8] The parameter ϕ captures the extent to which capital is internationally mobile, and plays an important role in our theory. We will focus on economies in which capital is mobile internationally, but imperfectly so. In particular, we will assume that

$$0 < \phi < \frac{\omega}{2\omega + \bar{\tau}^l(1-\omega)}, \tag{11}$$

This assumption rules out scenarios in which a single country is able to absorb the whole capital stock of the union. We will also assume that

$$G < z\bar{K}(1-2\phi)/(1-\phi), \tag{12}$$

[8] In our framework, the equilibrium on the tradable goods market does not depend on conventional monetary policy. This property simplifies considerably the analysis.

which ensures that governments are able to raise enough tax revenue to satisfy their budget constraints.[9]

3.1 A symmetric benchmark

Let us start by describing a scenario in which both countries avoid a fiscal crisis ($\tau_h^k = \tau_f^k = 0$). In this case, the private return to capital is equalized internationally, equilibrium on the credit markets requires $R = z$, and both countries consume $C_i^T = z\bar{K} - G$ units of the traded good.

In this equilibrium, governments balance their budgets using exclusively non-distortionary taxes on labor income. This is the case if

$$G \leq \frac{\bar{\tau}^l(1-\omega)}{\omega + \bar{\tau}^l(1-\omega)} z\bar{K}. \tag{13}$$

As it is intuitive, for both countries to avoid a fiscal crisis fundamentals have to be good enough (low government expenditure relative to endowment of investment goods, high return to investment, high capacity to raise fiscal revenue through non-distortionary taxes, ...).

Any allocation of capital such that $\bar{K}(1-2\phi)/(1-\phi) \leq K_h \leq \bar{K}/(1-\phi)$ and $K_f = 2\bar{K} - K_h$ is consistent with this equilibrium, and so the international distribution of capital is not uniquely pinned down. We resolve this indeterminacy by assuming that when the private return to capital is equalized across countries, agents allocate domestically their whole endowment of investment goods ($K_h = K_f = \bar{K}$).

3.2 Capital flights and endogenous breaking of symmetry

We now construct an equilibrium in which the home country experiences a capital flight, so that $K_h < \bar{K}$. Of course, since the two countries share the same fundamentals, assuming that it is country f the one suffering a capital flight would not change any of the results that follow.

A capital flight occurs when the domestic private return to capital falls below the foreign one. Hence, country h is hit by a capital flight when $\tau_h > \tau_f$. Under this condition, capital flows toward the foreign country until foreign households run against their borrowing constraint. Capital is then allocated according to

$$K_h = \frac{(1-2\phi)\bar{K}}{1-\phi} < \bar{K} < \frac{\bar{K}}{1-\phi} = K_f.$$

Note that investment in home capital is positive, since we have assumed $\phi < 1/2$. Equilibrium on the credit markets then requires $R = (1-\tau_h^k)z < z$, and so the capital flight depresses the equilibrium interest rate. Home tradable consumption is equal to

$$C_h^T = zK_h + R\left(\bar{K} - K_h\right) - G = z\left(1 - \frac{\phi\tau_h^k}{1-\phi}\right)\bar{K} - G, \tag{14}$$

while to balance the budget the home government has to set

$$\tau_h^k = \frac{(1-\phi)\left(G - \bar{\tau}^l \frac{1-\omega}{\omega} C_h^T\right)}{z(1-2\phi)\bar{K}}. \tag{15}$$

[9]See the proof to Proposition 1 for the details.

These two equations highlight the presence of a feedback loop between capital flows and fiscal policy. On the one hand, as captured by equation (14), a higher tax on home capital drives down desired investment at home and the equilibrium interest rate, causing a drop in home consumption of tradable goods. On the other hand, as encapsulated by equation (15), a lower home consumption of tradables depresses demand for non-traded goods and labor income in the home country. Facing a drop in the tax base, the government is then forced to increase the capital tax rate to balance the budget. As we will see, this amplification mechanism is at the heart of the model.[10]

Expression (14) implies that $C_h^T < z\bar{K} - G$, so the capital flight depresses home tradable consumption below its value under the symmetric equilibrium described in the previous section. The foreign country, instead, experiences an increase in its consumption of tradable goods. The reason is that foreign agents make a profit from borrowing cheaply on the international credit markets and investing the proceeds in domestic capital. This is the return that the foreign country earns from acting as a safe haven when the home country is hit by a capital flight.

To ensure that this equilibrium exists, we need to check that the capital flight hitting country h does lead to a fiscal crisis ($\tau_h^k > 0$). This is the case if

$$G > \frac{\bar{\tau}^l(1-\omega)}{\omega + \bar{\tau}^l(1-\omega)} z\bar{K},$$

which is just the complement of condition (13).[11] So fiscal crises and symmetry breaking happens in times of bad fundamental.

We collect these results in the following proposition.

Proposition 1 *Suppose that assumptions (11) and (12) hold. Then if (13) holds there is a unique symmetric equilibrium. In this equilibrium the interest rate is equal to the social return to investment ($R = z$). If (13) is violated, there are two stable asymmetric equilibria. In these asymmetric equilibria the union is fragmented, since one country experiences capital outflows ($K_i < \bar{K}$) and a fiscal crisis ($\tau_i^k > 0$), while the other receives capital inflows ($K_i > \bar{K}$). Moreover, fragmentation pushes the interest rate below the social return to investment ($R < z$).*

The scenario that we just described corresponds to a fragmented monetary union, that is a case in which two ex-ante identical member countries end up having very different outcomes in terms of capital flows and consumption of traded goods. Later on, we will show that this fragmentation extends to other macroeconomic variables, such as employment and inflation. Before that, however, it is useful to clarify the role played by fundamentals and animal spirits.

3.3 Fundamentals and animal spirits

In our framework, fundamentals determine whether financial fragmentation occurs. In fact, if condition (13) holds, fundamentals are good and the union settles on a symmetric no-fragmentation equilibrium. If fundamentals are bad, instead, a fiscal crisis occurs at least in one of the two

[10] We can now further clarify the role of assumption (11). When this condition is violated, after an increase in the capital tax rate the tax base drops so much that tax revenue falls. While this case is interesting, to streamline the analysis we focus on the more conventional scenario in which a higher capital tax rate increases the fiscal revenue.

[11] Moreover, if $\phi \leq \omega/(2(\omega + \bar{\tau}^{(}1-\omega))$ then $\tau_f = 0$ and the foreign country does not experience a fiscal crisis. Otherwise $\tau_h > \tau_f > 0$

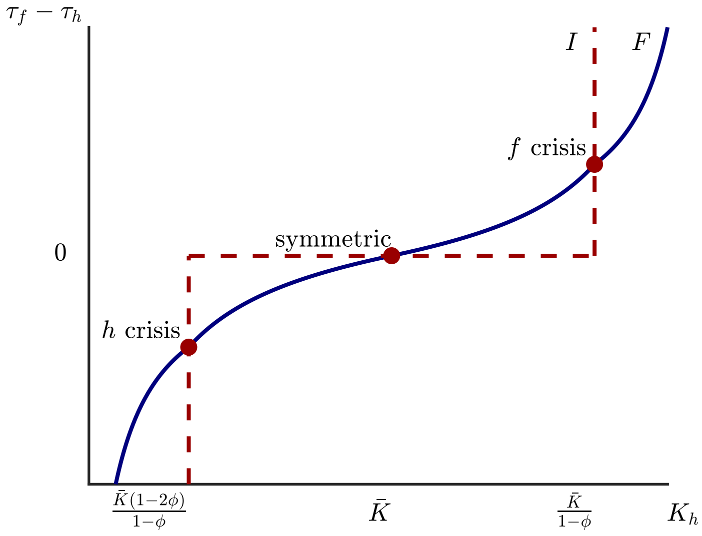

Figure 1: Symmetry breaking in the capital market. Notes: this figure shows how capital is allocated internationally when condition (13) is violated.

countries, and the union gets fragmented. Here is where expectations and animal spirits come into play. While when condition (13) is violated one country suffers a capital flight, fundamentals do not determine whether this is going to be the home or the foreign country. So, at the level of individual countries, a capital flight happens due to pessimistic animal spirits.

Animal spirits matter because of the self-reinforcing loop between capital flows, domestic economic activity and fiscal policy that we outlined above. Imagine that agents expect that country h will experience a capital flight. They then anticipate that weak economic activity will lower the tax base, forcing the home government to resort to distortionary capital taxation. In turn, high taxes on capital depress the private return on investment at home, triggering a capital flight which confirms the initial expectations. For this reasoning to go through, the foreign country has to act as a safe haven and receive the inflows coming from the home country. This logic explains why the capital flight equilibrium is inherently asymmetric, capturing our notion of fragmented monetary union.

Figure 1 shows graphically how the equilibrium on the capital market is reached. The I schedule encapsulates the impact of fiscal policy on households' investment decisions[12]

$$K_h = \begin{cases} \frac{(1-2\phi)\bar{K}}{1-\phi} & \text{if } \tau_h^k > \tau_f^k \\ \left[\frac{(1-2\phi)\bar{K}}{1-\phi}, \frac{\bar{K}}{1-\phi}\right] & \text{if } \tau_h^k = \tau_f^k \\ \frac{\bar{K}}{1-\phi} & \text{if } \tau_h^k < \tau_f^k. \end{cases} \tag{I}$$

Intuitively, if $\tau_h^k > \tau_f^k$ home agents ship as much capital as possible to the foreign country. If $\tau_h^k < \tau_f^k$ home agents borrow as much as possible from foreigners. When the two tax rates are equal, K_h may lay anywhere between these two bounds.

The second relationship captures how the allocation of capital affects fiscal policy, and so the private return to investment. This is the F schedule in Figure 1, which traces how $\tau_f^k - \tau_h^k$ evolves

[12]This schedule is obtained by combining expression (3) with the equilibrium relationship $R = z(1 - \max(\tau_h^k, \tau_f^k))$.

as a function of K_h. If condition (13) holds, then any value of K_h is associated with $\tau_h^k = \tau_f^k = 0$, and so the F schedule is just a horizontal line at 0. When condition (13) is violated, which is the case covered by Figure 1, the F schedule takes the form[13]

$$\tau_f^k - \tau_h^k = \begin{cases} -\frac{(\omega+\bar{\tau}^l(1-\omega))G/z-\bar{\tau}^l(1-\omega)\bar{K}}{\omega K_h-\bar{\tau}^l(1-\omega)\left(\bar{K}-K_h\right)} \min\left(1, \frac{2(\omega+\bar{\tau}^l(1-\omega))\left(\bar{K}-K_h\right)}{2\bar{K}-K_h}\right) & \text{if } K_h < \bar{K} \\ 0 & \text{if } K_h = \bar{K} \\ \frac{(\omega+\bar{\tau}^l(1-\omega))G/z-\bar{\tau}^l(1-\omega)\bar{K}}{\omega(2\bar{K}-K_h)+\bar{\tau}^l(1-\omega)\left(\bar{K}-K_h\right)} \min\left(1, \frac{2(\omega+\bar{\tau}^l(1-\omega))\left(K_h-\bar{K}\right)}{K_h}\right) & \text{if } K_h > \bar{K}. \end{cases} \tag{F}$$

While this expression is complicated, its properties are fairly intuitive. Capital taxes are higher in the country with the lowest capital stock. This explains why the tax differential $\tau_f^k - \tau_h^k$ is increasing in K_h. As we move capital from the foreign to the home country - recall that $K_f = 2\bar{K} - K_h$ - capital taxes in the foreign country rise relative to the home ones. Moreover, when capital is allocated symmetrically both countries tax capital exactly at the same rate, which explains why the F schedule crosses zero when $K_h = \bar{K}$.

As shown in Figure 1, when condition (13) is violated the I and F schedules intersect three times, meaning that three different equilibria are possible. The symmetric equilibrium, however, is unstable. In this equilibrium, the reason is, both countries are charging the same positive tax rate on capital. Now say that, starting from this point, a small amount of capital is moved from home to the foreign country. Facing a larger tax base, the foreign government will react by lowering τ_f^k, while the opposite logic implies that τ_h^k will rise. The tax differential that opens up will foster further capital flows from the home to the foreign country, until foreign agents become borrowing constrained. The economy will thus settle on the 'h crisis' equilibrium, in which the home country faces capital flights and a fiscal crisis, while the foreign country acts as a safe haven. Of course, expectations may instead coordinate on the 'f crisis' equilibrium. In this case, the foreign country experiences capital outflows and a fiscal crisis, while the home country receives capital inflows.

Figure 1 also clarifies the role played by international capital mobility. In our model, a higher ϕ is associated with more international capital mobility. Now imagine that ϕ is very small, so that the two vertical segments of the I schedule lie very close to the $K_h = \bar{K}$ point. In this case, a shift from the 'h crisis' equilibrium to the 'f crisis' one will produce a tiny movement of capital flows, and consequently have a small impact on other macroeconomic outcomes. As ϕ gets larger, so does the impact of shifts in animal spirits on capital flows and the macroeconomy.[14] This result

[13]To see how the F schedule is derived, let's focus on the $K_h < \bar{K}$ part. In this case, the home country charges a higher tax rate on capital and so $R = z(1-\tau_h^k)$. Using (8), (10) and $D_h = \bar{K} - K_h$ gives

$$\tau_h^k = \frac{(\omega + \bar{\tau}^l(1-\omega))G/z - \bar{\tau}^l(1-\omega)\bar{K}}{\omega K_h - \bar{\tau}^l(1-\omega)(\bar{K}-K_h)}.$$

Using (8), (10) and $K_f = 2\bar{K} - K_h$ and $D_f = \bar{K} - K_f$ gives

$$\tau_f^k = \tau_h^k \max\left(\frac{\omega K_h - 2\bar{\tau}^l(1-\omega)\left(\bar{K}-K_h\right)}{\omega(2\bar{K}-K_h)}, 0\right).$$

These two expressions combined give the $K_h < \bar{K}$ segment of the F schedule. The $K_h > \bar{K}$ part of the schedule is obtained using a similar approach, but noting that in this case $R = (1-\tau_f^k)z$. If $K_h = \bar{K}$ the allocation is symmetric and so $\tau_f^k = \tau_h^k$.

[14]There is an important clarification to be made. If capital mobility is perfect, which corresponds to a case in

suggests that the source of symmetry breaking that we emphasize is particularly important for monetary unions, in which capital mobility is imperfect but high (Fornaro, 2022).

To conclude this section, let us note that in our theory imperfect capital mobility creates fragmentation in international financial markets exclusively in periods of bad fundamentals. Indeed, when fundamentals are good - i.e. when condition (13) holds - the private return to capital is equalized internationally. It is only when fundamentals turn bad and condition (13) is violated that financial markets get fragmented, and international differences in the private return to investment appear within the union.

4 Implications for conventional monetary policy

We now turn to the market for non-traded goods. Households' demand for non-traded goods implies that

$$P_i^N C_i^N = \frac{1-\omega}{\omega} P^T C_i^T. \tag{16}$$

The term P^T encapsulates the impact of conventional monetary interventions on domestic demand. A higher P^T is associated with higher nominal demand for non-traded goods, because when traded goods become more expensive households redirect their demand to non-traded ones. In what follows, we will refer to monetary interventions leading to increases in P^T as monetary expansions, while declines in P^T can be interpreted as monetary contractions. The term C_i^T captures the role of capital flows. A country receiving capital inflows experiences a rise in its consumption of traded goods, which in turn boosts nominal demand for non-traded goods. Through this channel, capital inflows sustain nominal demand for non-traded goods, while capital outflows depress it.

How do shifts in nominal demand for non-traded goods affect employment and inflation? To answer this question, recall that $C_i^N = L_i \leq \bar{L}$ and $P_i^N = W_i \geq \bar{W}$. Moreover, equilibrium on the labor market implies that either the economy operates at full employment, or the constraint on downward wage adjustments binds. Domestic employment and the domestic component of inflation are then equal to

$$L_i = \min\left(\frac{1-\omega}{\omega}\frac{P^T C_i^T}{\bar{W}}, \bar{L}\right) \tag{17}$$

$$P_i^N = \max\left(\bar{W}, \frac{1-\omega}{\omega}\frac{P^T C_i^T}{\bar{L}}\right). \tag{18}$$

Intuitively, if $L_i < \bar{L}$ a marginal rise in nominal demand boosts employment, while leaving non-tradable prices unchanged. Conversely, if $L_i = \bar{L}$ an increase in nominal demand leads to higher domestic inflation, without affecting employment.

Using these results, we can frame the optimal monetary policy problem as choosing P^T to maximize

$$\sum_{i=h,f} \left(\omega \log C_i^T + (1-\omega)\log L_i - \chi\left(P_i\right)\right),$$

which $\phi \geq 1/2$ and all the capital can be absorbed by a single country, then the only possible outcome is one in which capital earns the same return in both countries and symmetry breaking does not occur. So efforts to increase capital mobility, i.e. to increase ϕ, may have a non-monotonic impact on macroeconomic outcomes.

subject to (17), (18) and $P_i = \left(P^T\right)^{\omega} \left(P_i^N\right)^{1-\omega}$. The central bank thus navigates an employment-inflation trade-off. As long as some country operates below full employment, increasing P^T leads to higher production and consumption of non-traded goods. But increasing P^T also boosts inflation, imposing a utility loss in those countries in which inflation exceeds its target (normalized to zero). Conventional monetary interventions, instead, do not affect tradable consumption, which is taken as given by the central bank.

4.1 Optimal monetary policy in a symmetric equilibrium

Suppose that condition (13) holds, so that both countries consume the same amount of traded goods, equal to $z\bar{K} - G$. Equations (16)-(18) then imply that both countries feature the same nominal demand for non traded goods, the same employment and the same inflation rate. We will use s subscripts to denote the value of a variable in this symmetric equilibrium.

The precise solution to the optimal monetary policy problem depends on the shape of the $\chi(\cdot)$ function and other parameter values. That said, we can draw some conclusions even without specifying the model further. Define $\bar{P}_s$ as the minimum inflation rate consistent with full employment, given by[15]

$$\bar{P}_s \equiv \bar{W} \left(\frac{\omega}{1-\omega} \frac{\bar{L}}{C_s^T}\right)^{\omega}.$$

Let us assume that $\bar{W}$ is such that $\bar{P}_s \geq 1$, so that when the economy operates at full employment inflation is non-negative. Then the optimal inflation rate satisfies $1 \leq P_s \leq \bar{P}_s$. Intuitively, setting $P_s = \bar{P}_s$ maximizes employment and consumption, while setting $P_s = 1$ minimizes the utility cost of inflation. Clearly, it cannot be optimal to set inflation outside of these two bounds.

From now on, we streamline the analysis by assuming that $\bar{W} = ((1-\omega)C_s^T/(\omega\bar{L}))^{\omega}$. In this case $\bar{P}_s = 1$, meaning that in the symmetric equilibrium the central bank faces no conflict between its employment and inflation targets. Under the optimal monetary policy, the central bank then sets $P^T = \bar{W}^{\frac{\omega-1}{\omega}}$ and attains $L_h = L_f = \bar{L}$ and $P_h = P_f = 1$.

4.2 Financial fragmentation, inflation and employment

Now imagine that condition (13) is violated, so that the equilibrium is asymmetric and the union financially fragmented. For concreteness, suppose that expectations coordinate on the h crisis equilibrium, in which the home country suffers a capital flight and a fiscal crisis. Of course, the results that we derive below also hold if it is the foreign country the one suffering a capital flight.

The key insight is that financial fragmentation triggers asymmetric demand condition across the union, since by equation (16)

$$\frac{P_h^N C_h^N}{P_f^N C_f^N} = \frac{C_h^T}{C_f^T} < 1.$$

In words, capital outflows depress demand at home, while capital inflows boost demand in the foreign country. It is then no longer possible for the central bank to hit its employment and inflation targets contemporaneously in both countries.

[15] This expression is obtained by combining expressions (1), (16), (17) and (18), and using the fact that in a symmetric equilibrium with full employment $C_i^T = C_s^T$ and $L_i = \bar{L}$.

To see this point more clearly, define union-wide inflation as $P_u = P_h^{1/2} P_f^{1/2}$. If the central bank were to set $P_u = 1$, which corresponds to the optimal policy under the symmetric equilibrium, the result would be unemployment in the home country and excessive inflation in the foreign one ($L_h < \bar{L}$, $P_f > 1$).

To characterize the optimal policy, it is useful to start from two extreme benchmarks. First, consider a dovish monetary policy, which fully focuses on maintaining full employment everywhere in the union. This monetary stance is optimal if the utility cost of inflation is not too large. Under this dovish benchmark, the central bank ensures that $L_h = L_f = \bar{L}$ by setting[16]

$$P_u = \left(\frac{C_s^T}{C_h^T}\right)^{\frac{1+\omega}{2}} \left(\frac{C_f^T}{C_s^T}\right)^{\frac{1-\omega}{2}} \equiv \bar{P}_u. \tag{19}$$

Since $\bar{P}_u > 1$, during an episode of financial fragmentation maintaining the union at full employment requires overshooting the inflation target. The reason is that capital outflows compress domestic demand in the home country. So, compared to a symmetric scenario, the central bank has to implement a more expansionary monetary policy to attain $L_h = \bar{L}$. This expansionary monetary stance pushes inflation above target in both countries, but the rise in inflation is more acute in the foreign one ($P_f > P_h > 1$), because capital inflows boost domestic demand there.

At the other extreme, consider a hawkish monetary policy, which focuses on preventing inflation from exceeding its target in any country of the union. This policy is optimal if the utility cost of having inflation above target is large enough. Since demand is higher in the country receiving capital inflows, under this hawkish benchmark the central bank ensures that $P_f = 1$ by setting

$$P_u = \left(\frac{C_s^T}{C_f^T}\right)^{\frac{\omega(1-\omega)}{2}} \equiv \underline{P}_u.$$

Since $\underline{P}_u < 1$, under this hawkish policy average inflation in the union falls below target. Since capital inflows boost demand in the foreign country, compared to a symmetric scenario monetary policy has to be tighter to maintain $P_f = 1$. This monetary stance is associated with full employment in the safe-haven country ($L_f = \bar{L}$), but unemployment in the country suffering a capital flight ($L_h < \bar{L}$).

The optimal monetary policy lies somewhere in between these two extreme benchmarks, and so the optimal inflation rate under financial fragmentation satisfies $\underline{P}_u \leq P_u \leq \bar{P}_u$. The result is a combination of excessive inflation and/or inefficiently low employment in the monetary union.

Proposition 2 *Suppose that the parameters are such that $\bar{P}_s = 1$. In a no-fragmentation equilibrium ($C_h^T = C_f^T$), both countries operate at full employment and have inflation on target. In a fragmented equilibrium ($C_h^T \neq C_f^T$), the union operates at full employment ($L_h = L_f = \bar{L}$) only if inflation overshoots its target in both countries ($P_h > 1, P_f > 1$).*

Financial fragmentation, by causing asymmetric demand conditions across the union, thus challenges the ability of conventional monetary policy to hit its inflation and employment targets.

[16] Recall that we normalized $\bar{W}$ so that $\bar{P}_s = 1$.

The reason, as we will see below, is that financial fragmentation effectively acts as a cost-push shock, i.e. an adverse shift of the Phillips curve which worsens the inflation-employment trade-off faced by the central bank.

4.3 Financial fragmentation and the Phillips curve

In our model, as it is standard, downward nominal wage rigidities imply that national Phillips curves are non-linear

$$P_i = \begin{cases} \left(\frac{L_i}{\bar{L}}\right)^{\omega} & \text{if } L_i < \bar{L} \\ \geq \left(\frac{C_s^T}{C_i^T}\right)^{\omega} & \text{if } L_i = \bar{L}, \end{cases}$$

where we have used our assumption $\bar{P}_s = 1$. When there is slack on the labor market ($L_i < \bar{L}$), employment is increasing in inflation and the country i Phillips curve is upward sloped. Once inflation is high enough so that full employment is attained ($L_i = \bar{L}$), the country-level Phillips curve becomes vertical.

To aggregate the two national Phillips curves in a union-wide one, define union-wide employment as $L_u \equiv (L_h + L_f)/2$. When the equilibrium is symmetric, the union-wide Phillips curve coincides with the two national ones

$$P_u = \begin{cases} \left(\frac{L_u}{\bar{L}}\right)^{\omega} & \text{if } L_u < \bar{L} \\ \geq 1 & \text{if } L_u = \bar{L}. \end{cases} \qquad (PC_{sym})$$

When inflation is negative both countries operate below full employment and the Phillips curve is upward sloped. Once inflation reaches zero ($P_u = 1$), both countries attain full employment and the Phillips curve becomes vertical. This case is illustrated by the PC_{sym} schedule in Figure 2.

The union-wide Phillips curve under financial fragmentation, illustrated by the PC_{frag} schedule in Figure 2, is instead given by

$$P_u = \begin{cases} \left(\frac{L_u}{\bar{L}}\right)^{\omega} & \text{if } L_u < \bar{L}\underline{P}_u^{\frac{2}{\omega(1-\omega)}} \\ \left(\frac{2L_u - \bar{L}}{\bar{L}}\right)^{\frac{1+\omega}{2}} \bar{P}_u & \text{if } \bar{L}\underline{P}_u^{\frac{2}{\omega(1-\omega)}} \leq L_u < \bar{L} \\ \geq \bar{P}_u & \text{if } L_u = \bar{L}. \end{cases} \qquad (PC_{frag})$$

If $P_u < \underline{P}_u^{\frac{2}{1-\omega}}$ both countries operate below full employment, and the Phillips curve under financial fragmentation just coincides with the symmetric-equilibrium one. If $\underline{P}_u^{\frac{2}{1-\omega}} < P_u < \bar{P}_u$ the foreign country operates at full employment, but there is slack on the labor market in the home country. In this case the PC_{frag} curve is steeper than the PC_{sym} one, because monetary expansions lead to higher employment in the home country, and to a rise in the domestic component of inflation (P_f^N) in the foreign one. If $P_u \geq \bar{P}_u$ the two countries reach full employment, and once again the PC_{frag} curve coincides with the PC_{sym} one.

As shown in Figure 2, financial fragmentation shifts unfavourably the Phillips curve, worsening the employment-inflation trade-off faced by the central bank. This result is due to the interaction of the aggregate demand asymmetries caused by financial fragmentation, and the non-linearities

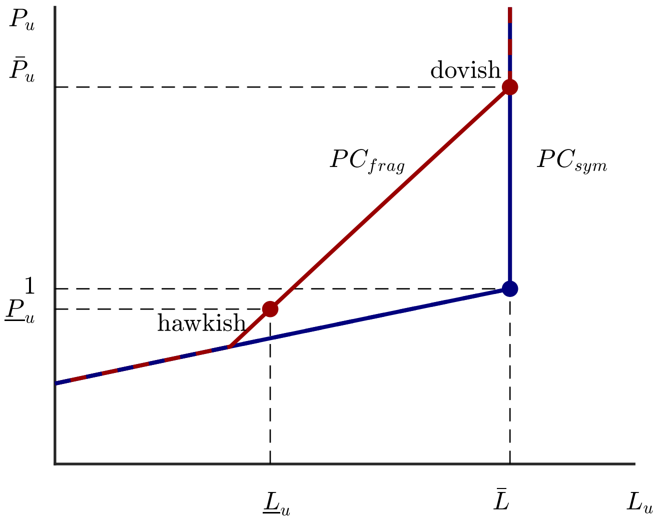

Figure 2: Financial fragmentation and the Phillips curve. Notes: the PC_{sym} schedule refers to the union-wide Phillips curve when the equilibrium is symmetric, while the PC_{frag} schedule shows the union-wide Phillips curve under financial fragmentation.

characterizing the national Phillips curves. Financial fragmentation thus triggers a cost-push shock, posing the central bank in front of a difficult trade-off between containing unemployment in the country suffering a capital flight, and inflation in the country acting as a safe haven. The outcome is a combination of unemployment and/or high inflation in the monetary union, and asymmetries in employment and inflation across its member countries.

5 Unconventional monetary policies

We now move away from the cashless limit that we have studied so far, and introduce money explicitly in the model. Suppose that households use money to perform transactions. In particular, let us assume that households need money to purchase a fraction ξ of their consumption goods, so that

$$M_i = \xi \left(P^T C_i^T + P_i^N C_i^N \right), \tag{20}$$

where M_i denotes money demand in country i. The central bank sets the total money supply M, and equilibrium on the money market requires $M = M_h + M_f$.

Households obtain money from the central bank in exchange for tradable consumption goods, so the central bank earns a seignorage revenue equal to M/P^T. The central bank fully rebates seignorage revenue to national governments, which use it to cover part of their expenditures. The fiscal rule (10) then becomes

$$\tau_i^k = \max\left(0, \frac{G - T_i - \bar{\tau}^l \frac{1-\omega}{\omega} C_i^T}{z K_i}\right), \tag{21}$$

where T_i is the transfer received by the country i government from the central bank. Naturally, a larger transfer creates fiscal space and reduces the need to employ distortionary capital taxation.

Moreover, transfers from the central bank amount to public capital inflows that boost tradable consumption. In fact, tradable consumption in country i is now given by

$$C_i^T = zK_i - RD_i - G + T_i - M_i/P^T, \tag{22}$$

where the term $T_i - M_i/P^T$ captures net transfers from the central bank.

Equations (16) and (20) imply that money demand is proportional to nominal expenditure on traded goods, $M_i = \xi P^T C_i^T/\omega$. The equilibrium on the money market then boils down to

$$M = 2\xi P^T C_s^T/\omega, \tag{23}$$

where $C_s^T = z\bar{K} - G$ denotes average consumption of traded goods across the union. Equation (23) implies that by setting the money supply M the central bank controls P^T. This is the conventional side of monetary policy. Moreover, since national governments receive all the revenue from seignorage

$$M/P^T = T_h + T_f. \tag{24}$$

Transfers from the central bank thus capture, albeit in a stylized way, unconventional monetary programs aiming at increasing national governments' fiscal space through public capital flows. For instance, purchases of government bonds by the central bank fall into this category, insofar as they lead to lower interest payments on public debt. We therefore associate the transfers T_i with the unconventional side of monetary policy.[17]

Definition 2 *A competitive equilibrium with unconventional monetary policies is a set of real allocations* $\{C_i^T, C_i^N, L_i, K_i, D_i, M_i\}$*, prices* $\{P_i,\ P_i^N,\ W_i,\ P^T\}$*, capital taxes* $\{\tau_i^k\}$ *and interest rate* R*, satisfying* (1) – (7)*,* (9) *and* (20)-(24)*, given* M *and* $\{T_i\}$ *set by monetary policy.*

As before, we consider a benevolent central bank, whose objective is to maximize the utility of the citizens of the union. The central bank operates under discretion, i.e. it lacks the ability to commit to a future policy path. In the context of our model, this means that the central bank sets M, T_h and T_f at the end of the period, after capital has been allocated across the union.

In this version of the model, assumption (11) is replaced by

$$0 < \phi < \frac{\omega + \xi}{2(\omega + \xi) + \bar{\tau}^l(1-\omega)}. \tag{25}$$

Moreover, to make things interesting, from now on let us assume that

$$G > \frac{\omega(1-\omega)\bar{\tau}^l + \xi\left(\omega + (1-\omega)\bar{\tau}^l\right)}{(\omega+\xi)(\omega + (1-\omega)\bar{\tau}^l)} z\bar{K}. \tag{26}$$

This condition, just like condition (17) for the cashless version of the model, implies that fundamentals are bad enough so that at least one government has to resort to capital taxation to balance

[17]Expression (23) implies that, once expressed in terms of tradable goods, the seignorage revenue earned by the central bank does not depend on the money supply M. While not crucial for our results, this property of the model simplifies considerably the analysis, because it separates cleanly the conventional side of monetary policy from the unconventional one.

its budget. A corollary of this condition is that we will focus on equilibria in which the interest rate is lower than the social return to investment ($R < z$).

5.1 An unrestricted benchmark

It is useful to start from a benchmark case, in which the central bank can freely set T_h and T_f. The optimal monetary policy then takes a particularly simple form. The central bank sets the transfers so that both countries consume the same amount of tradable goods ($C_h^T = C_f^T = C_s^T$), and the money supply so that $P_u = 1$. This policy is optimal because it attains full employment and inflation on target in both countries.[18]

In terms of instruments, the central bank achieves these objectives by setting

$$T_i = \xi C_s^T/\omega + (z - R)\left(\bar{K} - K_i\right) \tag{27}$$

$$M = \frac{\xi}{\omega}\frac{2C_s^T}{\bar{W}^{\frac{1-\omega}{\omega}}}. \tag{28}$$

The central bank thus uses transfers, that is public capital flows, to offset the impact of private capital flows on consumption. For instance, if the home country has suffered a capital flight ($K_h < \bar{K}$), it will receive net public inflows from the central bank ($T_h > M_h/P^T$).[19] Given $C_h^T = C_f^T = C_s^T$, the central bank then sets M so that $L_h = L_f = \bar{L}$ and $P_h = P_f = 1$.

The macroeconomic implications of this monetary policy stance are far reaching. Combining equations (21)-(27) gives that[20]

$$\tau_h^k = \tau_f^k = \frac{G}{z\bar{K}} - \left(\frac{\xi + (1-\omega)\bar{\tau}^l}{\omega}\right)\left(1 - \frac{G}{z\bar{K}}\right). \tag{29}$$

Under the unrestricted optimal monetary policy, therefore, taxes do not depend on how private capital flows allocate investment across the two countries. To see the logic behind this result, imagine once again that country h suffers a capital flight, pushing K_h below $\bar{K}$. The capital flight reduces the tax base in country h, which points toward an increase in τ_h^k. But the central bank reacts to the capital flight by increasing its transfer to country h, inducing a drop in τ_h^k. Under the optimal monetary policy these two effects exactly cancel out, explaining why τ_h^k does not depend on K_h.

Capital is then taxed at the same rate in both countries, regardless of how private investment is allocated internationally. This policy stance thus breaks the feedback loop underlying the self-fulfilling crises described in Section 3.2. Absent a return differential on capital investment, in fact, there is no reason for households to coordinate on a capital flight.

Proposition 3 *Suppose that assumptions (12), (25) and (26) hold. Under the optimal unconventional monetary policy fragmentation does not occur, i.e. both countries have the same consumption*

[18] Moreover, a symmetric allocation of tradable consumption is desirable because utility is concave in C_i^T.

[19] Recall that $M_i/P^T = \xi C_i^T/\omega$, and that in a symmetric equilibrium $C_i^T = C_s^T$.

[20] To derive this result, suppose that $K_h \leq \bar{K}$. Then it must be the case that $R = (1 - \tau_h)z$. Using this condition, (21)-(27) and $K_f = 2\bar{K} - K_h$ leads to equation (29). A similar reasoning applies to the case $K_f \leq \bar{K}$.

of tradable goods ($C_h^T = C_f^T$), operate at full employment ($L_i = \bar{L}$), and have inflation on target ($P_i = 1$). Moreover, under this policy the equilibrium is unique and symmetric ($\tau_h = \tau_f$, $K_h = K_f$).

A corollary of these results is that, to rule out financial fragmentation, the central bank does not actually need to transfer resources across countries in equilibrium. The expectation that the central bank will react in response to a self-fulfilling capital flight is enough to stabilize the union on the symmetric no-fragmentation equilibrium. The central bank does not even need commitment to credibly enforce this policy stance, which does not raise any time-consistency issues. The central bank does need, however, the flexibility to mobilize potentially large fiscal resources. We turn to this point next.

5.2 Fiscal backing and other constraints on monetary policy

So far, we have assumed that the central bank can set T_h and T_f freely. In reality, however, the central bank of a monetary union is likely to face restrictions on its unconventional monetary interventions. For instance, the central bank may lack fiscal backing from national governments. This consideration comes into play when the monetary authority wishes to transfer to a country more than its seignorage revenue. As an example, imagine that under the optimal unconventional monetary policy $T_h > M/P^T$. Under this policy stance, not only the government in country f does not receive any transfer, but it actually has to transfer fiscal resources to the central bank ($T_f < 0$). So this policy is feasible only if the central bank is fiscally backed by country f. Absent fiscal backing, transfers from the central bank are capped by total seignorage revenue ($T_i \leq M/P^T$). Moreover, regulatory or political constraints may impose even tighter restrictions on the design of unconventional monetary programs.

A simple way to model these constraints is to impose an upper bound $\bar{T} > M_i/P^T$ on the transfer that a member country can receive from the central bank. Under this restriction, the optimal unconventional monetary policy becomes

$$T_i = \frac{\xi}{\omega} C_s^T + \begin{cases} \min\left((z-R)\left(\bar{K}-K_i\right), \bar{T} - \frac{\xi}{\omega} C_s^T\right) & \text{if } K_i \leq \bar{K} \\ \max\left(-(z-R)\left(K_i - \bar{K}\right), \frac{\xi}{\omega} C_s^T - \bar{T}\right) & \text{if } K_i > \bar{K}. \end{cases} \tag{30}$$

Given an allocation of capital, the central bank transfers resources to the capital scarce country until tradable consumption is equalized or the upper bound on the transfer binds. Under this policy, the central bank is able to equalize consumption across the two countries if the allocation of capital is not too asymmetric. Otherwise, the country that has suffered a capital flight receives a positive net transfer from the central bank, but this is not enough to insulate its consumption from private capital flows.

Proposition 4 *Suppose that assumptions (12), (25) and (26) hold, and that the central bank sets transfers according to (30). Then there exists a stable symmetric no-fragmentation equilibrium. This is the unique equilibrium if*

$$\frac{\phi}{1-\phi} \leq \frac{\bar{T} - \frac{\xi}{\omega} C_s^T}{\left(G - \frac{\xi}{\omega} C_s^T\right)\left(1 + \frac{(1-\omega)\bar{\tau}^l}{\omega+\xi}\right) - \frac{(1-\omega)\bar{\tau}^l}{\omega+\xi} z\bar{K}}. \tag{31}$$

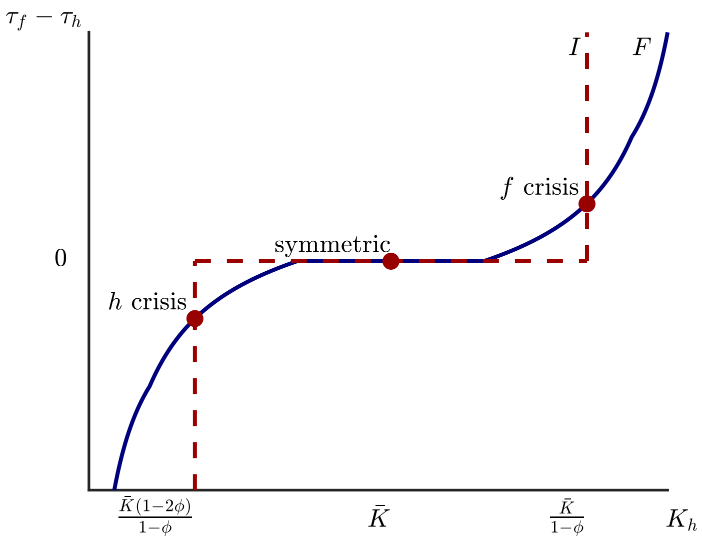

Figure 3: Capital markets equilibrium with unconventional monetary interventions. Notes: this figure shows how capital is allocated internationally when condition (31) is violated.

Otherwise, there are also two stable asymmetric equilibria. In these asymmetric equilibria the union is fragmented, i.e. one country features private capital outflows ($K_i < \bar{K}$) *and public capital inflows* ($T_i > M_i/P^T$)*, while the other private capital inflows* ($K_i > \bar{K}$) *and public capital outflows* ($T_i < M_i/P^T$)*.*

To understand Proposition 4, consider that condition (31) holds when private capital mobility (ϕ) is low relative to the public capital flows that the central bank can mobilize ($\bar{T}$). In this case, the constraint on unconventional monetary interventions never binds. All the results of the previous section then go through, and the presence of unconventional monetary programs settles the union on the symmetric equilibrium, without the need of in equilibrium interventions.

If condition (31) does not hold, instead, unconventional monetary interventions are no longer sufficient to rule out financial fragmentation. Perhaps the best way to understand this scenario is to use the diagram developed in Section 3.3. When monetary policy is conducted according to expression (30), the F schedule is horizontal at 0 for capital allocations satisfying $K^* < K_h < 2\bar{K} - K^*$,[21] while outside of these bounds the F schedule is upward sloped (see Figure 3). Intuitively, if private capital flows are not too large, the central bank has enough fiscal power to counteract them. This case corresponds to the horizontal portion of the F schedule. The upward-sloped portions of the F schedule, instead, capture scenarios in which private capital flows are too large to be fully offset by the central bank.[22]

[21] See the proof of Proposition 4 for the definition of the threshold K^*.

[22] The upward-sloped portions of the F schedule can be derived using steps similar to the ones outlined in footnote 13, though the algebra is more tedious. For instance, for $K_h < K^*$ the capital tax rates are given by

$$\tau_h^k = \frac{\left(\omega + \xi + \bar{\tau}^l(1-\omega)\right)(G - \bar{T})/z - \bar{\tau}^l(1-\omega)\bar{K}}{(\omega+\xi)\,K_h - \bar{\tau}^l(1-\omega)\left(\bar{K} - K_h\right)}.$$

$$\tau_f^k = \frac{1}{(\omega+\xi)\left(2\bar{K} - K_h\right)} \max\left(0, \tau_h^k\left((\omega+\xi)K_h - 2\bar{\tau}^l(1-\omega)\left(\bar{K} - K_h\right)\right) + 2\left(\omega + \xi + \bar{\tau}^l(1-\omega)\right)\frac{\bar{T} - \frac{\xi}{\omega}C_s^T}{z}\right).$$

There are two implications worth highlighting. First, aside from the two crisis equilibria, under the optimal unconventional policy a third stable equilibrium emerges: the symmetric one.[23] Hence, even when condition (31) is violated, the stabilizing effect of unconventional monetary interventions implies that expectations may coordinate on the symmetric no-fragmentation equilibrium.

Second, the macroeconomic impact of self-fulfilling crises is now milder, because the central bank partly offsets them through public capital flows. Interestingly, public capital flows are particularly powerful because they act as catalysts for private flows. To understand this result, suppose that expectations coordinate on the h crisis equilibrium. In this case, tradable consumption in country h is equal to

$$C_h^T = \frac{z\bar{K}\left(1 - \tau_h^k \frac{\phi}{1-\phi}\right) - G + \bar{T}}{1 + \xi/\omega}.$$

Naturally, a rise in the transfer boosts tradable consumption in the recipient country, thus mitigating the negative impact of capital outflows on consumption. In fact, differentiating the expression above gives

$$\frac{\partial C_h^T}{\partial \bar{T}} = \frac{\omega}{\omega + \xi}\left(1 - \frac{\partial \tau_h^k}{\partial \bar{T}} \frac{\phi}{1-\phi}\right) > 0.$$

The first term in parenthesis captures the direct positive impact of the transfer on consumption. This effect is smaller than one, since $\omega/(\omega + \xi) < 1$, because to increase consumption households need to acquire more money from the central bank. Hence, a unitary rise in the transfer produces a $\omega/(\omega + \xi)$ increase in net capital inflows from the central bank.

The second one, instead, encapsulates the fact that transfers from the central bank crowd in private capital flows. Intuitively, a higher transfer relaxes the government's budget constraint leading to a drop in the capital tax rate ($\partial \tau_h^k / \partial \bar{T} < 0$).[24] Lower taxes, in turn, attract private capital inflows by increasing the private return to investment. This channel amplifies the positive impact of net public inflows on tradable consumption during a capital flight.

Moreover, unconventional monetary interventions mitigate the impact of fragmentation on employment and inflation. Recall that financial fragmentation causes asymmetric demand conditions across the union, worsening the employment-inflation trade-off faced by the union's central bank. Unconventional monetary interventions reduce the dispersion in demand among member countries, and thus alleviate the employment and inflation losses associated with financial fragmentation.

This result is illustrated graphically by Figure 4.[25] As explained in Section 4.3, financial fragmentation acts as a cost push shock that shifts adversely the union's Phillips curve (from PC_{sym} to PC_{frag}). Unconventional monetary interventions, by reducing the dispersion in capital flows and tradable consumption, mitigate the adverse shift of the Phillips curve caused by financial fragmentation (compare the PC_{frag} schedule to the PC'_{frag} one). Less inflation is then needed to achieve a given level of employment, i.e. the inflation-employment trade faced by the central bank improves.

[23] Additionally, there are two unstable equilibria corresponding to the points $K_h = K^*$ and $K_h = 2\bar{K} - K^*$.

[24] In fact, if the home country has suffered a capital flight it will tax capital at rate

$$\tau_h^k = \frac{(1-\phi)\left((G - \bar{T})\left(\xi + \omega + (1-\omega)\bar{\tau}^l\right) - (1-\omega)\bar{\tau}^l z\bar{K}\right)}{z\bar{K}\left((1-2\phi)(\omega + \xi) - \phi(1-\omega)\bar{\tau}^l\right)}.$$

[25] The expressions for the Phillips curves are the same as those derived in Section 4.3.

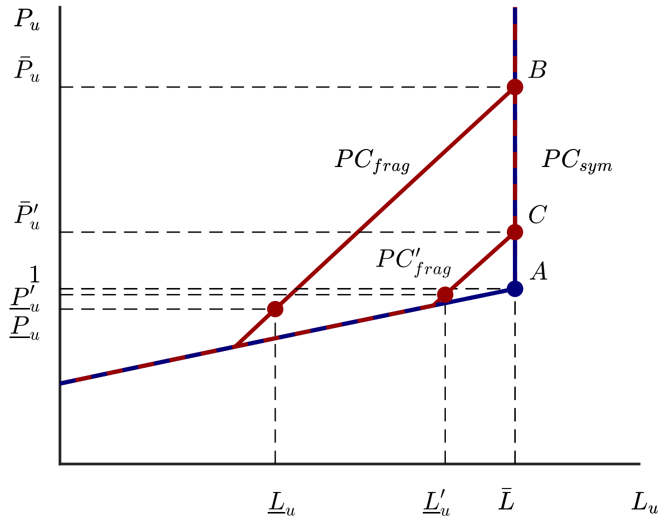

Figure 4: Unconventional monetary policies and the Phillips curve. Notes: the PC_{sym} schedule refers to the union-wide Phillips curve when the equilibrium is symmetric, while the PC_{frag} and PC'_{frag} schedules show the union-wide Phillips curve under financial fragmentation, respectively without and with unconventional monetary interventions.

A corollary of this result is that, perhaps surprisingly, an active use of unconventional monetary policies contains inflation in times of financial fragmentation. This insight can be grasped most clearly through an example. Imagine that the disutility from inflation is small, so that it is optimal to set $P_u = \bar{P}_u$ to attain full employment in both countries. By expression (19), the inflation rate consistent with full employment $\bar{P}_u$ is increasing in the dispersion of tradable consumption among member countries. The central bank will then react to a self-fulfilling crisis by letting inflation rise above target. In terms of Figure 4, a shift from the symmetric equilibrium to the fragmentation one moves the economy from point A to B. Now imagine that the central bank partly counteracts private capital flows through unconventional monetary interventions. The result is a drop in the inflation rate consistent with full employment, and the economy moves from point B to C.

In fact, there are two channels through which unconventional policies lead to lower inflation. First, public outflows cool down demand in safe-haven countries. Holding constant M, this effect leads to lower union-wide inflation. Moreover, public inflows sustain demand and employment in capital-flight countries. The central bank can then tighten monetary policy, i.e. contract the money supply M, and bring inflation down without hurting employment in countries suffering a capital flight. Through the lens of the model, therefore, unconventional monetary interventions create space for the central bank to contain inflation by engineering a conventional monetary tightening. This result turns on its head the view - sometime heard in policy debates - that unconventional monetary policies necessarily lead to higher union-wide inflation.

Summing up, the flexibility granted by unconventional monetary policies is useful to combat the threat posed by financial fragmentation to price stability. First, the presence of unconventional monetary programs may help to coordinate expectations away from episodes of self-fulfilling fragmentation. But unconventional policies are useful even when fragmentation actually happens. In this case, an active use of unconventional policies helps the central bank to get closer to its price stability objective.

5.3 The importance of international cooperation

Before concluding, let us spend a few words on the importance of international cooperation. As we have shown, unconventional policies lead to higher welfare for the union as a whole. But what about their impact on welfare in individual countries?

Unsurprisingly, capital-flight countries benefit from the net transfers received under the unconventional monetary programs. However, this is not the case for safe-haven countries. In fact, net public outflows represent a loss of income for them. Moreover, during self-fulfilling crises safe-haven countries benefit from inflows of cheap foreign capital. Unconventional monetary interventions reduce, or even eliminate, this additional source of income.

To be fair, safe-haven countries benefit from the lower inflation associated with unconventional monetary interventions. Hence, a narrow focus on pecuniary aspects gives an incomplete picture of the effect of unconventional monetary programs on welfare. In practice, however, the net impact of unconventional policies on welfare in safe-haven countries is likely to be negative. Indeed, we have maintained this assumption throughout the paper (see footnote 7).

This observation points toward the importance of international cooperation for a successful implementation of unconventional monetary programs. Ex-ante, that is before capital has been internationally allocated, all the countries of the union would agree on the kind of unrestricted unconventional interventions described in Section 5.1. But, if a self-fulfilling crisis actually occurs, ex-post safe-haven countries are likely to oppose the use of unconventional policies by the central bank. Our model thus suggests that financial fragmentation, at least of the kind described in this paper, is the outcome of lack of cooperation among countries member of the monetary union. Absence of cooperation, in fact, leads to an unequal distribution of the burden of adjustment during times in which fundamentals deteriorate.[26]

6 Conclusion

To conclude, let us speculate on an issue that we have voluntarily left out of the analysis: moral hazard. It is sometime argued that the prospect of receiving assistance from the central bank during fiscal crises leads governments to be fiscally imprudent. This consideration certainly has some merit, and is absent from our framework because we have assumed that public expenditure does not depend on the monetary regime.

On the other hand, there is also a countervailing aspect that we want to emphasize. The expectation of being hit by self-fulfilling fiscal crises, in fact, is likely to lead governments to accumulate precautionary savings by cutting their expenditure. In doing so, governments may scrap profitable public investment projects to insure against the risk of a fiscal crisis triggered by pessimistic animal spirits. This strikes us as a policy failure, that an appropriate use of unconventional monetary

[26]This result echoes the thesis put forward by Buiter et al. (1998), who argued that the 1992–93 Exchange Rate Mechanism crisis was due to lack of cooperation. In their view, the early 1990s monetary tightening originating from Germany should have been absorbed through a uniform small devaluation by other ERM participating countries. Lack of cooperation, instead, forced the adjustment on a small set of countries, which experienced large devaluations and capital flights.

policies helps to prevent. Developing a model that combines these two considerations, and allows the study of unconventional monetary programs on government expenditure, is an extremely interesting area for future research.

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Appendix

A Proofs and additional derivations

A.1 Proof of Proposition 1

Condition (13) holds. Proving that a symmetric equilibrium with $\tau_h^k = \tau_f^k = 0$ exists is straightforward. Using the fiscal rule (10), gives that governments do not tax capital if

$$G \leq \bar{\tau}^l \frac{1-\omega}{\omega} C_i^T. \tag{A.1}$$

Absent capital taxation, the private return to capital is z in both countries. No arbitrage between bonds and capital then requires $R = z$. Every agent then consumes the return on its initial endowment of investment goods, net of government expenditure, that is $C_i^T = z\bar{K} - G$. Using this result, one can easily see that (13) implies that (A.1), holds.

We now prove that, under assumption (11), this is the only possible equilibrium. There are three cases to consider. Suppose that $\tau_h > \tau_f \geq 0$. Seeking the higher return in the foreign country, home agents will ship as much capital as possible abroad and

$$K_h = \max\left(0, 2\bar{K} - K_f\right) = \bar{K}\frac{1-2\phi}{1-\phi}, \tag{A.2}$$

where the second equality uses $K_f \leq \bar{K}/(1-\phi)$ and (11). Since $K_h > 0$, no arbitrage between investment in home capital and bonds then requires $R = (1-\tau_h^k)z < z$, and consumption of tradables by agents in the home country is equal to

$$C_h^T = zK_h + R(\bar{K} - K_h) - G = z\bar{K} - z\tau_h^k\left(\bar{K} - K_h\right) - G.$$

Using this expression, (10) and (A.2) gives that

$$\tau_h^k = \max\left(0, (1-\phi)\frac{(\omega + \bar{\tau}^l(1-\omega))G - \bar{\tau}^l(1-\omega)z\bar{K}}{(\omega - \phi(2\omega + (1-\omega)\bar{\tau}^l)z\bar{K}}\right).$$

Assumption (11) and condition (13) imply that $\tau_h^k = 0$, meaning that we have found a contradiction.[27] The same procedure can be used to rule out the case $\tau_f > \tau_h \geq 0$.

We are left with the case $\tau_h = \tau_f > 0$. Using the fiscal rule (10), one can see that this corresponds to a symmetric equilibrium in which $K_i = \bar{K}$ and $C_i^T = z\bar{K} - G$. But we have just showed above that, if condition (13) holds, this symmetric equilibrium requires $\tau_h^k = \tau_f^k = 0$. We have thus found another contradiction, and proved that the symmetric no-fiscal crisis equilibrium is the only one consistent with condition (13).

Condition (13) does not hold. We have just proved above that in this case two asymmetric equilibria, in which one country experiences a capital flight and a fiscal crisis, exist. In these

[27] What if (11) does not hold? The country experiencing a capital flight is then on the wrong side of the (intertemporal) Laffer curve. That is, an increase in the capital tax rate depresses so much the interest rate and consumption of tradable goods that total tax revenue drops. In this case, when condition (13) holds the symmetric no-crisis equilibrium may coexist with two capital-flights equilibria, with all these three equilibria being stable.

equilibria, the country suffering a capital flight balances the budget by setting a capital tax rate equal to

$$\tau_i^k = (1-\phi)\frac{(\omega + \bar{\tau}^l(1-\omega))G - \bar{\tau}^l(1-\omega)z\bar{K}}{(\omega - \phi(2\omega + (1-\omega)\bar{\tau}^l)z\bar{K}}.$$

To be more precise, these equilibria exist if the right-hand side of the expression above is smaller than 1, otherwise there exists no upper bound on the capital tax rate $\bar{\tau}^k$ consistent with the government balancing the budget. Assumption (12) guarantees that this is the case.

When condition (13) does not hold, there is also a third symmetric equilibrium in which both countries charge the same tax rate on capital, given by

$$\tau_i^k = \frac{G - \bar{\tau}^l \frac{1-\omega}{\omega}\left(z\bar{K} - G\right)}{z\bar{K}} > 0.$$

This equilibrium, however, is unstable. The reason is that around this equilibrium τ_i^k is decreasing in K_i. So an infinitesimal deviation from the symmetric allocation of capital will result in a wedge in the private return to investment between the two countries. This will precipitate a capital flight, ultimately pushing the economy in one of the two asymmetric equilibria.

A.2 Proof of Proposition 2

The optimal monetary policy problem consists in maximizing

$$\sum_{i=h,f}\left((1-\omega)\log L_i - \chi\left(P_i\right)\right) + t.i.p., \tag{A.3}$$

where t.i.p. collects terms independent of monetary policy, subject to

$$L_i = \bar{L}\min\left(1, P_i^{\frac{1}{\omega}}\frac{C_i^T}{C_s^T}\right) \tag{A.4}$$

$$\frac{P_h}{P_f} = \left(\frac{\max\left(1, P_h^{\frac{1}{\omega}}\frac{C_h^T}{C_s^T}\right)}{\max\left(1, P_f^{\frac{1}{\omega}}\frac{C_f^T}{C_s^T}\right)}\right)^{\omega(1-\omega)}, \tag{A.5}$$

where we have used the assumption

$$\bar{P}_s \equiv \bar{W}\left(\frac{\omega}{1-\omega}\frac{\bar{L}}{C_s^T}\right)^{\omega} = 1,$$

to simplify the constraints.

Constraint (A.4) simply captures the national-level Phillips curves. Recall that we defined $C_s^T = z\bar{K} - G$, which corresponds to average consumption of traded goods in the union (i.e. $C_h^T + C_f^T = 2C_s^T$). Constraint (A.4) then implies that a country with tradable consumption below the union's average will require inflation above target to reach full employment.

Constraint (A.5), instead, encapsulates the fact that in a currency union the central bank has a single instrument (i.e. P^T) to manage the business cycle in multiple countries. This expression implies that if $C_h^T = C_f^T$ then both countries have the same inflation rate. If $C_h^T \neq C_f^T$ the two countries have the same inflation only if they both operate below full employment, that is if $P_i^{1/\omega} < C_i^T/C_s^T$. Otherwise, inflation is higher in the country with higher consumption of traded goods.

To prove the first part of the proposition, imagine that $C_h^T = C_f^T$. Then the central bank can set $L_i = \bar{L}$ and $P_i = 1$ in both countries. Since utility is increasing in L_i and the function $\chi(\cdot)$ reaches its minimum at $P_i = 1$, this corresponds to the optimal policy.

To prove the second part of the proposition consider that, by constraint (A.4), $L_i = \bar{L}$ requires

$$P_i \geq \left(\frac{C_s^T}{C_i^T}\right)^{\omega}. \tag{A.6}$$

Now imagine that $C_h^T < C_f^T$, so the expression above implies $P_h > 1$. Using constraint (A.5) then gives

$$P_f = P_h \left(\frac{C_f^T}{C_h^T}\right)^{\frac{1-\omega}{\omega}} > 1. \tag{A.7}$$

Hence, full employment at the union-level implies inflation higher than target in both countries. The same argument applies to the case $C_f^T < C_h^T$.

A.3 Proof of Proposition 3

Recall that the central bank sets T_h, T_f and M after capital has been allocated between the two countries. Clearly, a policy that attains $C_h^T = C_f^T = C_s^T$ is optimal from the point of view of the central bank. On the one hand, in fact, equalizing tradable consumption across the two countries increases the union's welfare because the utility from consumption is concave. Moreover, if $C_h^T = C_f^T$ then the central bank can guarantee full employment ($L_i = \bar{L}$) and inflation on target in both countries ($P_i = 1$) (see the proof to Proposition 2), thus minimizing the welfare losses due to unemployment and inflation.[28]

We now show that under the transfer rule (27) both countries consume the same amount of tradable goods and so $C_i^T = C_s^T$. Using equations (20) and (22) gives that

$$C_i^T = \frac{zK_i - R(K_i - \bar{K}) - G + T_i}{1 + \xi/\omega}. \tag{A.8}$$

Combining this expression with (27) gives $C_i^T = C_s^T$. We have thus proven that the transfer rule (27) corresponds to the optimal unconventional policy.

We are left to prove that under this policy the equilibrium features $\tau_h = \tau_f$. Imagine that $0 < K_h \leq \bar{K}$, so that $R = (1 - \tau_h^k)z$. Let us guess that $\tau_h^k > 0$. Using (27) and $C_h^T = C_s^T$, the fiscal rule then becomes

$$z\tau_h^k K_h = G - z\tau_h^k \left(\bar{K} - K_h\right) - \left(\frac{\xi}{\omega} + \bar{\tau}^l \frac{1-\omega}{\omega}\right) C_s^T, \tag{A.9}$$

[28] In practice, this is obtained by setting the money supply M according to (28).

which can be rearranged to obtain

$$\tau_h^k = \frac{G - \left(\frac{\xi}{\omega} + \bar{\tau}^l \frac{1-\omega}{\omega}\right) C_s^T}{z\bar{K}} > 0, \tag{A.10}$$

where the inequality makes use of assumption (26). Note that τ_h^k does not depend on K_h, because the optimal unconventional policy breaks the link between capital allocation and taxation.

Now guess that $\tau_f^k > 0$. Then the fiscal rule for the foreign government implies

$$z\tau_f^k K_f = G - z\tau_h^k \left(\bar{K} - K_f\right) - \left(\frac{\xi}{\omega} + \bar{\tau}^l \frac{1-\omega}{\omega}\right) C_s^T. \tag{A.11}$$

Using $K_f = 2\bar{K} - K_h$ and replacing τ_h using (A.10) proves that $\tau_f = \tau_h$. Of course, an analogous procedure can be used to prove the same result for the case $0 < K_f \leq \bar{K}$.

So at the start of the period agents anticipate that - regardless of private capital flows - the two countries are going to have the same private return to capital investment. They will thus be indifferent between any allocation of capital that satisfies the borrowing constraints, which is exactly the same kind of indeterminacy encountered in Section 3.1. As we did there, we resolve this indeterminacy by assuming that when $\tau_h = \tau_f$ agents coordinate on a symmetric allocation of capital and $K_i = \bar{K}$.

A.4 Proof of Proposition 4

We start by proving that if transfers are set according to (30) then a stable symmetric equilibrium exists. The key insight is that under this policy tradable consumption is equalized across the two countries, as long as the allocation of capital is not too asymmetric. To see this point, imagine that $K_h < \bar{K}$ and so $R = (1 - \tau_h)z$. Also suppose that

$$\frac{\xi}{\omega} C_s^T + \tau_h z \left(\bar{K} - K_h\right) > \bar{T}. \tag{A.12}$$

In words, we are considering a scenario in which the transfer is not large enough to equalize consumption across the two countries and $C_h^T < C_s^T$. In this case the central bank sets $T_h = \bar{T}$. Substituting out C_h^T and τ_h using (20)-(24) the condition above becomes

$$K_i < \bar{K}\left(1 - \frac{\bar{T} - \frac{\xi}{\omega}C_s^T}{\left(G - \frac{\xi}{\omega}C_s^T\right)\left(1 + \frac{(1-\omega)\bar{\tau}^l}{\omega+\xi}\right) - \frac{(1-\omega)\bar{\tau}^l}{\omega+\xi} z\bar{K}}\right) \equiv K^*. \tag{A.13}$$

Notice that $K^* < \bar{K}$. The implication is that for $K_h \in (K^*, \bar{K})$ the unconventional monetary policy rule (30) equalizes tradable consumption across the two countries. This proves that a stable symmetric equilibrium exists. Of course, the same logic applies to the case $K_f < \bar{K}$.

We now prove that if (31) holds the equilibrium is unique and symmetric. Recall that, due to imperfect financial integration, $K_i \geq \bar{K}(1-2\phi)/(1-\phi)$. If (31) holds then $K^* < \bar{K}(1-2\phi)/(1-\phi)$, so the only possible equilibrium is the symmetric one.

If (31) is violated and (26) holds, one can follow the steps outlined in the proof to Proposition

1 to prove that two stable asymmetric equilibria exist. In these equilibria, one country experiences private capital outflows ($K_i < \bar{K}$) and public capital inflows ($T_i = \bar{T} > M_i/P^T$), while the other receives private capital inflows ($K_i > \bar{K}$) and experiences public capital outflows ($T_i < 2M_i/P^T - \bar{T} < M_i/P^T$).