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This thesis contains three chapters that cover the past, present, and future of the euro area. In its first decade, the euro was considered a success. It facilitated European integration by increasing trade and financial linkages and by supporting economic growth. In the aftermath of the Global Financial Crisis however, its inherent fragility became evident. The build-up of macro-economic imbalances, fiscal vulnerabilities, and systemic financial risks resulted in the near collapse of the euro. The first two chapters of this thesis study causes of the build-up of macro-economic imbalances and fiscal vulnerabilities, namely redistributive effects of the euro and a shortage of public safe assets, and suggest policies to improve the stability and resilience of the common currency. The final chapter studies the implications of a recent euro-development, the potential introduction of a digital euro, for commercial banks and systemic financial risks.

Oscar Soons (1994) holds a BSc degree from the University of Rhode Island (2016, summa cum laude) and an MPhil degree in Economics from the Tinbergen Institute (2018, with distinction). In 2018, he joined the Finance Group of the University of Amsterdam as a PhD candidate under the supervision of Prof. Enrico Perotti. He is currently working as an economist in the monetary policy division of De Nederlandsche Bank (the Dutch central bank).

The Past, Present, and Future of the Euro Area Oscar Soons

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The Past, Present, and Future of the Euro Area

Oscar Soons

Universiteit van Amsterdam

The Past, Present, and Future of the Euro Area

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The Past, Present, and Future of the Euro Area

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Voor Carla

Contents

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Amsterdam, 2022

Introduction

This thesis contains three chapters that cover *the past, present, and future of the euro area*. In its first decade, the euro was considered a success. It facilitated European integration by increasing trade and financial linkages and by supporting economic growth. In the aftermath of the Global Financial Crisis however, its inherent fragility became evident. The build-up of macro-economic imbalances, fiscal vulnerabilities, and systemic financial risks resulted in the near collapse of the euro. The first two chapters of this thesis study causes of the build-up of macro-economic imbalances and fiscal vulnerabilities, namely redistributive effects of the euro and a shortage of public safe assets, and suggest policies to improve the stability and resilience of the common currency. The final chapter studies the implications of a recent euro-development, the potential introduction of a digital euro, for commercial banks and systemic financial risks.

The first chapter is joint work with Enrico Perotti. It analyzes causes and consequences of monetary unification among countries with different institutional quality, such as in the euro area. We develop a macroeconomic and political economy model where strong institutions promote production by reducing private costs and improving fiscal governance. Without a common currency, governments in countries with stronger institutions choose a more productive policy compared to those in countries with weaker institutions, resulting in higher production, a stronger currency, and lower taxes. Governments under weaker institutions opt for more public spending and may require a devaluation to ensure fiscal solvency in an economic downturn. Due to the possible devaluation, governments under weaker institutions have no access to foreign funding.

The model suggests that creating a diverse monetary union leads to currency re- and devaluations with lasting redistributive effects. Monetary unification gives rise to rapid market adjustments while institutional differences persist. The common exchange rate reflects the joint characteristics of all member states, so it implies a revaluation for weaker currency countries and a devaluation for stronger currency countries. Productive and fiscal capacity in countries with stronger institutions benefit from a competitive gain due to the currency devaluation. In contrast, in countries with weaker institutions public spending is less constrained due to the absence of a devaluation, which results in more access to credit and a lower cost of funding, just as their productive and fiscal capacity is reduced by the currency revaluation. Firms and employment in countries with stronger institutions benefit from a productive boost, while savers in countries with weaker institutions benefit from a stronger and stable currency. We suggest that in crises times the stability of a diverse monetary union requires a re-balancing mechanism to offset the persistent shift in fiscal capacity when weaker countries can no longer resort to a devaluation, such as permanent internal fiscal transfers.

The second chapter is single authored. It studies the demand for and supply of financial and real safety in a monetary union, examples are the supply of government bonds and public goods related to health care, respectively. There is empirical evidence for a strong demand for safety, both steady and inelastic. An insufficient supply of financial and real safety has undermined the stability of the euro area. The Covid-19 pandemic revealed the shortcomings of the national provision of public safety goods, such as related to health care and social security. A sudden loss of safe assets also played a key role in the Global Financial Crisis and European sovereign debt crisis. I develop a macro-finance model of a monetary union to formalize the safety benefits of (common) fiscal policy. In the model, households have a well-defined safety demand that is satisfied by (i) consuming public safety goods or (ii) safe asset holdings, provided by the private or the public sector, domestic or foreign. Governments choose their provision of public safety in order to maximize domestic welfare, financed by taxation.

In a Nash equilibrium governments provide a lower amount of public safe assets and public safety goods compared to the choice of a social planner. Consequently, households rely too much on private sector safe assets to satisfy their safety demand. The reason is that when a government chooses spending, it only considers the resulting safety benefits and taxation costs to domestic households. However, public spending also comes with a positive externality for foreign savers as it increases the total supply of public safety in the monetary union. A social planner does consider the costs and benefits for all households in the monetary union. I show that common fiscal policy can lead to a Pareto improvement by compensating for the lower-than-optimal national provision of public safe assets and public safety goods. Interestingly, this theoretical result does not rely on actual fiscal transfers, as studied in the first chapter of this thesis, and it also applies when some member states may default.

The third chapter is joint work with Manuel Muñoz. This chapter develops a banking model to study the implications of Central Bank Digital Currencies (CBDCs). In recent years, the use of digital payment methods for transactions has been increasing at the expense of cash. In response to this shift, central banks have started to investigate the potential benefits and implications of issuing CBDCs. One widely stated fear is that CBDCs may not only be used as a means of payment, but also replace bank deposits as a store of value. After all, a CBDC may have lower storage costs compared to cash due to its digital nature. To study the risk of bank disintermediation, we augment the classic Diamond and Dybvig (1987) banking model with public money as a store of value and heterogeneous beliefs about the probability of a bank run. We study the consumers' choice between bank deposits and cash holdings as a store of value, and the impact this choice has on bank lending. In the model, those consumers that are pessimistic about bank stability, so who believe the probability of a bank run to be high, prefer cash rather than bank deposits. Furthermore, aggregate cash holdings are higher when disagreement about bank stability is high, so in times of high uncertainty. These results are consistent with the main empirical observations on demand for cash as a store of value.

The model shows that the issuance of a CBDC that is a more attractive store of value compared to cash introduces a trade-off. On the one hand, those consumers who were already holding cash as a store of value benefit by replacing cash with CBDC. On the other hand, CBDC leads to bank disintermediation as it lowers the subjective probability of a bank run above which consumers prefer to hold public money rather than bank deposits. In other words, some consumers with an intermediate believe about bank stability prefer CBDC over bank deposits whereas they preferred bank deposits over cash in the absence of CBDC. Interestingly, while CBDC partially replaces deposits, long-term lending decreases less than proportionally to deposits. This is because banks set their lending in order to maximize depositor welfare and the remaining depositors are, on average, more optimistic about bank stability. Banks re-balance their portfolio according to the shift in depositor beliefs and increase their portfolio share of long-term investment. Thus, while in absolute terms the issuance of a CBDC leads to a decline in bank funding and bank lending, in relative terms it translates into more maturity transformation by banks. By adequately calibrating CBDC remuneration and quantity limits, the regulator can control the impact on banks by affecting the consumers' choice between holding cash, CBDC, or deposits as a store of value.

Chapter 1

The euro as a diverse monetary union

1.1 Introduction

We study how a diverse monetary union such as the euro came into existence and why it survived the fragility associated with its lack of a common fiscal commitment. The early literature on currency areas stressed the trade-off between trade benefits and independent monetary policy of a common currency, but did not study its effect on public policy or trade competitiveness (Mundell, 1961). The implicit view was that market mechanisms would over time ensure any required adjustment. Yet, a key insight from institutional economics is that differences in institutional structure are very persistent and may take generations to converge (North, 1991; Williamson, 2000).

This paper studies the cross-country impact of a diverse monetary union (DMU) such as the euro area, when deep institutional differences across member economies do not adjust at the pace of market and trade flows. Our political economy view takes a positive approach from the earlier literature, where Persson and Tabellini (1996) study the welfare balance of risk sharing and moral hazard and Casella (2005) considers optimal fiscal transfer in a diverse union. Many authors saw the euro as providing monetary credibility to economies with a history of devaluations (Giavazzi and Pagano, 1988; Alesina and Barro, 2002), implicitly viewing the process as a convergence to the Deutschemark. Others recognized a heavy burden of adjustment for weaker economies, although little attention was given to the impact of an external revaluation and its redistributive effects across diverse member countries.

We analyze such effects of a DMU in a macro and political economy framing where good institutions promote productive investment by reducing private costs and improving fiscal governance. We define a DMU as a common currency between a weaker economy (periphery) prone to devaluations and without access to foreign funding, and a more fiscally prudent economy (core) that never devalues. The model results appear to match well several economic trends since the introduction of the euro, both in the initial favorable phase and since 2009.

Before DMU, in each country private investment and interest rates responds to domestic public spending, anticipating future state-contingent taxation. Market exchange rates reflect the current trade balance, the outcome of private and public choices. The final state may be favorable or unfavorable. In the worse state a weak economy needs to devalue to avoid a public debt default.

This framing allows us to study a credible common currency equilibrium between two diverse countries. To solve our two-period model, we assume that trade and capital flow elasticity are within reasonable bounds (to rule out any free lunch for public spending) and that the common external exchange rate after DMU reflects average economic performance of member countries. This implies a devaluation for stronger economies and a revaluation for weaker economies, but also allows financial integration, lowering rates and releasing credit constraints in weak economies as it eliminates the possibility to devalue.

By definition, in a credible DMU even weak economies do not devalue, so they can borrow more and at lower rates. While a strong economy becomes more competitive in a credible DMU as it de facto implies an exchange rate devaluation, in a weak economy productive capacity may gain or lose depending on the balance among three endogenous factors: a positive interest rate effect, a currency revaluation effect, and a change in taxation. Overall, in a weak country production increases only for a large drop in interest rates and a low chance of a bad state.

Since a sovereign country cannot fully commit to a DMU, we study under what condition it will be maintained by both also in the worse state. In a credible DMU, a strong country government has incentive to join as its production benefits from a devaluation in all states as long as the chance of the bad state is low, since production increases even if a transfer is needed in bad times to avoid a break-up. Intuitively, the competitiveness gain in fiscal capacity implies that a core country government also has an interest in supporting a DMU through bad times. As a result, from the very start a credible DMU redistributes fiscal capacity, as the common exchange rate improves productive incentives at the core and deteriorates them at the periphery.

The results indicate that a credible DMU may arise when the institutional difference among member countries is large enough to provide an exchange rate benefit for the strong country to balance any fiscal support in distress, but not so large to lead to large expected transfers. Since joining a DMU is a political decision, a weak country government may still choose to do so to benefit from higher borrowing capacity even if their productive incentives suffer. Thus, in a credible DMU productive incentives do not necessarily improve in all countries, yet it can prove sustainable provided countries are not too different.

Understanding these effects offers insight on why a diverse monetary union may be credible and why governments may choose to join and remain committed to it even when occasional fiscal transfers are required to avoid a breakup. It implies that the euro financial integration created a hidden transfer union from the start, which needs some ex post fiscal rebalancing to survive in stress times. A DMU has redistributive effects also within countries. In stronger economies it has a positive effect on firm profits and employment (though not wages), while savers may lose purchasing power. In weaker countries investment incentives and employment are likely to be harmed, while savers gain from a stronger currency, and the public sector benefits.

In an extension we consider the case of private institutional quality, such as ease of legal or contractual enforcement. Good private institutions improve productivity and have similar effects on private production as good public institutions but opposing effects on public spending. Good private institutions reduce private investment costs and create more fiscal capacity, so public spending may be higher as the fiscal burden on productive incentives is lower.

The rest of this section places our approach in the literature and discusses suggestive evidence in history, documenting diverging trends of core and periphery economies in the financial integration phase and in the post-distress phase of the euro. Section 1.2 presents the model and solves for the case of independent currencies. Section 1.3 solves for a credible monetary union equilibrium among diverse countries, showing under what condition such a DMU emerges and remains credible even in adverse states. Section 1.4 offers a simulation and a discussion of the redistributive effects of a DMU. Section 1.5 concludes. All proofs are contained in the appendix.

1.1.1 Discussion and related literature

We focus on a DMU's financial effects and ignore other beneficial effects for all member countries, such as diversification or trade enhancement. We also ignore relative competitiveness gains of avoiding foreign competitive devaluations (Frieden, 1998). Our approach recognizes key fiscal and policy decisions as political choices, taken by governments operating in an own institutional framework. This adds to the early positive literature on monetary unification (Persson and Tabellini, 1996; Casella, 2005). Our approach seems suited for a foundation to the ex ante choice of strong and weaker economies of joining a DMU, as well as their incentive to remain in it in bad times.

All our results are driven by a notion of a different "speed of adjustment" for nominal and real variables, combined with persistent national institutions. Dynamic macro models explain costly adjustment to a shock by nominal inertia (rigid wages or debt) or persistent hysteresis effects due to the loss of human capital (Blanchard and Summers, 1986). Our approach goes further by introducing persistent institutions (North, 1991), most relevant to model policy choices as they shape public governance and social demands. This insight allows to explain why a revaluation shock may have longer term effects than in a traditional model, undermining productive capacity permanently (similar to the "Dutch disease" or resource curse effect). The impact is likely to be larger for countries with weaker institutions, as seen in the diverging response to the 1970 oil crisis (Von Hagen, 1992).

Good institutions can be defined as those supporting good governance, productive incentives and social cohesion (Acemoglu et al., 2005). We model public institutional quality as the weight placed in government preference on productive versus political benefits (such as private payoffs or improved chance of re-election), as in the classic political economy view in Grossman and Helpman (1994) and Foarta (2018). Cross-country evidence shows that better institutions lead to more stability and growth, limiting distortions due to political motives or special interests (Barro, 1991; Alesina et al., 1996; Acemoglu et al., 2003).

Our reduced form model of political preferences nests two interpretations of poor institutions. The public choice approach is concerned with poor public governance as the result of limited accountability and uninformed voters (Buchanan and Wagner, 1977). A broader interpretation explains poor policy choices as the result of conflicts from divergent policy preferences (Persson and Svensson, 1989; Alesina and Tabellini, 1990; Milesi-Ferretti and Spolaore, 1994). Weingast et al. (1981) argue that larger deficits reflects different regional preferences. Poterba (1994) show fiscal adjustment is more delayed under less durable governments, such as those built on diverse coalitions as shown by Grilli et al. (1991).

The simple setup refrains from any judgment on why poor institutions cause inefficiencies. This may be due to a culture of poor governance leading to less constrained political opportunism, or an heterogenous nation with contrasting preferences that any government must assuage to remain in office (Alesina and Perotti, 1995). Good institutions are more common in homogeneous societies, perhaps due to easier consensus on public decisions (Alesina and La Ferrara, 2000). In culturally and ethnically divided countries different preferences may lead to more conflicts, and excess spending may be critical to remain in power. The literature recognize that deep institutional changes are not a political choice but require favorable conditions and a longer historical horizon (Williamson, 2000; Roland, 2004).

In our model all trade is priced in dollar, as in the dominant currency paradigm (Gopinath et al., 2020), and the trade balance is driven by investment choices. In reduced form, the dollar exchange rate determination reflects the current account balance. Specifically, countries with low absorption run a surplus on the rest of the world and accumulate reserves, resulting in a stronger currency. This view is clearly consistent with the European experience before the euro.

Our results depend on the plausible notion that a DMU produces an intermediate currency level for the euro relative to its strong and weak predecessors. A hidden devaluation gained by a currency union with weaker economies is assumed to have no political cost, as in practice it is less visible and may take place gradually over time. In contrast, an ex post devaluation to ensure fiscal solvency comes at a political cost and imposes a devaluation premium on sovereign debt. Finally, we assume that foreigners are not willing to invest in devaluing countries, possibly because of unequal treatment in default (Kohlscheen, 2010).

1.1.2 Historical experiences with currency revaluations

A key mechanism in our model is the deterioration of productive incentives due to the currency revaluation in a weak country. Indeed, there are various examples in history of revaluations driven by favorable exogenous causes (such as discovery of natural resources) that boosted revenues in the short term had painful consequences over time, a so called “resource curse”.

Imperial Spain suffered economic decline from massive silver inflows from its colonies after 1500. The large rise in its currency caused severe loss of productive capacity in traded goods. Spanish iron and textile producers lost significant market share to England and Sweden and never fully recovered (Drelichman, 2005).

In 1925 Churchill choose to return sterling to gold, a step he later recognized as an historical blunder. He overrode Mainard Keynes who had anticipated high and persistent disruption due to monetary and institutional rigidities (Keynes, 1925). Keynes attacked other economists’ view of adjustment in the long-run: “economists set themselves too useless a task if in tempestuous seasons they can only tell us that when the storm is long past the ocean is flat again”. He famously added that “in the long run we are all dead”.

After natural gas discoveries in the Netherlands in the 1970s, the guilder rose sharply in value. The revenue boost led to a sharp increase in wages and public spending, a rise in the price of nontraded goods and even a rare current account deficit. By 1977 the Economist magazine had coined the term “Dutch disease” to describe the decline of Dutch competitiveness that led to partial deindustrialization (Frankel, 2010;

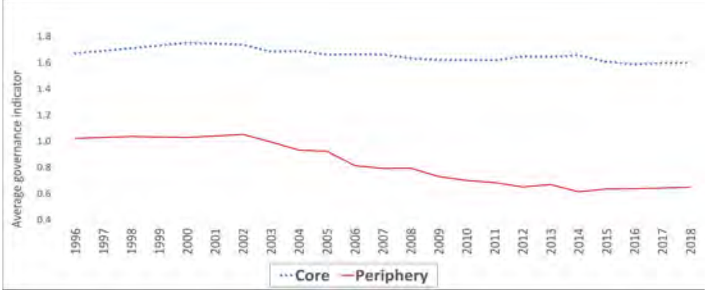
Van Wijnbergen, 1984).

More recently, German reunification in 1990 imposed huge adjustment costs as East German wages were raised after a one-to-one currency union around the Deutschemark. Even after painful labor reforms and decades of support, a gap between East and West persists. Thus, even in a monetary union with a common cultural tradition, institutional convergence may take generations.

1.1.3 Evidence on the effects of the euro

The euro area is an institutionally diverse monetary union, as measured by its Worldwide Governance institutional indicators (WGI). Political governance and public sector efficiency differ widely within the euro area, and define core and periphery countries based on their average WGI scores.[1] Figure 1.1 depicts the average WGI measure for core countries with a higher institutional quality (Germany, The Netherlands, Austria, Finland) and periphery countries (Italy, Spain, Portugal and Greece), while France, Ireland and Belgium have intermediate measures. The differences are large and persistent, and did not converge after the creation of the euro (Fernández-Villaverde et al., 2013).

Figure 1.1: Persistently diverse institutional quality

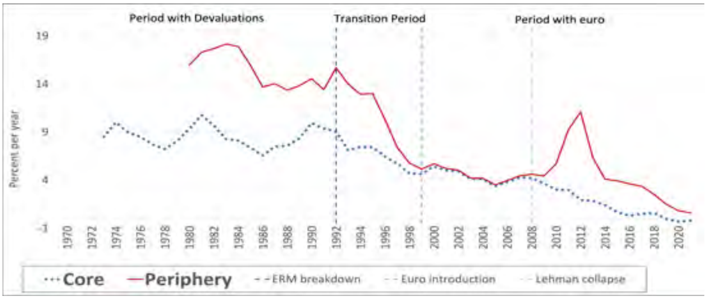


The average WGI indicator for core (Germany, Netherlands, Austria, Finland) and periphery countries (Italy, Spain, Portugal and Greece) are statistically different according to the Welch's unequal variances t-test. Data: Kauffmann and Kraay (2016)

The euro integration significantly lowered borrowing costs for periphery countries (Figure 1.2). Currency risk evaporated in the transition to the euro, anticipating the convergence to a common safe asset (Driessen and Perotti, 2004; Baele et al., 2004; Kalemli-Ozcan et al., 2010). Because of the gradual process, individual countries' exchange rate re- or devaluations were not clearly observable, though it was recognized that weak currencies were adjusting to a higher benchmark.

[1] Our measure averages the six WGI dimensions of political governance: Voice and Accountability, Political Stability, Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law and Corruption.

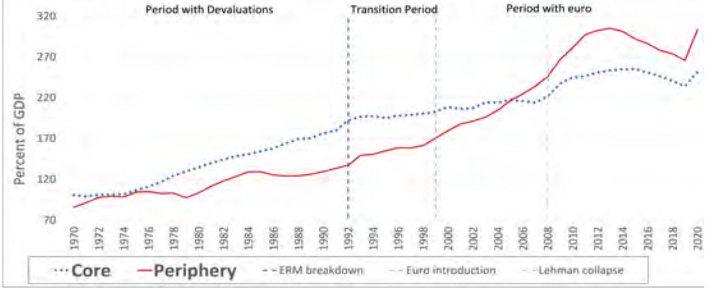
Figure 1.2: Long-term interest rate convergence



The figure displays the average 10-year government bond yields in core and periphery countries. Data: IMF.

The EMU provided periphery countries with more access to credit but imposed little fiscal discipline. The Maastricht fiscal rules were soon breached, by both core and periphery countries (Wyplosz, 2014). Figure 1.3 shows the evolution of the sum of private and public debt over GDP since the euro, showing how the rise of debt was not only due to public spending (as it was the case for Portugal and Greece), but also excess private lending booms built on public debt guarantees (as in Spain). Banks funded mostly real estate and non-tradable sectors, leading to higher real wages and reduced competitiveness (Brunnermeier and Reis, 2015; Gopinath et al., 2017).

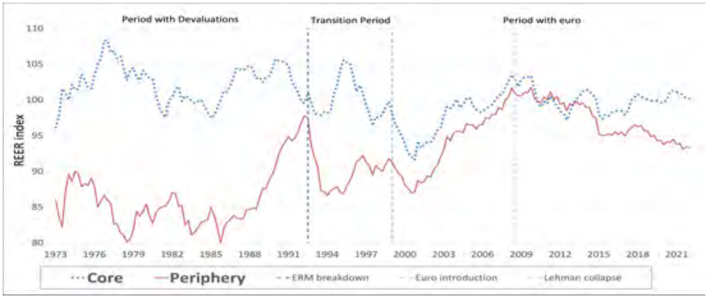
Figure 1.3: Total debt accumulation



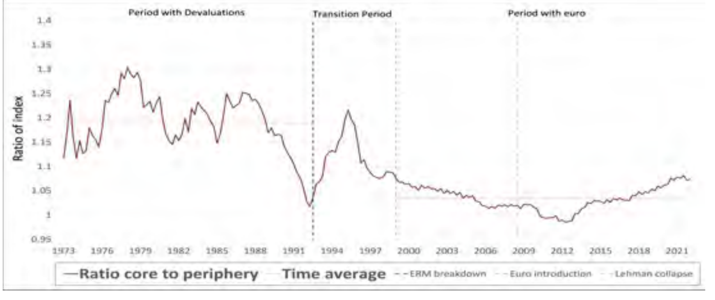
The figure displays the average sum of public and private debt over GDP in core and periphery countries. Data: IMF.

Figure 1.4 displays core and periphery real effective exchange rate (REER), a good indicator of relative competitiveness as it considers a currency value compared to its trade partners. Since the euro the average core REER fell while at the periphery it rose in the good years before the crisis, suggesting a gain in competitiveness for core countries, while the periphery lost ground. The ratio of the core to periphery REER in the bottom figure filters out common factors and the effect of any arbitrary choice of the index year. This data suggest that the European common currency led to a devaluation for stronger economies and a revaluation for weaker ones, an effect consistent with evidence on exchange rate misalignment in the euro area (Jeong et al., 2010; Duwicquet et al., 2012; El-Shagi et al., 2016).

Figure 1.4: Real effective exchange rate convergence



(a) Level



(b) Ratio

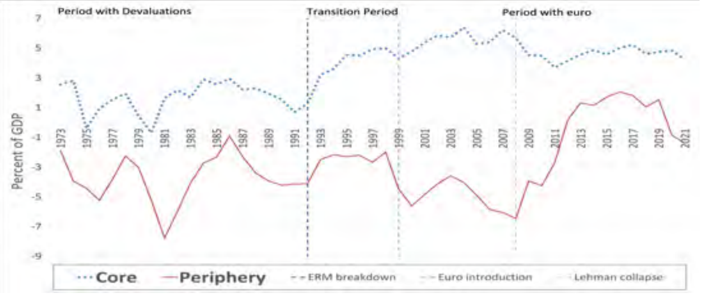
The figure displays the level and ratio of the average real effective exchange rate of core and periphery EMU countries, indexed so that 2010 = 100. Data: BIS.

A large exchange rate change has a persistent impact on competitiveness through its effect on real wages and fiscal capacity. The effect is clearly visible in the evolution of trade balances at the periphery and core since the Maastricht treaty, as presented in Figure 1.5. Core countries had historically a better trade position and stronger currencies. Since the euro their trade balance significantly improved, while the performance at the periphery deteriorated markedly. Critically, the difference in net trade is driven by low periphery export rather than by high periphery imports.

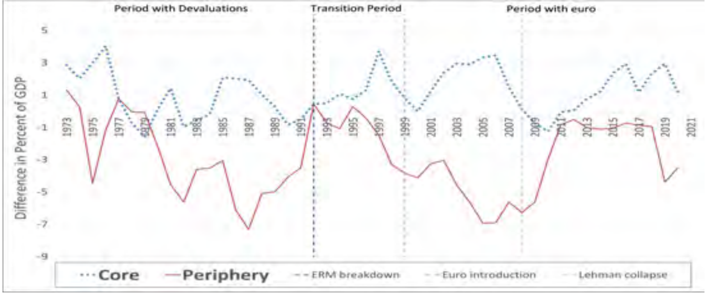
To highlight the exchange rate effect, Figure 1.5 also compares net trade balances of core and periphery countries with non-euro OECD countries with similar institutional quality. Between 1999 and the euro crisis, periphery countries lost competitiveness while core countries outperformed comparable non-euro OECD countries.[2] This pattern of exchange rate convergences and trade divergences also appeared during the realignment attempts in the late 1980s.

[2] The control group for core countries includes Australia, Iceland, Canada, Norway, Sweden, Switzerland, and New Zealand, and for the periphery it includes Turkey, Mexico, Israel, South Korea, Poland, Hungary, Czech Republic and Chile.

Figure 1.5: Trade balance divergence



(a) Trade balance



(b) Trade balance compared to non-euro peers

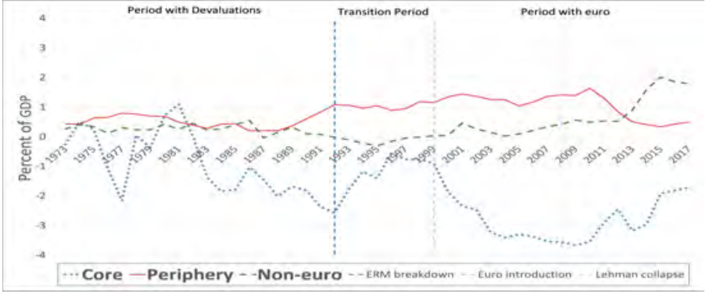
The figure displays the net trade balance of goods and services over GDP of core and periphery countries, and the trade balance difference between core and periphery countries and their non-euro peers with similar institutional quality. Data sources: OECD and the World Bank.

It is impossible to study the impact of the euro against a hypothetical scenario without its introduction. Still, Figure 1.6 offers a rather suggestive piece of evidence. The figure reports bilateral goods trade balances of Italy and Germany, the countries with the largest share of manufacturing output before the euro. It shows clearly how the Italian trade position with core countries deteriorates more than trade with non-euro countries, while there is no effect on trade with other periphery countries. On the contrary, the German trade position with periphery countries improves more than with non-euro countries, while there is no effect on trade with other core countries. This is suggestive of a redistributive external exchange rate effect of the euro on productive and fiscal capacity.

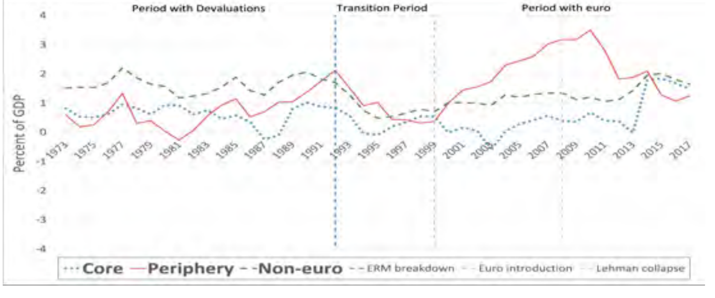
Figure 1.7 provides suggestive evidence that a key exchange rate effect has been the rise in real unit labor costs in periphery countries since the euro, while it decreased in core countries, consistent with a currency re- and devaluation. Periphery countries with a significant manufacturing sector such as Italy suffered most from the revaluation and were less able to adjust when the recession forced ever-higher taxation.

Next, we introduce a model that can account for this set of diverging trends.

Figure 1.6: Bilateral trade in goods balances



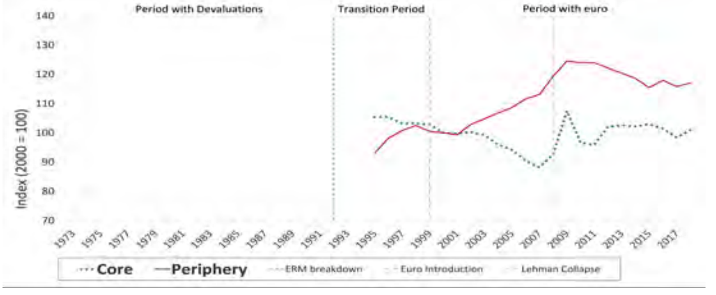
(a) Italy



(b) Germany

The figure displays the bilateral tradable goods balances of Italy and Germany with the core, periphery, and institutionally stronger non-euro countries. Institutionally stronger non-euro countries include Sweden, Switzerland, Norway, Iceland, Canada, New Zealand, and Australia. Data: Simoes and Hidalgo (2011).

Figure 1.7: Manufacturing



(a) Unit labor costs

(b) Output

The figure displays the manufacturing unit labor cost and output in core and periphery countries. Both series are indexed such that 2000 = 100. Data: OECD.

1.2 Model

1.2.1 Model environment

We consider an economy with two countries $j \in \{S, W\}$. Each country consists of households, firms, and a government operating in an institutional environment of quality β. A country's institutional quality may be high (β^S) or low (β^W). A higher institutional quality is more supporting of productive choices, both private and public. We will refer to a country with high institutional quality as a strong or core country, and those with lower quality as a weak or periphery country.

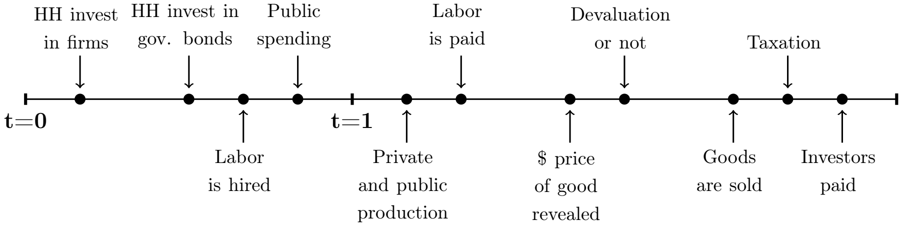
Investment takes place at $t = 0$ and production and consumption occur at $t = 1$. The payoff of production at $t = 1$ is contingent on the state of the global economy, either good or bad. The state of the economy is indexed by s and determines the only uncertain variable: the $t = 1$ dollar market price $\theta_s \in \{\theta_H, \theta_L\}$ of the traded good produced by firms, with $Pr(s = H) = p$. Future states are perfectly correlated across countries.

All exchange rates are set in terms of a reference currency (rest of the world), henceforth referred to as the dollar. We assume that initially each country has its own currency, whose exchange rate with the dollar ϵ_s is endogenous to national policy choices. Later we study the case of monetary unification, modelled as an (endogenous) common exchange rate with the dollar.

Timing Figure 1.8 presents the timeline. At $t = 0$ households start with a unit endowment of domestic currency. They first invest in firms, and then in domestic and foreign government bonds. Households also provide labor to firms and the government.

At $t = 1$ firms produce a traded good, and governments produce public goods. Once production is completed and wages are paid, the state of the global economy is revealed. Upon observing the state, governments may devalue if at risk of default. Next, the traded good is sold, revenues are exchanged for domestic currency at the exchange rate, and firms are taxed by the government to repay public debt. Firms distribute residual profits to its investors.

Figure 1.8: Timeline



Government Each government is run by a politician whose policy preferences trade off productive capacity with weight β versus a political or private benefit $B(G)$ from public spending G with weight $(1-\beta)$.[3] Institutional quality is defined by the weight $\beta \in$

[3] Higher public spending may personally benefit politicians when poor institutions reflect poor accountability of public choices or increase the chance of re-election in a diverse and more conflictual

(0, 1). By construction, in a high β country domestic institutions support a productive uses of resources. Our measure of economic welfare reflects the value of public goods $V(G)$ plus private output $f(L_F)$, where f is the production function and L_F denotes the labor used in production.

We assume henceforth that both political benefits $B(G)$ and social value of public goods $V(G)$ are linear in spending so $V'(G) = v$ and $B'(G) = b$.[4]

The government funds its spending by issuing public debt in its own currency, subject to a country-specific interest rate i. Public debt is repaid by taxing domestic production at the state contingent tax rate τ_s, which is chosen ex post and must be below a maximum feasible tax rate $\bar{\tau}$ above which massive tax evasion occurs.[5] Taxes are paid in domestic currency while firm dollar revenues are scaled by the exchange rate ϵ_s, so a weaker currency increases nominal fiscal capacity at $t = 1$.

When the maximum tax rate condition $\tau_s \leq \bar{\tau}$ becomes binding in the bad state, the government is at risk of default. A government can only avoid an unacceptable default by devaluing its currency. An anticipated devaluation has two effects.[6] A devaluation implies lower expected real wages, so it increases productive incentives and fiscal capacity. On the other hand, a devaluation has a political cost denoted as $H(\epsilon_0 - \epsilon_{DEV})$, which is increasing in the size of the devaluation.

To summarize, the government chooses its spending by balancing productive and political benefits

$$\max_G E[U^{gov}] = \beta\Big(f(L_F) + V(G)\Big) + (1 - \beta)B(G) - \mathbb{1}_{DEV}H(\epsilon_0 - \epsilon_{DEV}), \tag{1.1}$$

subject to the fiscal solvency constraint and the maximum tax rate constraint

$$\tau_s \frac{\theta_s f(L_F)}{\epsilon_s} \geq G(1 + i), \tag{1.2}$$

$$\tau_s \leq \bar{\tau}, \tag{1.3}$$

where the political cost $\mathbb{1}_{DEV}$ is paid if there is a devaluation at $t = 1$.

Labor is paid the nominal wage w, so public sector labor demand L_G equals

$$L_G = \frac{G}{w}.$$

Households and Firms A unit continuum of identical households has an initial unit endowment in domestic currency. Households are risk neutral and derive utility from public goods and from state-dependent consumption c_s at the final date. We assume that households suffer a disutility from very large real losses such as in a devaluation, a reduced form of risk aversion that ensures tractability. We denote this disutility by the strictly increasing function $H(\epsilon_0 - \epsilon_{DEV})$, where $H(0) > 0$. This formulation implies that larger devaluations are increasingly disruptive.

society.

[4] In reality, the marginal political utility of public good provision v may vary over time. For instance, during a pandemic the value v may be extremely high, leading all governments to spend much more.

[5] The threshold tax rate may be endogenized by a choice between paying tax and costly tax evasion.

[6] A devaluation may be the result of the central bank expanding domestic money supply. We abstract from any seignorage profits.

Households work and invest. They invest I in the productive technology (referred to as firms), B in domestic government bonds and F in foreign government bonds. We assume that international capital markets supply an adequate amount of risk-free bonds at the rate r. Households receive bond repayments and firm profit π_s at the final date. In the final period all domestic-currency denominated income is converted into dollars to consume the traded good, using the state contingent exchange rate ϵ_s.

Workers are paid a predetermined nominal wage w in domestic currency before the global state of the world is known. Labor supply is perfectly elastic, while firm labor demand L_F equals

$$L_F = \frac{I}{w},$$

thus, employment increases when wages fall or investment rises.

To summarize, households solve the following problem, anticipating public policy choices:

$$\max_{I,B,F} E[U^{HH}] = E[c_s] + V(G) - \mathbb{1}_{DEV} H(\epsilon_0 - \epsilon_{DEV}), \tag{1.4}$$

subject to their budget constraint

$$I + B + F \leq 1, \tag{1.5}$$

and where

$$c_s = \frac{1}{\theta_s}\Big(\pi_s(I)\epsilon_s + w(L_F + L_G)\epsilon_s + B(1+i)\epsilon_s + F\epsilon_0(1+r)\Big). \tag{1.6}$$

Household investment I funds firm labor costs. Firms produce at decreasing returns to scale

$$f(L_F) = A + L_F^{\alpha},$$

with $0 < A < \frac{1+r}{\overline{\tau}\theta_L}$ and $0 < \alpha < 1$.[7]

Firm profits π_s in domestic currency equal the after-tax revenues minus labor costs

$$\pi_s = (1 - \tau_s)\frac{\theta_s f(L_F)}{\epsilon_s} - wL_F.$$

Exchange Rate Determination We define the nominal exchange rate as dollars required to acquire one unit of domestic currency, so a weaker currency has a lower exchange rate. The external exchange rate is assumed to be linearly increasing in the ratio of the current account balance (reserves) to domestic money supply. While the domestic money supply is constant unless the government chooses to devalue, the current account balance depends on private and public choices. It is equal to the endowment minus investment and government spending

$$CA = 1 - I - G.$$

[7] Our results do not change if capital investment is also a choice variable (Perotti and Soons, 2019).

The exchange rate at $t = 1$ is given by

$$\epsilon_1 = \begin{cases} 1 + kCA, & \text{in normal times} \\ \epsilon_{DEV}. & \text{upon a devaluation,} \end{cases}$$

Here $k \geq 0$ measures the elasticity of the exchange rate to the reserve accumulation. The exchange rate is normalized to 1 when total spending equals domestic endowment. When domestic absorption at $t = 0$ (public spending and private investment) is less than domestic endowment, $G+I < 1$, the economy runs a trade surplus and accumulate reserves, leading to a stronger currency.

The contingent devaluation ϵ_{DEV} is set by a solvency and maximum tax rate constraint (constraints 1.2 and 1.3). Spending and contingent devaluation are anticipated and priced at $t = 0$, so lack of arbitrage implies $\epsilon_0 = E[\epsilon_s]$.

No Free Lunch Restrictions To solve the model, we introduce plausible restrictions on k, the elasticity of exchange rates to the reserve accumulation, so as to ensure a "no-free-lunch" setup. Our goal is to restrict attention to equilibria with a moderate response of fiscal capacity to public spending, ruling out extreme outcomes.

Assumption 1. $\underline{k} < k < \bar{k}$.

The upper bound on k ensures that excess public spending cannot pay for itself by a huge boost to taxable production via a large exchange rate effect. In other words, it ensures that the beneficial exchange rate effect of spending is not too large compared to its fiscal burden, ruling out equilibria with maximum public spending. The lower bound on k eliminates the counter-intuitive equilibria where excess public spending boost the net trade surplus, strengthening the currency. We henceforth assume that Assumption 1 holds.

The model cannot be solved in closed-form, since interest, tax and exchange rates are endogenous to private and public choices in both countries. We show by simulation the existence of our equilibrium results in a plausible parameter range that satisfy the no-free-lunch restriction.

Effects of Public Policy Public spending affects political utility in four ways. First, it pays labor L_G to produce public goods with a social value. Second, public spending offers direct political benefits. Third, spending affects private investment in two ways: directly via the required taxation, and indirectly via affecting interest and exchange rates. Fourth, high spending forces an unpopular devaluation to avoid a sovereign debt default. The political cost of a devaluation reflects the associated household disutility.

While risk-free and devaluation-free sovereign bonds pay a safe rate r in all states, a government that devalues needs to pay a premium. Due to the household disutility of devaluation, domestic investors demand an interest rate that ensures indifference between investing in risk-free foreign bonds and funding high domestic spending

$$(1 + i) = (1 + r) + (1 - p)\frac{H(\epsilon_0 - \epsilon_{DEV})}{\epsilon_0}. \tag{1.7}$$

Thus, even though they are risk neutral, households require extra compensation to ensure the same expected utility from investing in domestic bonds or in sovereign bonds in stable currencies. We refer to the interest rate differential as the devaluation premium $\Delta i = i - r$.

We assume that international investors do not fund a government that may devalue, as they expect to be disadvantaged relative to domestic savers in any debt conversion. As a result, spending by a government expected to devalue in the bad state is ex-ante constrained by net domestic savings, equal to the private endowment net of private investment.

1.2.2 Equilibrium before monetary unification

Public spending The first order condition for the government choice of its spending G states

$$-\beta\Big(f'(L_F)\frac{\partial L_F}{\partial G} + v\Big) = (1-\beta)b - \mathbb{1}_{DEV}\frac{\partial H(\epsilon_0 - \epsilon_{DEV})}{\partial G}\Big(\frac{\partial \epsilon_0}{\partial G} - \frac{\partial \epsilon_{DEV}}{\partial G}\Big), \tag{1.8}$$

where the marginal weighted public good and productive capacity benefits equal the marginal political benefit of public spending, net of any devaluation cost. The key factor is the net impact of spending on productive capacity. This depends on the aggregate effect of interest, exchange rate an expected taxation.

As a benchmark consider the case when $k = 0$, so without exchange rate effect of public spending. In that case, public spending balances the weighted benefits of public good provision and its political benefit with the fiscal burden and a potential devaluation cost. Even under perfect institutions ($\beta = 1$), a government may choose to devalue when a high value of public goods v leads to high spending. Thus, a country is at risk of devaluation if the combined social and political utility of spending is sufficiently high. Low β government choose high spending when their private benefit b from spending is high, and high β governments choose high spending when the social value of public goods v is high.

When $k > 0$ more spending results in a weaker exchange rate, which benefits production. Thus, a higher k leads to some extra fiscal capacity and incentivizes public spending, but only partial under Assumption 1.

Productive capacity Household choose investment to maximize their consumption, anticipating public spending and repayment policy. Their first order condition states

$$E[(1-\tau_s)f'(L_F)] = E[\epsilon_0(1+r)\frac{w}{\theta_s}]. \tag{1.9}$$

The left side of expression (1.9) is the expected marginal after-tax profit of investment while the right side is its opportunity cost, the return to government bonds in terms of consumption goods. Firm production may differ across diverse countries due to the impact of different public spending, which has three effects: a fiscal effect, an interest rate effect, and an exchange rate effect.

First, higher public spending leads to a higher tax rate, provided that there is an upper bound on the tax rate above which there is extreme fiscal evasion. Second, when spending is excessive, its nominal repayment in the bad states requires a devaluation. As a devaluation is anticipated, the borrowing rate will include a devaluation premium (henceforth, the interest rate effect). Both these effects of public spending increase expected tax rates and decrease firm incentives to produce. Third, higher public spending reduces the trade account, weakening the exchange rate. Since nominal wages are fixed, real wage costs decrease. This positive effect of spending may counterbalance its negative fiscal cost. A devaluation further exacerbates this effect. Thus, the net impact of public spending depends on the equilibrium interactions between all financial variables.

Under our no free lunch Assumption 1, the net impact of public spending on productive investment is negative. Thus, from this framing it is intuitive that governments under stronger institutions will choose for lower public spending as they place a larger weight on the negative effect of spending on private production. This leads to lower tax rates, a stronger currency, and higher private production in stronger countries. This is indeed true when the production function is sufficiently concave, or $-\frac{f''(L_F)}{f'(L_F)} > \bar{f}$, where

$$\bar{f} = \frac{\frac{\partial^2 L_F}{\partial G^2}}{\frac{\partial L_F}{\partial G}\frac{\partial L_F}{\partial G}}.$$

Lemma 1 summarizes the effect of political choices in a country with an own currency. The simulation confirms Lemma 1 for reasonable parameters.

Lemma 1. *Provided that there are no devaluations, governments in countries with higher institutional quality have lower public spending and higher private production when* $-\frac{f''(L_F)}{f'(L_F)} > \bar{f}$.

Fiscal capacity and the devaluation choice The maximum tax rate constraint defines a state-dependent maximum fiscal capacity FC_s equal to

$$FC_s = \bar{\tau}\frac{\theta_s f(L_F)}{\epsilon_s}. \tag{1.10}$$

Fiscal capacity is higher in case of a weaker exchange rate (lower ϵ_s), so a devaluation creates ex post fiscal capacity.

A government at risk of default sets the maximum tax rate and devalues just enough to ensure adequate fiscal revenues. Combining constraints 1.2 and 1.3, this defines the endogenous level of devaluation ϵ_{DEV} as

$$\epsilon_{DEV} = \frac{\bar{\tau}\theta_L f(L_F)}{G(1+i)}. \tag{1.11}$$

In its spending choice (determined by expression 1.8), each government balances the productive and political impact of spending. We show that for a government to run the risk of a devaluation, its institutional quality must be sufficiently low so that its private gain exceeds to household disutility from a devaluation. A government with $\beta < \beta^*$ chooses to spend more, set the maximum tax rate, and devalue in the low state.

Proposition 1. *Governments with* $\beta < \beta^*$ *choose public spending requiring a tax rate that exceeds the maximum tax rate, and thus devalue in the low state of the economy.*

Definition of a weak and strong country We henceforth refer to a weak country when its government spends more and chooses to devalue in the low state, which is the case when $\beta^W < \beta^*$ as per Proposition 1. Since devaluing governments have no access to international funding, public spending in a weak country is limited by net domestic savings. This is a binding constraint when the maximum tax-rate is sufficiently high, which we assume to be the case. A strong country is defined by β^S such that it never devalues, so $\beta^S > \beta^*$.

Supposedly a strong government could also consider devaluing its currency to boost private production without there being a need to do so. However, in our framing a strong government will never choose such a policy as households equally dislike a devaluation compared to in the weak government while a devaluation 1) gives no political benefits (no additional private benefits of public spending), and 2) a devaluation is more beneficial at the lower level of investment in the weaker country due to the concavity of the production function.

1.2.3 Effects of private institutional quality

So far we have modelled overall institutional quality as reflected in public institutions, although in reality it also reflects the quality of private institutions (legal enforcement, transaction costs, social capital). While private institutional quality is likely correlated with public governance, it has also a direct effect on productivity and the ease of conducting business activity.

To assess the distinctive effect of private institutions, we now indicate their quality by $\gamma \in (0, 1)$ as a measure of additional costs required to produce that affects marginal productivity. Now the production function equals

$$f(L_F) = A + \gamma L_F^{\alpha},$$

so the case of perfect private institutions ($\gamma = 1$) corresponds to our original formulation.

Consider first the benchmark case of a fixed exchange rate (when $k = 0$). All else equal, a lower quality of private institutions results in lower productivity, lower private investment, and thus lower fiscal capacity. Furthermore, due to the concavity of the production function, the impact of public debt is worse at lower levels of investment. Thus, we obtain an opposite result than before: ceteris paribus, lower private institutional quality (lower private productivity) result in lower public spending. Intuitively, a less favorable productive environment increases the social cost of public spending but not its political value, so even a low β government would partially compensate by reducing the burden of taxation.

Introducing the full exchange rate effect further raises the impact of private inefficiencies on production. For a given initial endowment and compared to the case of imperfect private institutions, the external surplus is now higher as both public spending and private production are discouraged. A stronger currency further discourages private production.

Proposition 2 formalizes this intuition under a threshold condition, where we define

$$\bar{\bar{f}} = \frac{\frac{\partial^2 L_F}{\partial G \partial \gamma}}{\frac{\partial L_F}{\partial \gamma}\frac{\partial L_F}{\partial G}}.$$

Proposition 2. *Under Assumption 1, public spending and private production are increasing in private institutional quality when* $-\frac{f''(L_F)}{f'(L_F)} > \bar{\bar{f}}$.

Public spending is increasing in private institutional quality provided that the production function is sufficiently concave. Our simulation confirms this to be the case under reasonable parameter values. Proposition 2 relies on the no free lunch Assumption 1.[8]

In conclusion, private and public institutional quality β and γ have similar effects on private production but opposing effects on public spending. Good public institutions encourage private investment by limiting excessive public spending. Good private institutions support private productivity and create more fiscal capacity, so public spending may be higher as the fiscal burden on productive incentives is lower. Table 1.1 summarizes the combined effects of public and private institutional quality.

In the remainder of this paper we assume $\gamma = 1$, focusing on the right-column of Table 1.1. As public and private institutional quality are empirically correlated, our results in the basic model will tend to over-attribute to public institutions the effect on productive incentives while under-estimating their role on public spending. In the context of the euro, this may lead to an overestimate of the role of political governance on the poor economic performance of periphery countries.

Table 1.1: Public and private institutional quality

	Weaker private institutions	**Stronger private institutions**
Weaker public institutions	Medium public spending Low private production	High public spending Medium private production
Stronger public institutions	Low public spending Medium private production	Medium public spending High private production

1.3 Diverse monetary union equilibrium

We study an institutionally diverse monetary union, defined as a currency union between a weak and a strong country, with $\beta^W < \beta^*$ and $\beta^S > \beta^*$ as defined in the previous section.[9] We analyze its effects and establish equilibrium existence by simulation, showing how a DMU is possible and credible when its member countries differ enough in their institutional quality, but not too much.

1.3.1 A diverse monetary union

In a monetary union households start with a unit of endowment in the common currency, and governments issue debt in the common currency.[10] We denote variables in the monetary union equilibrium with a superscript MU.

[8] Note that in this formulation the required bounds on k to ensure that private production is discouraged by more public spending are affected by private institutional quality γ.

[9] Fernández-Villaverde et al. (2013) argues that financial integration under the euro may have undermined institutional quality in periphery countries. This would enlarge the effects of a DMU but would not affect our main results.

[10] The change in denomination does not cause capital gain or losses as we abstract from previous holdings of domestic claims. We discuss wealth effects in Section 1.4.

The common exchange rate A credible DMU serves as a commitment device for governments not to devalue in the future. The common currency will be repriced vis-a-vis the numeraire currency (dollar) on the common current account balance, given by

$$\epsilon^{MU} = 1 - k(CA^{SMU} + CA^{WMU}).$$

In a diverse monetary union, the equilibrium dollar exchange rate for the common currency lies between national exchange rates when the institutional quality in the weak country is sufficiently low, but not too low.

Condition 1. *A sufficient condition for the common exchange rate to be valued between the individual exchange rates is* $\underline{\beta} < \beta^W < \bar{\beta}$.

Condition 1 identifies a plausible form of a DMU as a political arrangement among countries that are diverse enough to gain each in its own way, but not so different as to create an unstable union. Before DMU the strong country lent abroad its surplus, gaining reserves leading to a high currency value relative to the reference currency. When the (previously constrained) weak country government spends more after a DMU, the combined current account balance falls. Under Condition 1, the DMU external exchange rate will reflect a de facto devaluation for the stronger country, while the weaker country faces a revaluation. This shift lowers domestic real wages in the stronger country and encourage investment, and vice versa in the weaker country.

In the extreme case when β^W is below the lower threshold, the weak country government will spend so much that the common exchange rate will be below its own exchange rate when it was constrained to domestic savings and at risk of devaluation. When β^W is above the upper threshold, the additional spending by the weak country government may be fully compensated by a decrease in spending in the strong country such that the common exchange rate will be above its the its previous level in the strong country. We choose to ignore these extreme cases as economically implausible and henceforth assume Condition 1 to hold.

Solvency in the low state We can now assess the implications of a DMU for solvency. The DMU impact on the maximum fiscal capacity is given by

$$FC_s^{MU} - FC_s = \bar{\tau}\theta_s f(L_F)\Big(\frac{1}{\epsilon^{MU}} - \frac{1}{\epsilon_s}\Big). \tag{1.12}$$

It is easy to see that even for an unchanged production level in the strong country, its fiscal capacity benefits simply because its exchange rate is now weaker, and vice versa for a weak country that revalues. The total impact of DMU on solvency in the weak country also depends on the response of production. Yet, even when the weak country increases in production, real fiscal capacity may decrease because of the revalued exchange rate.

For all members of a monetary union to be solvent without devaluing, if a weak country is at risk of default, it must be able to receive a transfer T_L in the low state from the strong country. The required transfer depends on public spending, the interest rate, and its maximum fiscal capacity. It is equal to

$$T_L^W = G^{WMU}(1 + r) - \bar{\tau}\frac{\theta_L f(L_F^{WMU})}{\epsilon^{MU}}, \tag{1.13}$$

where we assume that any fiscal transfer is conditional on maximum fiscal contribution by the receiving country.

All else equal, the transfer is higher in case of a stronger common exchange rate, and thus increases in institutional difference. In other words, a weaker country requires a larger transfer when matched with a stronger country as the resulting common exchange rate will imply a larger revaluation. This already offers an important insight. The fiscal transfer does validate excess spending by the weaker country, but it is legitimized by the implicit transfer made by the common exchange rate effect that redistributes productive and fiscal capacity. The need for a transfer is thus not only the result of institutional weakness or moral hazard, but also a rebalancing factor compensating for the ex ante redistributive effects on fiscal capacity.

1.3.2 The impact on public spending

Even though institutional quality is unaffected, a common currency influences spending incentives. A DMU alters the productive effect of public spending through its exchange rate effect, interest rate effect, and by relaxing borrowing constraints.

In the strong country fiscal capacity benefits from a revalued exchange rate, but its expected fiscal burden depends on the frequency of a fiscal transfer. Both the devaluation gain and the transfer depend on the domestic and foreign spending and investment decisions, thus on their institutional difference. Taken together, the DMU impact on public spending in the strong country depends on assumed parameter values.

In the weak country DMU lowers interest rates and relaxes the foreign borrowing constraint, so the government can spend more and at a lower price. A previously constrained government is particularly likely to increase spending. In a DMU, the weaker government can commit to a higher real value of its public debt.

1.3.3 The impact on production

Similar to expression (1.9), the firm productive decision in country $j \in \{S, W\}$ solves

$$E[(1-\tau_s^{jMU})f'(L_F^{jMU})] = E[\epsilon_0^{MU}(1+r)\frac{w}{\theta_s}], \tag{1.14}$$

so productive incentives are affected by a DMU's impact on the external common exchange rate, expected taxation and interest rates (via its impact on tax rates). Comparing expressions (1.9) and (1.14) shows that production rises after DMU in country j provided that the balance between these effects is such that

$$E\Big[\frac{1}{\theta_s}(\epsilon_0^{MU}-\epsilon_0^{j})\Big] < E\Big[\frac{1}{\theta_s}(\tau_s^{j}\epsilon_0^{MU}-\tau_s^{jMU}\epsilon_0^{j})\Big]. \tag{1.15}$$

Production in the strong country The strong country does not gain from a lower interest rate after DMU, so its new productive choice only balances the exchange rate effect against expected taxation. To assess the overall effect, first consider the hypothetical case of unchanged tax rates. In that case, expression (1.15) simplifies to

$$\epsilon^{MU} < \epsilon^{S}.$$

Thus, in this hypothetical scenario output rises in the strong country after DMU if the common currency is weaker than its own, which is the case under Condition 1.

Now consider the change in tax rates in the strong country. The expected tax rate in the strong country after DMU is given by

$$E[\tau_s^{SMU}] = E\Big[\frac{G^{SMU}(1+r)\epsilon_0^{MU}}{\theta_s f(L_F^{SMU})}\Big] + (1-p)\frac{T_L^W \epsilon_0^{MU}}{\theta_L f(L_F^{SMU})}, \tag{1.16}$$

namely its own debt repayment plus a transfer in the low state. The DMU effect on expected taxation depends on the change in public spending, the transfer, and its probability relative to the fiscal capacity benefit, a productive gain in all states. If the probability of the transfer is sufficiently low ($p > p_S^*$), the exchange rate benefit for productive incentives in the strong country is larger than the cost in terms of a higher expected tax rate, and so production and its fiscal capacity benefits.

Proposition 3. *Production in the stronger country benefits from DMU when $p > p_S^*$.*

While a DMU between a strong and a weak country requires an occasional transfer, it also provides a persistent exchange rate benefit. When the transfer is required with a sufficiently low probability, the strong country benefits from diversity.

Production in the weak country Next we consider the weaker country. Consider expression (1.15) that ensures an increase in private production in a DMU. First, in case of unchanged tax rates, production decreases in a DMU in the weak country since the common currency is stronger than its own (Condition 1). Thus, for production in the weak country to benefit, it must be that expected tax rates decrease.

The expected tax rate in the weak country after DMU is given by

$$E[\tau^{WMU}] = p\frac{G^{WMU}(1+r)\epsilon_0^{MU}}{\theta_H f(L_F^{WMU})} + (1-p)\bar{\tau}, \tag{1.17}$$

namely its own debt repayment in the high state and the maximum tax rate in the low state.

On the one hand, the weak country benefits from the lower interest rate $r < i^W$ in the absence of a devaluation premium, which reduces the required repayment in the good state. On the other hand, the exchange rate revaluation harms its tax base. For the weak country, joining a credible DMU is a commitment not to devalue. This also means that public debt is higher in real terms, so even under constant spending its fiscal burden becomes heavier. Since a credible DMU releases the borrowing constraints, private productive incentives are also hurt when the government spends more.

Plugging in for the tax rate in expression (1.15), we find that the balance between the three effects (interest rate, exchange rate and tax rate) is positive when the probability of the high state is sufficiently high $p > p_W^*$.

Proposition 4. *Production in the weak country benefits from DMU when $p > p_W^*$.*

The fiscal benefit of lower interest rates is only realized in the good state. In the bad state the weak government is forced into the maximum tax rate jut as before the DMU. So, if $p > p_W^*$ the benefit of lower interest rates in the good state compensates for the devaluation effect and any increase in public spending. p_W^* is increasing in β^S:

in a DMU with a stronger country the negative exchange rate effect is larger, so for fewer weak countries the (constant) interest rate benefit prevails.

In general, productive capacity in weak countries increases after DMU only when the devaluation premium is large, and the institutional quality of the strong country is not too high. Then the combination of a transfer and lower interest rates outweighs the revaluation effect and the increase in spending.

1.3.4 A diverse monetary union as a credible equilibrium outcome

We now turn to evaluate the political choice to leave or join a DMU. A DMU is a credible equilibrium outcome if politicians choose to join, and strong country governments agree to a fiscal transfer in bad times.

Stronger governments prioritize productive effects, so they favor joining if productive incentives improve provided the probability of the transfer is sufficiently low relative to the required transfer (Proposition 3). The effect of joining on public spending is less pronounced than for constrained countries and in general ambiguous, as it depends on the net fiscal capacity gain.[11] The participation constraint reduces to $\beta^S > \beta^{S-J}$, where

$$\beta^{S-J} = \frac{b(G^S - G^{SMU})}{f(L_F^{SMU}) - f(L_F^S) - v(G^S - G^{SMU}) + b(G^S - G^{SMU})}, \tag{1.18}$$

which compares the potential loss of public spending to the net productive benefit.

Weaker governments benefit from DMU as they no longer incur the political cost of devaluation and enjoy lower rates. In addition, a credible DMU enables an increase in public spending. In general, the lower is institutional quality, the more the weak government increases spending after DMU. We can identify a purely political motive to join a DMU for a weak country government, even though domestic productive capacity may be hurt. Define the threshold β^{W-J} as

$$\beta^{W-J} = \frac{b(G^{WMU} - G^W) + H(\epsilon_0^W - \epsilon_{DEV}^W)}{f(L_F^W) - f(L_F^{WMU}) - v(G^{WMU} - G^W) + b(G^{WMU} - G^W)}. \tag{1.19}$$

The government in countries whose institutional quality β^W is below β^{W-J} will choose to join because it weights the political benefits of increased spending and no more devaluation cost more than the potential productive costs to its economy due to a revalued exchange rate.

A credible DMU equilibrium requires also that the strong country chooses ex post to pay the transfer. In our simple model there is no incentive in the second period to maintain the DMU by an ex post transfer. However, a credible commitment can be rationalized in a dynamic setting. Once the stage game in its current form is repeated indefinitely, the policy decision by the strong country compares the immediate transfer with a stream of discounted benefits. The DMU emerges as a credible equilibrium when expected benefits are larger than the occasional transfers (occurring with probability $1-p$ in each period), since a currency break up leads to a permanent return to a higher

[11] A high β^S government weighs productive incentives highly, so it may join a DMU even if this leads to lower spending.

currency rate.[12] This allows us to define a maximum incentive compatible transfer $\bar{T}$ (see Appendix).

We can now indicate sufficient conditions for the emergence of a credible DMU equilibrium.

Proposition 5.
Both a weak and a strong country government will agree to a DMU if $\beta^W \leq \beta^{W-J}$, $\beta^S \geq \beta^{S-J}$ *and* $T_L^W \leq \bar{T}$.

Proposition 5 implies that a credible DMU can emerge provided member countries are diverse but not too different.

A mutually beneficial DMU Clearly, because of political distortions the fiscal and financial effects of a DMU may not be mutually beneficial in productive terms. From Propositions 3 and 4, it is clear that a DMU is mutually beneficial only for a subset of the credible DMU's defined in Proposition 5, only when the probability of a crisis is sufficiently low.

Proposition 6.
Production in all DMU member states of a credible DMU benefit when $p > \max(p_S^*, p_W^*)$.

In reality a DMU also offers large real benefits in terms of trade integration and reduced transaction costs not covered in by our model. We next turn to a simulation of the model to gain some sense of its implications, under parameters satisfying our assumptions.

1.4 Quantitative simulation and redistribution

We establish existence of our equilibrium and compute its comparative statics by simulating the model under reasonable parameters that satisfy our restrictions.

Input parameters

Table 1.2 presents the values for the exogenous parameters included in the model.

Table 1.2: Parameter values

Parameter	Value
p	0.95
θ_H	2.0
θ_L	1.0
k	0.2
w	1.0
r	0.05
$\bar{\tau}$	0.20

Parameter	Functional form
α	0.5
A	0.8
v	0.01
b	0.01
$H(\epsilon_0 - \epsilon_{DEV})$	$0.01 + 0.05 * (\epsilon_0 - \epsilon_{DEV})$
δ	0.95

[12] Provided all surplus is consumed at the end of each period, the exchange rate is stable. A full intertemporal analysis where endogenous choices may be non-stationary is beyond the scope of our paper.

1.4.1 Equilibrium before monetary unification

Figure 1.9 shows how unconstrained government spending before a DMU decreases in institutional quality while its productive capacity rises, satisfying the general criteria defining good institutions. Constrained governments with $\beta^W < \beta^*$ would devalue in the bad state so are limited to domestic funding. Under this parametrization the no-free-lunch condition is satisfied.

Figure 1.9: Without DMU

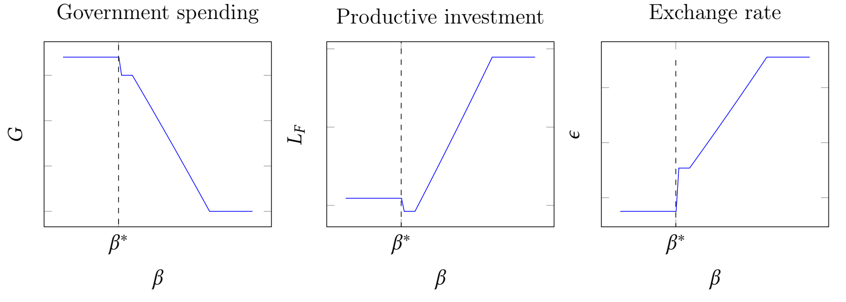
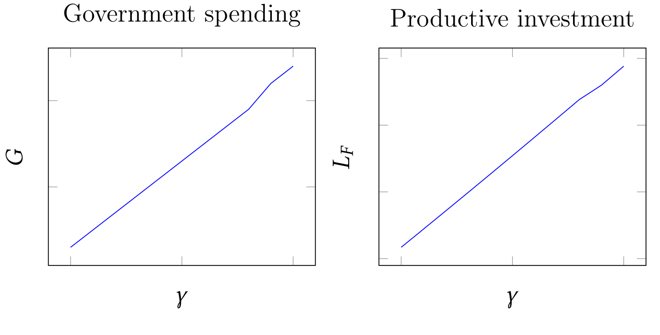


Figure 1.10 shows additional impact of private institutional quality. The figure confirms Proposition 2: private institutional quality supports both public spending and private investment.

Figure 1.10: Private institutional quality



1.4.2 Diverse monetary union equilibrium

Next, we compute the equilibrium of a DMU between a stronger and a weaker country that satisfy our range of strong and weak countries.

Table 1.3 shows the equilibrium outcomes for (excess) government spending and productive capacity as well as the required occasional transfer to sustain the DMU. The common exchange rate in this example indeed implies a hidden devaluation for the strong country and a revaluation for the weak country (Condition 1). The exchange rate benefit leads to an increase in production in the stronger country (and thus its fiscal capacity), even with a significant fiscal transfer compared to public spending, which is only paid in case of the low state.

The main benefit for the weaker economy is a fall in interest rates after DMU. Here this devaluation premium is modest, so the interest rate benefit of a DMU is too small compared to the exchange rate and fiscal effect, such that productive investment decreases. Yet, in this example the government in a weak institutional context gains enough from increased public spending to choose to join the DMU even though it undermines productive capacity for the country. The necessary transfer is smaller than its threshold bound, so this DMU is a credible equilibrium outcome (Proposition 5).

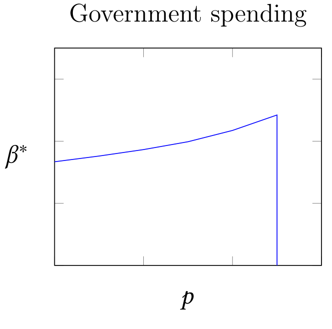
Table 1.3: DMU equilibrium outcomes

	No DMU		DMU	
	Strong	Weak	Strong	Weak
G	0	0.34	0	0.65
L_F	0.74	0.65	0.76	0.46
ϵ_0	1.05	0.91	1.03	1.03
T_L^W	0	0	-0.4	+0.4

1.4.3 Comparative statics

We illustrate the main comparative statics in terms of institutional quality, our variable of key interest. Figure 1.11 shows the threshold value β^* below which a government devalues in terms of the chance of a bad state. A higher p implies that fewer countries need to devalue as good prospects favor investment and boost fiscal capacity, so it reduces the range of weak countries. When p is very high, no government chooses public spending that requires a devaluation.

Figure 1.11: Devaluation bound



We next calculate the comparative statics of key effects of DMU in the weak country with respect to its institutional quality. Figure 1.12 shows that a weaker country increases spending more after DMU and needs a larger transfer. The increase in transfer is larger than the increase in spending as DMU lowers fiscal capacity in the weak country.

Figure 1.12: Fiscal effects weak country

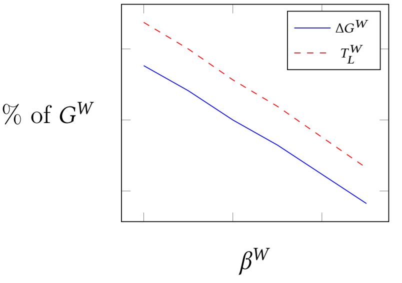
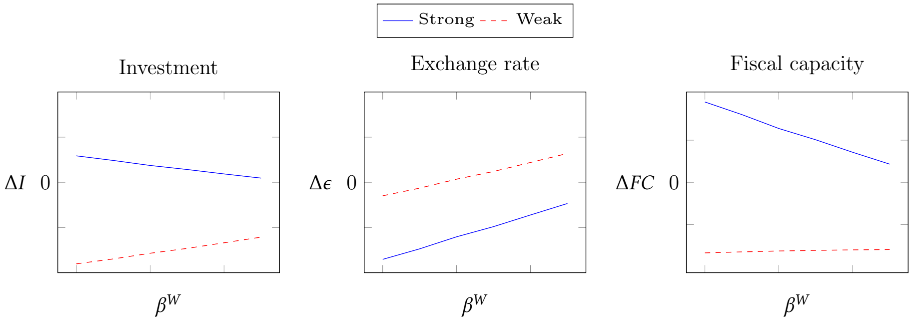


Figure 1.13 shows how the DMU impact on key variables in the strong and weak country depends on institutional quality. The left figure shows that the productive benefit of the strong country is decreasing in the weak country's institutional quality, and so is the loss for the weak country. Thus, a strong country is better off as the monetary union become more diverse, while production in the weaker country is increasingly undermined.

The middle figure shows the exchange rate effect as the key DMU redistributive effect. Strong countries benefit from a more diverse monetary union because this implies a larger devaluation compared to their exchange rate when they are on their own. On the contrary, a weak economy faces a larger revaluation when it joins with a stronger economy.

The right figure shows the effect on fiscal capacity resulting from the productive and exchange rate effects. A DMU results in an ex ante redistribution of fiscal capacity, which justifies an ex post fiscal transfer from the point of view of a strong country.

Figure 1.13: Comparative statics on DMU impact



1.4.4 Redistributive effects of a diverse monetary union

Our DMU equilibrium analysis points to ex ante and ex post redistributive effects between countries, bearing in mind that joining a DMU is a political decision. Intuitively, governments in stronger countries are more alert to productive benefits while in weaker countries they favor political motives more. Thus, across countries the clear beneficiaries of a DMU are production in the stronger countries and public spending for constrained governments, while production in weaker countries may fall. A common exchange rate tends to redistribute productive incentives and fiscal capacity from weaker to stronger economies making it a transfer union from the start, ahead of any explicit fiscal flows.

Redistributive effects also occur within countries. The setup does not lend itself to a full assessment as the representative household includes productive workers, public workers, investors, and retired savers. Still, consider the individual payoffs to investors Π_I, firm workers Π_L, government workers Π_G, and savers Π_S in each country (the components of household consumption).

$$\begin{aligned}
\Pi_I &= \pi_s(I)\epsilon_s, \\
\Pi_F &= wL_F\epsilon_s, \\
\Pi_G &= wL_G\epsilon_s, \\
\Pi_S &= B(1+i)\epsilon_s + F\epsilon_0(1+r).
\end{aligned}$$

Productive and public employees care about total real labor income as well as higher employment since labor is supplied elastically. Thus, workers may collectively gain from a lower exchange rate via higher employment even though individual real wages fall. Firm investors care about after-tax real profits, while nominal savers care about the real value of their savings.

Even before any investment decisions are altered, the exchange rate adjustment due to a DMU has immediate redistributive effects via real wages and fiscal capacity. Ex post the direction of redistributive effects depend on the state of the economy, as summarized in Tables 1.4 and 1.5.

A weaker common currency benefits productive incentives in the stronger country, with larger gains in good times. In bad times the required transfer increases the tax rate, and its anticipation reduces the productive benefit. In the weaker country firm profits are hurt by reduced competitiveness, and by the higher tax rates caused by more public spending.

In the stronger country productive employment benefits from better productive incentives, while public employment decreases when the government is less inclined to spend. Real wages are lower because of the common currency. All combined, public employment is certainly worse off, while productive labor may benefit.

In the weaker country the opposite is the case. Real wages increase because of the revaluation. Productive employment decreases due to loss of competitiveness and higher tax rates, while public employment benefits from higher government spending. In bad times the labor loss is attenuated by higher real wages as there is no devaluation. So public employment and its wages certainly benefits from DMU, while the effect on productive labor is more negative.

A final observation is that savers with a nominal claim, not explicitly introduced in the model, would be affected differently than investors in firms. Such savers in the stronger country receive the same real interest rate as before DMU, but the weaker currency reduce the real value of nominal wealth. In the weaker country they used to get a high real return in good times and a low real return in bad times. After DMU they get a safe return and benefit from a higher real valuation, so they may benefit from DMU.[13] Note however that in a repeated game, the initial capital loss for savers in strong country may be compensated over time by higher equity returns.

[13] Recall that households receive as endowment a unit of the common currency, a nominal claim that

Tables 1.4 and 1.5 provide an overview of the discussed direction of the redistributive effects within countries for a credible DMU that may not be mutually beneficial.

Table 1.4: Redistribution in the stronger country

	θ_H	θ_L	Expected
Investors	+	≈	+
Productive labor	≈	≈	≈
Public labor	-	-	-
Savers	-	-	-

Table 1.5: Redistribution in the weaker country

	θ_H	θ_L	Expected
Investors	-	-	-
Productive labor	≈	≈	≈
Public labor	+	+	+
Savers	-	+	≈

A benefit is denoted by +, a loss by −, and an ambiguous effect by ≈.

1.5 Conclusion

After more than 20 years of the euro, it is clear that persistent imbalances may arise in a monetary union between institutionally diverse countries. At the time of the euro creation the mainstream view was that next to considerable real benefits from enhanced trade, a DMU may serve member countries with low credibility as a commitment technology to not devalue, reducing interest rates. It was also recognized that an enhanced commitment to a harder constraint implied painful adjustment in weaker member countries. However, institutional change proved harder and slower than market adjustments, leading to a permanent shift in competitiveness and fiscal capacity across countries. This challenges a simplistic view of distress in the eurozone as reflecting different fiscal discipline alone.[14]

By introducing the notion of persistent institutional differences, our framing relates closely to the popular distinction between Eurozone "core" and "periphery" countries with different adjustment capacity and fiscal solvency. This paper advances the view that a DMU is likely to be redistributive from the start, favoring production and fiscal capacity in core countries. Yet even ignoring its trade benefits, a DMU can be credible and mutually beneficial even when it requires contingent fiscal transfers to weak members. In fact, such ex post transfer partially counterbalances the ex ante shift in fiscal capacity.

Our positive political economy approach allows to study why a redistributive monetary arrangement may be agreed ex ante and sustained ex post. We analyze how structural differences limit or distort the adjustment process, focusing on political drivers rather than welfare considerations. The results suggest that a DMU can be a credible political arrangement among countries diverse enough to gain each in its own way, but not so different as to create huge transfers and an unstable union.

Next to any favorable trade effects of DMU, stronger countries gain competitiveness through a de facto devaluation while weaker countries may have productive gains when the interest rate benefit is large. Interestingly, a weaker government may opt for monetary unification even when disadvantageous to domestic performance, as it gains

appreciates if the new parity rises in a DMU.

[14] Greenspan (2011) stated that the euro crises reflected "not just about labor costs and prices, but culture. There remains the question of whether ... the south would ever voluntarily adopt northern prudence."

fiscal credibility and spending capacity. Yet, while a DMU relaxes constraints on excess spending, it can be sustainable when institutional differences are so large to lead to a favorable exchange rate realignment, but not so large to require massive transfers.

In conclusion, we show how a diverse monetary union creates significant redistributive effects among and within countries, such that a DMU becomes a de facto transfer union before any fiscal transfers are ever decided. On aggregate, productive benefits disproportionately accrue to the institutionally stronger country while politicians benefit in weaker countries. There are also redistributive effects within each country. Producers and private employment in core countries and savers and public employment in periphery countries gain, balanced by an indirect transfer from producers in periphery countries and savers in core countries.

A consequence of this positive analysis is that a diverse monetary union without a re-balancing mechanism will create instability. Yet, pure fiscal transfers will not be the most efficient outcome in our context, due to the persistent institutional weaknesses of the periphery. A solution that addresses this point is to direct any transfer via a central entity (even one with an intermediate governance level), de facto imposing a shift in spending authority away from the national level. Such an institutional changes can alleviate moral hazard concerns associated with fiscal solidarity. As Farhi and Tirole (2017) state in the context of a banking union, "all (countries) can be made better off by combining a commitment to solidarity .. with an externalization of supervision". More generally, the analysis legitimizes compensating common policies to redistribute the productive costs and benefits of a DMU. This paper has taken a focused view on the effects of a DMU. Future work should consider explicitly the key issue of its monetary policy, both in a positive and as a normative analysis.

1.6 Appendix: proofs

1.6.1 Assumption 1

Without a devaluation, the household problem (1.4) is restated as

$$\max_{L_F} E[(1-\tau_s)f(L_F) + \frac{1}{\theta_s} w L_G \epsilon_0 + \frac{1}{\theta_s}(1-I)(1+r)\epsilon_0] + V(G).$$

The first order condition equals

$$E[(1-\tau_s)f'(L_F) - \frac{w}{\theta_s}(1+r)\epsilon_0] = 0.$$

Thus, firm labor demand is given as

$$L_F = \left(\alpha \frac{E[(1-\tau_s)]}{E[\frac{w}{\theta_s}(1+r)\epsilon_0]}\right)^{\frac{1}{1-\alpha}},$$

and its change in public spending equals

$$\frac{\partial L_F}{\partial G} = \frac{\alpha}{1-\alpha}\left(\alpha \frac{E[(1-\tau_s)]}{E[\frac{w}{\theta_s}(1+r)\epsilon_0]}\right)^{\frac{\alpha}{1-\alpha}} \frac{-E[\frac{\partial \tau_s}{\partial G}\frac{w}{\theta_s}(1+r)\epsilon_0] - E[\frac{w}{\theta_s}(1+r)\frac{\partial \epsilon_0}{\partial G}(1-\tau_s)]}{E[\frac{w}{\theta_s}(1+r)\epsilon_0]^2}. \quad (1.20)$$

The upper bound on k ensures that production is decreasing in public spending, which is the case when

$$-E[\frac{w}{\theta_s}\frac{\partial \epsilon_0}{\partial G}(1-\tau_s)] < E[\frac{w}{\theta_s}\frac{\partial \tau_s}{\partial G}\epsilon_0], \quad (1.21)$$

where

$$\epsilon_0 = 1 + k(1 - wL_F - G)$$
$$\tau_s = \frac{G(1+r)\epsilon_0}{\theta_s f(L_F)}$$

and

$$\frac{\partial \epsilon_0}{\partial G} = -k(w\frac{\partial L_F}{\partial G} + 1)$$
$$\frac{\partial \tau_s}{\partial G} = \frac{\left((1+r)\epsilon_0 + G(1+r)\frac{\partial \epsilon_0}{\partial G}\right)f(L_F) - f'(L_F)\frac{\partial L_F}{\partial G}G(1+r)\epsilon_0}{\theta_s f(L_F)^2}$$

When $k = 0$, condition (1.21) is satisfied for all $L_F \geq 0$ and $G \geq 0$ as in that case $\epsilon_0 = 1$ and $\frac{\partial \epsilon_0}{\partial G} = 0$, and public spending only harms production by increasing taxation. A positive $k > 0$ implies a larger left side of condition (1.21), while the impact on taxation on the right side is reduced. Thus, there exist a $\bar{k}$ such that when $k = \bar{k}$, condition (1.21) holds with equality and $\frac{\partial L_F}{\partial G} = 0$, and when $k < \bar{k}$ condition (1.21) is satisfied.

The lower bound on k ensures that the exchange rate ϵ_0 is always decreasing in public spending. This is the case when

$$w\frac{\partial L_F}{\partial G} > -1. \quad (1.22)$$

When $k = \bar{k}$ it holds that $\frac{\partial L_F}{\partial G} = 0$, and thus condition (1.22) is satisfied. However, when $k = 0$, condition (1.22) becomes

$$\frac{\alpha}{1-\alpha}\Big(\alpha \frac{E[(1-\tau_s)]}{E[\frac{w}{\theta_s}(1+r)]}\Big)^{\frac{\alpha}{1-\alpha}} \frac{E[\frac{\partial \tau_s}{\partial G}\frac{w}{\theta_s}(1+r)]}{E[\frac{w}{\theta_s}(1+r)]^2} < 1, \tag{1.23}$$

which depending on parameter values may not hold. If not, there exists a $\underline{k} < \bar{k}$ such that when $k = \underline{k}$ it holds that $w\frac{\partial L_F}{\partial G} = -1$, and such that when $\underline{k} < k < \bar{k}$ condition (1.21) is satisfied.

1.6.2 Lemma 1

Government spending in case of no devaluation solves

$$-\beta\Big(f'(L_F)\frac{\partial L_F}{\partial G} + v\Big) = (1-\beta)b, \tag{1.24}$$

which is rearranged as

$$-f'(L_F)\frac{\partial L_F}{\partial G} = \frac{(1-\beta)}{\beta}b + v.$$

The right side is decreasing in β, so in equilibrium when β is higher the left side must be lower. This left side is increasing in G when $-\frac{f''(L_F)}{f'(L_F)} > \bar{f}$, where

$$\bar{f} = \frac{\frac{\partial^2 L_F}{\partial G^2}}{\frac{\partial L_F}{\partial G}\frac{\partial L_F}{\partial G}}.$$

Thus, when $-\frac{f''(L_F)}{f'(L_F)} > \bar{f}$, it must be that $\frac{\partial G}{\partial \beta} < 0$ and $G^S < G^W$. Furthermore, as we know from Assumption 1 that $\frac{\partial L_F}{\partial G} < 0$, it must also be that $L_F^W < L_F^S$.

1.6.3 Proposition 1

The upper bound on k from Assumption 1 ensures that $\frac{\partial L_F}{\partial G} < 0$, while the lower bound ensures that $\frac{\partial \epsilon_0}{\partial G} < 0$. It follows from expression (1.20) that $\frac{\partial \tau_s}{\partial G} > 0$. Using Lemma 1, it must be that $\frac{\partial \tau_s}{\partial \beta} \leq 0$: governments with weaker institution set higher tax rates.

Define G^* such that a government that spends G^* is constrained by the maximum tax rate but does not need to devalue its currency, where G^* solves

$$G^* = \bar{\tau}\frac{\theta_L f(L_F)}{(1+r)\epsilon_0}.$$

A government compares the political benefit of the additional spending more than G^* and the expected effect on production with the household disutility of devaluation. A government chooses for additional spending and to devalue when for public spending $G > G^*$ it holds that

$$(1-\beta)b + \beta\Big(f'(L_F)\frac{\partial L_F}{\partial G} + v\Big) > -\frac{\partial H'(\epsilon_0 - \epsilon_{DEV})}{\partial G}\frac{\partial \epsilon_{DEV}}{\partial G}, \tag{1.25}$$

which is restated as

$$\beta < \frac{-\frac{\partial H'(\epsilon_0-\epsilon_{DEV})}{\partial G}\frac{\partial \epsilon_{DEV}}{\partial G} - b}{f'(L_F)\frac{\partial L_F}{\partial G} + v - b} = \beta^*. \tag{1.26}$$

1.6.4 Proposition 2

In a strong country, government spending solves

$$-\beta\Big(f'(L_F)\frac{\partial L_F}{\partial G}+v\Big)=(1-\beta)b,$$

where the impact of γ is given by

$$\frac{\partial f'(L_F)\frac{\partial L_F}{\partial G}}{\partial\gamma}=f''(L_F)\frac{\partial L_F}{\partial\gamma}\frac{\partial L_F}{\partial G}+f'(L_F)\frac{\partial^2 L_F}{\partial G\partial\gamma}. \tag{1.27}$$

Private investment equals

$$L_F=\Big(\alpha\gamma\frac{E[(1-\tau_s)]}{E[\frac{w}{\theta_s}(1+r)\epsilon_0]}\Big)^{\frac{1}{1-\alpha}},$$

so, all else equal, private investment is increasing in γ.

Suppose there is no exchange rate effect ($k=0$). In that case,

$$\frac{\partial L_F}{\partial\gamma}=\frac{\alpha}{1-\alpha}\Big(\alpha\gamma\frac{E[(1-\tau_s)]}{E[\frac{w}{\theta_s}(1+r)]}\Big)^{\frac{\alpha}{1-\alpha}}\frac{E[(1-\tau_s)-E[\frac{\partial\tau_s}{\partial\gamma}]\gamma}{E[\frac{w}{\theta_s}(1+r)]},$$

where the impact of γ on taxation is given by

$$\frac{\partial\tau_s}{\partial\gamma}=\frac{(1+r)f(L_F)\frac{\partial G}{\partial\gamma}-G(1+r)\Big(L_F^{\alpha}+\alpha\gamma L_F^{\alpha-1}\frac{\partial L_F}{\partial\gamma}\Big)}{\theta_s f(L_F)^2}.$$

Thus, when holding spending constant and when $k=0$, better private institutions implies lower tax rates, which reinforces the positive direct impact of γ on private investment. What is the impact on spending? Expression (1.27) is certainly positive when $-\frac{f''(L_F)}{f'(L_F)}$ is sufficiently large, in which case the impact must be positive.

The increase in spending moderates the positive impact of γ on taxation and production. When also $k>0$, the additional exchange rate effect benefits private production and thus further encourages public spending since $\frac{\partial G}{\partial\gamma}>0$ and $\frac{\partial L_F}{\partial\gamma}>0$ imply that $\frac{\partial\epsilon_0}{\partial\gamma}<0$.

To summarize, when $-\frac{f''(L_F)}{f'(L_F)}>\bar{\bar{f}}$, it holds that $\frac{\partial G}{\partial\gamma}>0$ and $\frac{\partial L_F}{\partial\gamma}>0$, where

$$\bar{\bar{f}}=\frac{\frac{\partial^2 L_F}{\partial G\partial\gamma}}{\frac{\partial L_F}{\partial\gamma}\frac{\partial L_F}{\partial G}}.$$

1.6.5 Condition 1

The common exchange rate is certainly valued in between the individual exchange rates when

$$CA^S>CA^{MU}>CA^W,$$

where, by definition, the weak country has a balanced current account before DMU, or $CA^W = 0$, and $CA^S > 0$.

Now, for $CA^S > CA^{MU}$ it must hold that

$$CA^{WMU} < CA^S - CA^{SMU}, \tag{1.28}$$

while for $CA^{MU} > CA^W$ it must hold that

$$-CA^{WMU} < CA^{SMU}. \tag{1.29}$$

The previously constrained weak government increases spending after DMU, so $CA^{WMU} < 0$ and $\frac{\partial CA^{WMU}}{\partial \beta^W} > 0$: a weaker government will increase spending more, resulting in a larger current account surplus. Thus, expression (1.28) is satisfied when the institutional quality in the weak country is sufficiently low, or $\beta^W < \bar{\beta}$.

Expression (1.29) is satisfied when in the DMU the weak country deficit is smaller than the strong countries surplus. This requires that the increase in public spending is not too large, so when the institutional quality of the weak country not too low, or $\beta^W > \underline{\beta}$.

1.6.6 Proposition 3

From

$$E\Big[\frac{1}{\theta_s}(\epsilon_0^{MU} - \epsilon_0^j)\Big] < E\Big[\frac{1}{\theta_s}(\tau_s^j \epsilon_0^{MU} - \tau_s^{jMU} \epsilon_0^j)\Big]$$

we obtain

$$p\frac{1}{\theta_H}(\epsilon_0^{MU} - \epsilon_0^S) + (1-p)\frac{1}{\theta_L}(\epsilon_0^{MU} - \epsilon_0^S) < p\Big(\frac{1}{\theta_H}(\frac{G^S(1+r)\epsilon_0^S\epsilon_0^{MU}}{\theta_H f(L_F^S)} - \frac{G^{SMU}(1+r)\epsilon_0^{MU}\epsilon_0^S}{\theta_H f(L_F^{SMU})})\Big) +$$
$$(1-p)\Big(\frac{1}{\theta_L}(\frac{G^S(1+r)\epsilon_0^S\epsilon_0^{MU}}{\theta_L f(L_F^S)} - \frac{G^{SMU}(1+r)\epsilon_0^{MU}\epsilon_0^S}{\theta_L f(L_F^{SMU})} - \frac{T_L^W \epsilon_0^{MU}\epsilon_0^S}{\theta_L f(L_F^{SMU})})\Big),$$

which is restated as

$$p_S^* = \frac{\frac{1}{\theta_L}\Big(\frac{G^S(1+r)\epsilon_0^S\epsilon_0^{MU}}{\theta_L f(L_F^S)} - \frac{G^{SMU}(1+r)\epsilon_0^{MU}\epsilon_0^S}{\theta_L f(L_F^{SMU})} - \frac{T_L^W\epsilon_0^{MU}\epsilon_0^S}{\theta_L f(L_F^{SMU})} - \epsilon_0^{MU} + \epsilon_0^S\Big)}{\Big(\frac{1}{\theta_H} - \frac{1}{\theta_L}\Big)(\epsilon_0^{MU} - \epsilon_0^S) - \Big(\frac{1}{(\theta_H)^2} - \frac{1}{(\theta_L)^2}\Big)\Big(\frac{G^S(1+r)\epsilon_0^S\epsilon_0^{MU}}{f(L_F^S)} - \frac{G^{SMU}(1+r)\epsilon_0^{MU}\epsilon_0^S}{f(L_F^{SMU})}\Big) - \frac{1}{(\theta_L)^2}\frac{T_L^W\epsilon_0^{MU}\epsilon_0^S}{f(L_F^{SMU})}}.$$

1.6.7 Proposition 4

From

$$E\Big[\frac{1}{\theta_s}(\epsilon_0^{MU} - \epsilon_0^j)\Big] < E\Big[\frac{1}{\theta_s}(\tau_s^j \epsilon_0^{MU} - \tau_s^{jMU} \epsilon_0^j)\Big],$$

we obtain

$$p\frac{1}{\theta_H}(\epsilon_0^{MU} - \epsilon_0^W) + (1-p)\frac{1}{\theta_L}(\epsilon_0^{MU} - \epsilon_0^W) < \ldots$$
$$p\Big(\frac{1}{\theta_H}(\frac{G^W(1+i^W)\epsilon_H^W\epsilon_0^{MU}}{\theta_H f(L_F^W)} - \frac{G^{WMU}(1+r)\epsilon_0^{MU}\epsilon_0^W}{\theta_H f(L_F^{WMU})})\Big) + (1-p)\Big(\frac{1}{\theta_L}\bar{\tau}(\epsilon_0^{MU} - \epsilon_0^W)\Big),$$

which is restated as

$$p_W^* = \frac{\frac{1}{\theta_L}\Big((\bar{\tau}-1)(\epsilon_0^{MU}-\epsilon_0^W)\Big)}{\Big(\frac{1}{\theta_H}-\frac{1}{\theta_L}\Big)(\epsilon_0^{MU}-\epsilon_0^W)-\frac{1}{(\theta_H)^2}\Big(\frac{G^W(1+i^W)\epsilon_H^W\epsilon_0^{MU}}{f(L_F^W)}-\frac{G^{WMU}(1+r)\epsilon_0^{MU}\epsilon_0^W}{f(L_F^{WMU})}\Big)+\frac{1}{\theta_L}\bar{\tau}(\epsilon_0^{MU}-\epsilon_0^W)}.$$

1.6.8 Proposition 5

For a strong government to choose for a common currency it must benefit:

$$\beta^S\Big(f(L_F^{SMU})+V(G^{SMU})\Big)+(1-\beta)B(G^{SMU}) > \beta^S\Big(f(L_F^S)+V(G^S)\Big)+(1-\beta)B(G^S),$$

which is true when

$$\beta^S > \frac{b(G^S-G^{SMU})}{f(L_F^{SMU})-f(L_F^S)-v(G^S-G^{SMU})+b(G^S-G^{SMU})} = \beta^{S-J},$$

The weaker government benefits from DMU when

$$\beta^W\Big(f(L_F^{WMU})+V(G^{WMU})\Big)+(1-\beta)B(G^{WMU}) > \beta^S\Big(f(L_F^W)+V(G^W)\Big)+\ldots$$
$$(1-\beta)B(G^W)-H(\epsilon_0^W-\epsilon_{DEV}^W)$$

which is true when

$$\beta^W > \frac{b(G^{WMU}-G^W)+H(\epsilon_0^W-\epsilon_{DEV}^W)}{f(L_F^W)-f(L_F^{WMU})-v(G^{WMU}-G^W)+b(G^{WMU}-G^W)} = \beta^{W-J}.$$

We now show when the required transfer will indeed be paid in equilibrium. Consider our model as a simple repeated stationary game. Once in the low state, the strong government could choose not to pay the transfer at the cost of breaking up the common currency. For the transfer to be paid, the government's expected discounted utility of a credible DMU in the future has to exceed the one-time political benefit derived from not paying the transfer, denoted by U^{govT}, plus the expected discounted utility outside the DMU in the future. We use a discount rate $\delta < 1$.

$$U_L^{govMU}+\sum_{t=1}^{\infty}E[\delta^t U_t^{govMU}] \geq U_L^{govMU}+U^{govT}+\sum_{t=1}^{\infty}E[\delta^t U_t^{gov}].$$

This is restated as

$$\frac{\delta}{1-\delta}\Delta E[U^{gov}] \geq U^{govT},$$

where $\Delta E[U^{gov}] = E[U^{govMU}]-E[U^{gov}]$, and $U^{govT} = T_L^W\Big(\beta^S v+(1-\beta^S)b\Big)$.

In words, the discounted gains from monetary unification must be larger than the one-time political benefit derived from resisting a transfer. This defines a maximum transfer $\bar{T}$ for which a monetary union is credible.

Chapter 2

The safety demand and common fiscal policy in a monetary union

2.1 Introduction

The resilience of the European Monetary Union (EMU) has been severely tested since the Global Financial Crisis, when its fragility in the absence of a common fiscal framework was revealed. Economist have long argued that some form of fiscal integration is critical to ensure the smooth functioning of a monetary union, with a focus on fiscal transfers to compensate for regional differences in case of a single monetary policy (Kenen, 1969). Although there have been many proposals for fiscal transfer schemes in the euro area, until the Covid-19 crisis there was a lack of political agreement, potentially due to the risk of permanent transfers.[1] This paper recognizes that fiscal integration in a monetary union may not only mean a fiscal transfer scheme, but it can also entail common fiscal policy, i.e. common public spending funded by common debt.

The contribution of this paper is to show that some degree of common fiscal policy can benefit all member states of a monetary union by offering a more efficient provision of safety, which avoids inefficient dependence on private sector safe assets. This result does not rely on fiscal transfers and also is the case when some member states are at risk of default. The safety benefits of common fiscal policy as studied in this paper are conceptually different from the risk sharing benefits of a fiscal transfer scheme, as studied in much of the literature (Farhi and Werning, 2017). While risk sharing benefits arise from smoothing consumption between member states subject to asymmetric shocks, safety benefits arise from supporting the minimum consumption in common crises.

The safety benefits of common fiscal policy are potentially large, for two reasons. First, euro area economies are increasingly integrated and synchronized, leaving the euro area more exposed to common shocks, such as the Covid-19 pandemic. During the pandemic, the shortcomings of the national provision of public safety across the euro area were revealed, such as related to healthcare and social security. Unprecedented (common) public support programs were required to limit the collapse of economic activity in all member states. Second, there is evidence for a global shortage of safe

[1] Among others, proposals include Enderlein et al. (2013); Berger et al. (2019); Beetsma et al. (2021), the "Four Presidents Report" by van Rompuy et al. (2012) and the "Five Presidents Report" by Juncker at al. (2015).

assets (Caballero et al., 2017). A sudden loss of safe assets played a key role in the financial crisis and European sovereign debt crisis (Caballero, 2006; Brunnermeier et al., 2011). Caballero et al. (2016) suggest that a structural shortage of safe assets can push economies into a "safety trap" situation in which output is constrained by the supply of safe assets.

I formalize the safety benefits of common fiscal policy in a two-country model of a monetary union with perfectly correlated economies. Households are risk neutral above a minimum consumption level and below which they suffer a large disutility. These preferences result in a well-defined and stable safety demand, consistent with the empirical evidence (Gorton et al., 2012; Krishnamurthy and Vissing-Jorgensen, 2012, 2015). The safety demand can be satisfied by safe asset holdings or by consuming real safety goods (e.g., essential goods and services related to law and order, infrastructure, or health care), provided by the private or the public sector, domestic or foreign.

The results depend on the notion that governments cannot commit to any fiscal policy, but rather set public spending to maximize domestic household welfare. Governments issue bonds to fund public spending on real safety goods which they provide more efficiently than the private sector. Domestic households are taxed ex post to repay public debt. While in a baseline model countries are identical, I also study an extension in which the only ex ante difference between countries is that some government may be at risk of default, motivated by the euro area experience.

In equilibrium governments provide a lower amount of public safety compared to a constrained social planner and households rely too much on private sector safe assets. The intuition for this result is as follows. When a government chooses spending, it only considers the resulting safety benefits and taxation costs to domestic households. However, public spending also comes with a positive externality for foreign savers. To illustrate, suppose that one government provides little public safety, so that domestic households need to rely more on private sector safe assets and foreign bonds. In that case, those foreign bond holdings reallocate public safety benefits across borders without sharing its fiscal costs, so they lower the "net public safety benefits" for foreign households and force foreign households to also rely more on private sector safe assets. In this example, an increase in public spending by the government that provides little public safety not only decreases the domestic reliance on private sector safe assets, but also decreases foreign bond holdings and thus the foreign reliance on private sector safe assets. Governments do not internalize this positive spillover of their public spending on foreign savers and thus set public spending too low.[2] The result is that, anticipating foreign spending incentives, all governments choose to provide an insufficient amount of public safety in a Nash equilibrium.

I show that some degree of a common fiscal policy can lead to a Pareto improvement by compensating for the lower-than-optimal national provision of public safety. I introduce a common institution that implements common public spending funded by common public debt issuance. The common institution provides common public safety directly, rather than acting as an intermediary between capital markets and national governments. I analyze how the impact of such common fiscal policy across member states depends on how the repayment of common debt is shared and on the solvency

[2] This results is an application of the traditional public finance result that in the case of spillover benefits, the output of public goods by a local government seeking to maximize the welfare of its own resident is likely to be sub-optimal (Oates, 1968).

of member states.

When the common debt is repaid by equal member state contributions, the common fiscal policy is equivalent to a credible and simultaneous commitment to increase the national public safety provision. In the baseline model without sovereign default risk, national governments of identical countries choose equally low public spending. In that case common fiscal policy provides a tool to overcome the inability of national governments to commit to the optimal fiscal policy that internalizes the positive spillover effect of public spending.

Common fiscal policy can be Pareto improving also when some member states are at risk of default. To ensure common debt repayment in case of a potential sovereign default, I assume that the solvent country may agree to repay a larger share of common public debt in some states. Although this commitment increases the expected tax burden in the solvent country, I show that some degree of common public spending may still be mutually beneficial whenever the defaulting country does not spend excessively, for two reasons. First, the issuance of common debt to fund common spending increases the public safety supply available to households in the solvent country. Second, the shared repayment of common debt lowers the impact of common debt issuance on the required haircut on the debt of the defaulting country, which benefits production in the solvent country since households in low-debt countries hold foreign bonds to satisfy their safety demand.[3]

The literature on European fiscal integration has focused on comparing the potential risk sharing benefits of fiscal transfers and financial stability benefits of common debt, with their moral hazard costs.[4] Compared to previous proposals for further fiscal integration in the euro area, the novelty in my proposal is twofold. First, instead of a fiscal transfer scheme, I propose a common institution that directly provides essential public goods and services, possibly related to law and order, border protection, environmental policy, public healthcare, unemployment insurance, or common deposit insurance. Second, I propose to finance this common institution with the issuance of common debt repaid by member states contributions over time, rather than relying on national governments to issue debt to fund a common budget or to create a European safe asset by tranching national debt. These features ensures that common fiscal policy increases the total provision of public safety rather than substituting for national public safety provision, provided that the common institution is concerned with total welfare rather than national welfare. It also ensures limited moral hazard: Once the common institution is in place, national politicians have no direct control over its spending and member states do not benefit from issuing more national debt within the monetary union.

[3] In the model, the minimum payment on public debt in case of a sovereign default is anticipated and provides safe income. Households in the solvent low-debt country invest in the debt of a high-debt country with default risk since, under some conditions, in a market clearing equilibrium it remains a better safety technology than excessively relying on the private sector for safety.

[4] In addition to the papers in footnote 1, see also De Grauwe and Moesen (2009); Claessens et al. (2012); Brunnermeier et al. (2017); Zettelmeyer and Leandro (2018); Leandro and Zettelmeyer (2019)

2.1.1 Discussion and related literature

The model's safety preferences are similar to those in habit formation models used in asset pricing (Campbell and Cochrane, 1999). As in Ahnert et al. (2018), I assume the disutility in case of low consumption to be sufficiently large so that households strictly prioritize obtaining their minimum consumption level, no matter the cost. Due to the discontinuity in risk aversion, the demand for safety is price insensitive and different - in theory - from a demand for insurance due to any concave utility function, and from a liquidity demand as in Diamond and Dybvig (1983); Stein (2012). Varying risk aversion has also been used by Benhima and Massenot (2013) who include preferences with decreasing relative risk aversion, and Caballero et al. (2016) who include a subset of infinitely risk averse agents.

The safety demand is satisfied by safe assets (safe financial returns) or by real safety goods (essential goods and services), provided by the public or the private sector. For instance, households can save their income by investing in government bonds or private sector safe assets and purchase private healthcare, or the government can provide healthcare funded by taxation. The substitution between public safety provision and private sector safe assets reflects the evidence that while the US and a few European governments are the prime issuers of safe assets, the private sector may also produce assets with safety benefits (Sunderam, 2015; Krishnamurthy and Vissing-Jorgensen, 2015; Gorton, 2017; He and Song, 2022; Kacperczyk et al., 2020). Yet, private sector safe assets are less efficient, for instance due to fire sale externalities or a reliance on market liquidity (Stein, 2012). I do not consider the intermediating role of banks as safe asset providers, as done by Gorton and Pennacchi (1990); Dang et al. (2017); Diamond (2020).

An important feature of the model is that public spending does not only supports contemporaneous consumption, but it has persistent benefits and thus also supports future consumption. These future safety benefits of public spending are essential for government spending to have a positive safety effect when netting out the effect of the required taxation on the ex ante safety demand. I consider governments to be more efficient compared to the private sector in providing certain essential goods and services, which implies that public good provision can improve welfare, as is common in political economy models (Persson and Tabellini, 2002).

In an extension, I impose two restrictions on government finances that allow to study a monetary union in which some member states may default. First, fiscal policy is subject to a political fixed cost, which is the only ex ante difference between countries. High political fixed costs may be due to a conflictual context with contrasting preferences, leading to higher costs for any government to ensure it remains in power (Alesina and Perotti, 1995). Second, households can choose to hide their income at a cost, and they do so when tax rates exceed a threshold. Governments must impose a haircut on its bonds when its debt repayment requires a tax rate larger than this threshold, as in Niemann and Pichler (2017). Thus, only a fraction of bond income is safe when public spending is high.

This paper most closely relates to the literature that studies the macro-economic implications of imbalances in the safe asset demand and supply. Caballero et al. (2020) show that net safe asset issuers import and export recessions, while Diamond (2020) argues that a shortage of safe assets fuels risky bank lending and increases bank leverage. Theoretical work has also suggested that a safe asset shortage can lead to a "safety trap", a situation characterized by a persistent output reduction due a binding zero lower bound on nominal interest rates (Caballero et al., 2016). In contrast, in my model a large safe asset demand compared to public safety provision leads to lower output as it forces households to rely too much on private sector safe assets, similar to the misallocation of capital in Benhima and Massenot (2013). Furthermore, as compared to the literature, I not only study the implications of a low public provision of safety, but I also provide a possible cause for such a situation. The results on insufficient public safety provision apply to all open economies with little barriers and costs to capital flows.

The extended model is consistent with trends in the euro area data. While all euro area economies have a large demand for safe assets (Figure 2.3), governments in the core countries supply a comparatively low amount of public debt. In the model, households in low-debt countries invest in foreign bonds to avoid relying too much on private sector safe assets. This direction of safety seeking capital flows matches the experience in the euro area outside of crisis times (see Figure 2.4 and Figure 2.5). I suggest that these capital flows allow core economies to operate successfully with a low domestic public safety provision at the expense of periphery economies who are dis-proportionally liable for the fiscal cost of public safety provision.

The rest of this paper is structured as follows. I present the baseline model in Section 2.2. In section 2.3, I first explain the equilibrium portfolio choice of households, followed by the fiscal policy set by a constrained social planner and by national governments. The difference is that the social planner considers total welfare, while national governments only consider domestic welfare. In section 2.4, I study the introduction of a common institution that sets common fiscal policy. Section 2.5 considers an extended model in which a country may default. Section 2.6 concludes. All proofs are contained in the appendix.

2.2 The baseline model

Consider an economy with a core and a periphery country $j \in C, P$ that are ex ante identical. There is a single good (the numeraire) and there are two time periods $t = 0, 1$. At $t = 1$ the state of the economy is revealed to be $s \in \{H, L\}$, where $Pr(s = H) = p$. The state is perfectly correlated across countries and determines the return on investments. In what follows I drop the superscript j when it is not necessary.

Households

A unit mass of households is endowed with e units of the good at $t = 0$. The utility of the representative household equals

$$U = \begin{cases} c_0 + \delta c_1, & \text{if } c_0, c_1 \geq c^{min} \\ -\infty, & \text{if } c_0, c_1 < c^{min} \end{cases}$$

where c_t is consumption at date t in state s. The discount rate equals δ.

These preferences imply that households are risk-neutral once they obtain a minimum consumption level c^{min}, reflecting a subsistence need. If their consumption is insufficient, they suffer a large disutility. To distinguish between a safety demand and a liquidity demand, I assume that the disutility is very large so that risk-return trade-offs in obtaining safety do not exist. Then, households strictly prioritize obtaining their subsistence need.

At $t = 0$ households can either consume their endowment or invest in financial assets. Households in country j invest I in domestic productive projects, C in domestic conservative projects, and B_i in government bonds of country i.[5] At $t = 1$ household receive the return on their investments and pay a lump sum tax T out of this taxable income. Governments set public spending, which contributes $V_t(G)$ to consumption at time t.

Thus, the household portfolio choice is subject to the following budget constraints

$$c_0 \leq e - I - C - \sum_{i \in S,W} B_i + V_0(G), \tag{2.1}$$

$$c_1^s \leq R_I^s I + R_C^s C + \sum_{i \in S,W} R_B^{i,s} B_i - T^s + V_1(G). \tag{2.2}$$

The private sector offers productive and conservative investment projects (public sector safe asset). Productive investments I generate return R_I^s at $t = 1$ equal to R_H in the good state, and nothing otherwise. Conservative investments C generate return R_C^s at $t = 1$ equal to R_L in the good state, and $\lambda(C)$ in a downturn, with $0 > \lambda' > -\frac{\lambda(C)}{C}$ and $\lambda'' = 0$. These conditions imply that when conservative investment is used more, its minimum safe return decreases, but additional investment does result in more safe income. This assumption is common in the literature on fire sales and rules out multiple equilibria (Lorenzoni, 2008). I denote $\Delta R = R_H - R_L$, and make the following additional assumptions

Condition 1.

1. $e = 1 + c^{min} - V_0(G^j)$.
2. $pR_H > \frac{1}{\delta}$.
3. $pR_H > pR_L + (1-p)\lambda(0)$.

The first part of Condition 1 is a normalization on the endowment to focus on the $t = 1$ safety demand. It implies that households in both countries have one unit to invest after obtaining their minimum consumption level at $t = 0$. Thus, I do not consider differences in public spending efficiency or in cross-country wealth accumulation. The second part of Condition 1 implies that households only consume their subsistence need at $t = 0$ as productive investment is preferred to $t = 0$ consumption. The third part of Condition 1 ensures that the expected return of productive investment is always larger than that of conservative investment, although it provides no safety.

Government

Governments set their public spending to maximize domestic household utility. They spend G at $t = 0$ to provide $V_t(G)$ of consumption at time t, with $V_t > 0$, $V_t' > 0$

[5] Private capital markets are thus segmented at the national level, motivated by the limited capital market integration in the euro area. In case of further capital market integration results are qualitatively unaffected, but there is no more unique portfolio allocation.

and $V_t'' \leq 0$. This public good technology implies that government spending supports contemporaneous and future consumption. Governments only spend at $t = 0$, so they must invest today to support consumption at $t = 1$.

Governments have no endowment. To fund their spending, they issue bonds B that pay an endogenously determined interest rate r at $t = 1$. I denote the return on bonds issued by country j as R_B^j. A lump sum tax T is collected at $t = 1$ for debt repayment. In the baseline model, the government's ability to tax ex post ensures that all public debt is always repaid fully, so there is no sovereign default risk. It follows that $T = (1+r)G^j$ in all states.

I assume that $V_1(G) = \theta G$, so the $t = 1$ consumption derived from public spending is linear in spending. To study interior public spending choices, I assume an interior value for θ

Condition 2. $V_1(G) = \theta G$, where $\underline{\theta} < \theta < \bar{\theta}$.

Condition 2 rules out the corner solution in which a government with no political fixed cost chooses for no public spending (when θ is low). It also rules out that governments optimally satisfy the entire safety demand via public safety provision (when θ is high).

A monetary union

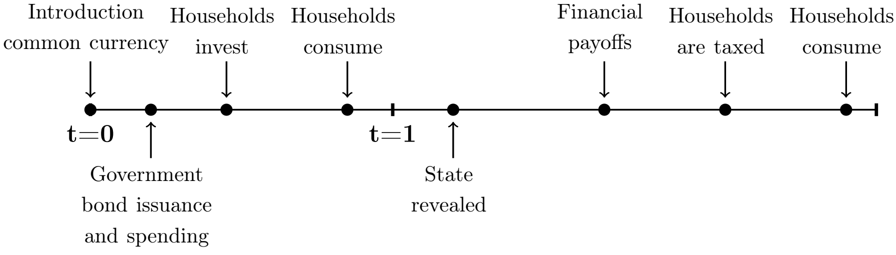
At the beginning of period $t = 0$ the two countries have joined in a monetary union, so introduce a common currency without a common fiscal framework. I treat the decision to join as given and study the equilibrium outcomes with and without common fiscal policy.[6] Particularly, introducing a common currency means that there are no exchange rate related costs when investing in foreign assets, so bonds issued by other member states are equally attractive as domestic bonds. To avoid the multiplicity of equilibria, I assume that households place a small probability on a potential break-up scenario in which case foreign investments instantly revalue. I assume that this perceived break up probability is sufficiently small so that its quantitative effect on bond pricing is negligible, but the preference for domestic sovereign bonds remains. There is extensive evidence for a home-bias and home-currency-bias in global portfolio allocations (French and Poterba, 1991; Maggiori et al., 2020).

Timing

The timing of the model is as in Figure 2.1. First, a common currency is introduced. Then, each government chooses their public spending and issues bonds. Next, households choose their asset portfolio and consume early. At $t = 1$ the state of the world is revealed, investment returns are paid, governments collect taxation, and households consume.

[6] Perotti and Soons (2019) study the political choice to join and sustain a monetary union.

Figure 2.1: Timeline



2.3 The monetary union equilibrium

I first study the household portfolio choice, and then discuss the fiscal policy chosen by a constrained social planner who maximizes total household welfare. Next, I study the national choice equilibrium in which each government chooses fiscal policy to maximize domestic household welfare.

2.3.1 The household portfolio choice

Safe asset demand Households prioritize always ensuring their subsistence need. They consume part of their endowment to satisfy their subsistence need at $t = 0$ and they invest in safe assets to also ensure their subsistence need at $t = 1$. The household's safety demand consists of the minimum consumption requirement plus taxation in the low state. Public spending contributes to future safety provision, so household's safe asset demand M^j in country j is equal to its safety demand minus the public consumption support.

Definition 1. *The safe asset demand M^j is equal to*

$$M^j(G^j) = c^{min} + T^{j,L} - \theta G^j \tag{2.3}$$

Note that both the safety demand and the safe asset demand would vary across countries with different public spending, although the minimum consumption requirement is constant. The safety demand is certainly increasing in public spending as households anticipate future taxation. If the equilibrium interest rate is such that $R_B^j > \theta$, then also the safe asset demand is increasing in public spending. In the baseline model I assume this is the case, while in Section 2.5 I derive the required condition (i.e. a bound on public spending).

Households satisfy their safe asset demand by investing in domestic and foreign public debt, or by investing in private safe assets. Their safe income in a downturn must be at least their safe asset demand, so they invest subject to a safety constraint

$$R_B^j B_j^j + R_B^i B_i^j + R_C^{j,L} C^j \geq M^j, \tag{2.4}$$

where foreign bonds are indexed by i.

Households are risk neutral once their safety demand is satisfied, and productive investment has the highest expected return (Condition 1). Thus, the safety constraint optimally binds and households maximize consumption by only investing productively after ensuring sufficient safe income.

Safe asset portfolio and capital flows Before characterizing public spending, I solve for the household portfolio choice for a given a certain amount of public spending by each government. Households can acquire foreign bonds to satisfy their safe asset demand, so in equilibrium there may be net capital flows. To simplify notation, suppose for now that the core country, $j = C$, has a positive net demand for foreign bond holdings while the periphery country, $j = P$, is a net supplier of bonds.

For each country, the binding safety constraint (2.4) determines the safe return obtained from private sector safe assets. By substituting for the safe asset demand in expression (2.4), it shows that the safe income obtained from the private sector depends on the subsistence need, public spending, taxation, and the safe income from bond holdings:

$$\text{Country C: } \lambda(C^C)C^C = M^C - R_B^C B_C^C - R_B^P B_P^C = c^{min} - \theta G^C + \underbrace{T^C - R_B^C B_C^C - R_B^P B_P^C}_{<0}. \quad (2.5)$$

$$\text{Country P: } \lambda(C^P)C^P = M^P - R_B^P B_P^P \qquad = c^{min} - \theta G^P + \underbrace{T^P - R_B^P B_P^P}_{>0}. \quad (2.6)$$

From expressions (2.5) and (2.6), it follows that net capital flows impact the dependence on private sector safe assets as they reallocate public safety across borders. In the safety importing country (expression 2.5), household's bond income is larger than the required domestic taxation as they receive some foreign bond income while the required taxation is not shared. On the contrary, in the safety exporting country (expression 2.6) the required taxation is larger than household's income from bond holdings. This is a non-Ricardian feature of the model.

After substituting in for taxation in expressions (2.5) and (2.6), safe income obtained from the private sector in each country is determined as

$$\text{Country C:} \quad \lambda(C^C)C^C = c^{min} - \theta G^C - R_B^P B_P^C. \quad (2.7)$$

$$\text{Country P:} \quad \lambda(C^P)C^P = c^{min} - \theta G^P + R_B^P B_P^C. \quad (2.8)$$

Ceteris paribus, households in the safety importing country rely less on private sector safe assets when they increase foreign bond holdings, B_P^C, while in that case foreign households are crowded out of the domestic bond market and forced to rely more on private sector safe assets.

The possibility of cross-country capital flows implies that in equilibrium all safe assets will be priced so that households across countries are indifferent between obtaining safe income from private sector safe assets or from domestic or foreign bonds. As a result, the minimum return on private sector safe assets must be equal across countries, even though these assets are not directly traded[7], or

$$\lambda(C^C) = \lambda(C^P). \quad (2.9)$$

[7] Without a common currency, there would be exchange rate risk and the minimum return on private sector safe assets would not be equalized across countries.

From the above system of three equations (expressions 2.7, 2.8 and 2.9), I solve for conservative investment in each country in the monetary union as

$$C^j\lambda(C^j) = c^{min} - \frac{\theta}{2}(G^C + G^P). \tag{2.10}$$

Thus, the equilibrium indifference pricing implies that there is equal conservative investment in all countries in a monetary union, which is decreasing in the public spending by each member state.

By substitution expression (2.10) into expression (2.7), I solve the for equilibrium net capital flows as

$$B_P^C = \frac{\frac{\theta}{2}(G^P - G^C)}{R_B^{P,L}}. \tag{2.11}$$

Clearly, when public spending is equal across countries there are no net capital flows. Otherwise, households in the country with lower public spending acquire foreign bonds to avoid relying too much on private sector safe assets.

Productive investment After ensuring sufficient safe income, risk neutral households maximize expected consumption by only investing productively. Thus, productive investment in country j is equal to the endowment minus the resources allocated to ensure the subsistence need:

$$I^j = 1 - B_j^j - B_i^j - C_j^j.$$

This can be restated for core and periphery country as

$$I^C = 1 \quad \underbrace{-G^C\Big(1 - \frac{\theta}{\lambda(C^C)}\Big) + B_P^C\Big(\frac{R_B^P}{\lambda(C^C)} - 1\Big)}_{\text{efficiency of safety provision}} \quad - \quad \underbrace{\frac{c^{min}}{\lambda(C^C)}}_{\text{subsistence need}}, \tag{2.12}$$

and

$$I^P = 1 \quad \underbrace{-G^P\Big(1 - \frac{\theta}{\lambda(C^P)}\Big) - B_P^C\Big(\frac{R_B^P}{\lambda(C^P)} - 1\Big)}_{\text{efficiency of safety provision}} \quad - \quad \underbrace{\frac{c^{min}}{\lambda(C^P)}}_{\text{subsistence need}}. \tag{2.13}$$

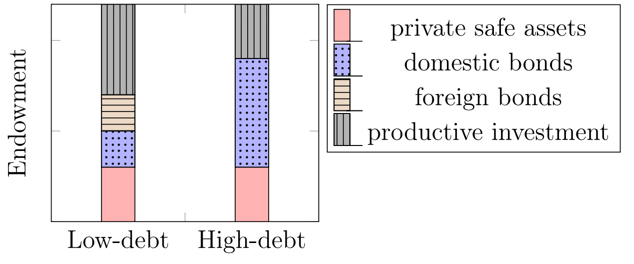
Productive investment is determined by the endowment, the efficiency of safety provision, and the minimum consumption need. From expression (2.12) and (2.13), it follows that productive investment is higher when households have a higher endowment or a lower minimum subsistence need, when government spending is more efficient in providing public safety, or when the private sector is better in producing safe assets.

Lemma 1. *Productive investment is higher*

1. *when the endowment is higher.*
2. *when the subsistence need* c^{min} *is lower.*
3. *when the efficiency of public safety provision* θ *is higher.*
4. *under an upwards shift of the minimum return* $\lambda(C)$ *on private sector safe assets.*

Figure 2.2 illustrates the portfolio choice in a hypothetical low-debt country (safety importing) and a high-debt country (safety exporting). When $R_B^j > \theta$, the safe asset demand in the low-debt country with low taxation is smaller than in the high-debt country. Investment in private safe assets is equal across member states. The interest rate on public debt clears the market and households in the low-debt country acquire foreign bonds. The residual endowment, after ensuring the safety demand is satisfied, is invested productively. Thus, productive investment is higher in the low-debt country with a lower safety demand.

Figure 2.2: Household portfolio choice by country



Bond returns So far I have described the household portfolio choice as a function of the return on sovereign bonds, R_B^j. However, sovereign interest rates are endogenously determined. To ensure market clearing, sovereign debt is priced to make households indifferent between obtaining safe income from bonds or from private sector safe assets. In the baseline model, no member state is at risk of default, so both governments pay the same safe rate r. The indifference sovereign interest rate is solved for as

$$r(C^j) = \frac{\lambda(C^j) R_H}{\Delta R + \lambda(C^j)} - 1. \tag{2.14}$$

The equilibrium interest rate depends crucially on the minimum return $\lambda(C)$ of private sector safe assets. Sovereign interest rates are lower when private sector safe assets have a lower minimum repayment, which happens when households rely more on the private sector for their safe income. In that case, the scarcity of public safe assets results in a larger endogenous safety premium (lower interest rate r) on bonds.

2.3.2 The social planner's fiscal policy

The social planner understands the household portfolio choice and sets public spending in each country to maximize the sum of household utility in the monetary union, given by

$$\max_{G^C, G^P} E[U^{MU}] = E[U^C] + E[U^P],$$

subject to the household budget constraints (2.1) and (2.2) and the safety constraint (2.4), where the safety constraint optimally binds.

Using the household budget constraints (2.1), (2.2) and the binding safety constraint (2.4), the joint welfare maximization can be restated in terms of the minimum consumption requirement and productive investment

$$\max_{G^C,G^P} E[U^{MU}] = 2c^{min} + \delta\Big(E[R_I]I^{MU} + 2c^{min}\Big), \tag{2.15}$$

where productive investment in the union, I^{MU}, equals the sum of investment in each country (expression 2.12 and 2.13):

$$I^{MU} = I^C + I^P = 2 - \underbrace{(G^C + G^P)\Big(1 - \frac{\theta}{\lambda(C^P)}\Big)}_{\text{safety provision efficiency}} - \underbrace{\frac{2c^{min}}{\lambda(C^P)}}_{\text{the subsistence need}}). \tag{2.16}$$

Proposition 1 characterizes the social planner's fiscal policy choice. In a monetary union of identical countries, the social planner sets spending as G^{GE} in both countries and there will be no net capital flows (see expression 2.11).[8]

Proposition 1. *A constrained social planner implements the following fiscal policy*

$$G^{SP-j} = G^{GE} \quad \textit{for } j \in C, P$$

where spending G^{GE} satisfies

$$\frac{\theta}{\lambda(C^{GE})} + \frac{\partial\lambda(C^{GE})}{\partial G^{GE}}\frac{2c^{min} - G^{GE}\theta}{\lambda(C^{GE})^2} = 1.$$

and conservative investment C^{GE} solves expression (2.10).

The social planner considers quantity and price effects of public spending on household optimal portfolio choice in each country. An increase in public spending increases the safe asset demand as it increases the required taxation, but it also increases the provision of public safety as it supports future consumption and increases the bond supply. The result is a substitution from private sector safe assets and foreign bonds towards domestic public safety (a quantity effect).

An increase in public spending also alters equilibrium investment returns. The substitution towards public safety decreases the dependence on private sector safe assets. As a result, the minimum return on private sector safe assets increases (a price effect). In response, sovereign interest rates must also increase to clear the market. This price effect reinforces the increase in the supply of public safety.

Two other aspects of Proposition 1 are worth highlighting. First, the social planner's fiscal policy choice does not depend on net capital flows. From the perspective of the social planner, the location of bond holders is irrelevant as it does not affect the aggregate benefits and cost of public safety provision. Second, without capital flows, the net financial safety effect of government bonds, and taxation is zero. This result shows that issuing public debt does not produce net financial safety for domestic households as they pay the required taxation. It is only the direct consumption support of public

[8] If public spending does not provide safety at $t = 1$, so when $\theta = 0$, optimal public spending is zero. This is because I normalized the endowment. Otherwise, public spending would be set such that the household benefit of public spending at $t = 0$ equals the loss of productive investment due to resource absorption by the public sector, so $V_0'(G) = \delta E[R_I]$.

spending that affects the portfolio choice. To clarify this baseline result, consider the household portfolio choice in case of the social planner's fiscal policy choice:

$$B_j^j = G^{GE}, \qquad C^j = \frac{c^{min} - \theta G^{GE}}{\lambda(C^{GE})},$$
$$B_i^j = 0, \qquad I^j = 1 - G^{GE} - \frac{c^{min} - \theta G^{GE}}{\lambda(C^{GE})}.$$

The social planner implements equal public spending, so there are no net capital flows and domestic households hold all domestic bonds. Conservative investment is obtained from expression (2.10) and is equal across member states. The residual endowment is invested productively. The net financial safety effect of public spending is given by the safe income received from government bonds, minus the required taxation, where the last two terms are equal and thus cancel out:[9]

$$\textit{net financial safety from public spending} = R_B^j B_j^j - T^j = 0 \tag{2.17}$$

2.3.3 National fiscal policy

In the euro area, each member state is responsible for its own fiscal policy. This section analyzes how national governments choose their fiscal policy and how it differs from the social planner's choice.

The government of each country $j \in C, P$ sets fiscal policy to maximize domestic households expected utility. Using the household budget constraints (2.1) and (2.2) and the binding safety constraint (2.4), this maximization problem can be stated in terms of the minimum consumption requirement and productive investment

$$\max_{G^j} E[U^j] = c^{min} + \delta\Big(E[R_I]I^j + c^{min}\Big). \tag{2.18}$$

The equilibrium with national public safety provision is a Nash equilibrium in which each government chooses public spending to maximize domestic household welfare, while anticipating the foreign optimal response to its own spending choice. The Nash equilibrium is defined as follows

Equilibrium Definition.
The Nash equilibrium consists of a vector of household portfolio choices I^j, C^j, B_j^j, B_i^j, government spending decisions G^j and interest rates r^j, $\forall j \in C, P$ and $\forall i \in C, P$, where $i \neq j$, where both governments set fiscal policy to maximize domestic households' expected utility (2.18), household portfolio choices satisfy their budget constraints (2.1) and (2.2), and where both governments do not deviate given foreign fiscal policy.

The nationally optimal fiscal policy differs from the social planner's fiscal policy choice. In addition to the quantity and price effect explained in the previous section, national governments additionally consider that their public spending affects equilibrium capital flows. The national fiscal policy is characterized as follows.

[9] In models with heterogeneous agents the net financial safety from public spending can be positive for some households when taxation is redistributive (Ahnert et al., 2018; Caballero et al., 2016).

Proposition 2 *Governments implement the nationally optimal fiscal policy*

$$G^C = G^P = G^{NE},$$

where public spending G^{NE} is such that there is no incentive to deviate given that the other country also spends G^{NE}, which is lower than the social planner's spending choice, so $G^{NE} < G^{GE}$, and which satisfies

$$\frac{\theta}{2\lambda(C^{NE})} + \frac{\partial\lambda(C^{NE})}{\partial G^{NE}} \frac{c^{min} - \theta G^{NE}}{\lambda(C^{NE})^2} + \frac{\theta}{2R_B^i} = 1, \tag{2.19}$$

and conservative investment C^{NE} solves expression (2.10).

Why do governments not coordinate on the social planner's fiscal policy choice? Suppose they agree to implement the social planner's choice $G^j = G^{GE}$ so that $C^j = C^{GE}$ and there are no net capital flows. If one government would marginally lower spending, holding foreign spending constant, its households substitute domestic public safety for holdings of foreign bonds (expression 2.11) while households in both countries increase their reliance on private sector safe assets (expression 2.10). The resulting change Π in domestic household utility is positive:

$$\Pi = \delta E[R_I]\Big[\frac{\partial\lambda(C^{GE})}{\partial G^j}\frac{c^{min}}{\lambda(C^{GE})^2} - \frac{\theta}{2}\Big(\frac{1}{R_B^P} - \frac{1}{\lambda(C^{GE})}\Big)\Big] > 0.$$

The domestic welfare gain is due to the fact that when public spending is lower, taxation is lower and the domestic safe asset demand decreases, while households also obtain more safe income from foreign bonds at no additional fiscal cost. While domestic household are better off, foreign welfare decreases as foreign households are forced to rely too much on private sector safe assets. In other words, national governments do not internalize the positive externality that an increase in their public spending has on foreign welfare. Public spending by any government increases the total supply of public safety, and thus lowers foreign bond holdings and the need to rely on private sector safe assets. Thus, governments cannot credibly commit to the social planner's public spending choice as domestic household benefit when they deviate.

Each governments understands the foreign incentives to lower public safety provision. In the appendix I show that for either government the optimal response to the foreign government lowering spending is to lower spending itself. The reason is that, off the equilibrium path, in a safety exporting country the marginal domestic benefit of public spending is smaller than in the safety importing country, so that optimal public spending in a safety exporting country is below that in a safety importing country. Thus, governments in safety exporting countries optimally lower spending in an attempt to undercut the public spending by the safety importing country. As a result, fiscal policy unravels to lower public spending by each government. This strategic behavior determines the unique Nash equilibrium as defined in Proposition 2 where both countries spend G^{NE}, there is no incentive to deviate, and there are no capital flows.

In the equilibrium with national fiscal policy, there is lower national public safety provision compared to the fiscal policies implemented by the social planner and there are no net capital flows. In this case both countries are certainly better of under the social planner's fiscal policy choice that maximizes welfare in the absence of capital flows. The unravelling of public spending lowers the total public safety supply, forcing households to rely too much private sector safe assets. Domestic households in both countries would benefit from an increase in public spending, but only if the other government also increases public spending.

To summarize, each member state supplies less public safety compared to the social planner's choice. Both governments cannot credibly commit to implement the social planner's fiscal policy choice as they do not internalize a positive externality of its public spending for foreign households. On the contrary, domestic households benefit from foreign “public safety spillovers" when a government lowers public spending. Thus, in contrast to the fiscal policy implemented by a social planner, the national choice is crucially determined by capital flows. Although there are no net capital flows in a Nash equilibrium, the *possibility* of net capital flows results in a commitment problem.

The disincentive for national public safety provision applies to all countries in which savers can rely on foreign bonds to satisfy their safe asset demand, so to open economies with low cost to capital flows. Thus, while the results are not unique to a monetary union, their impact is larger in a monetary union as a common currency lowers barriers and costs to capital flows. Yet, a monetary union also provides the opportunity to improve on the equilibrium under national fiscal policy by common fiscal policy, as studied in the next section.

2.4 Common fiscal policy

In this section I show that some degree of common public spending funded by common debt issuance can increase household welfare in all member states.

Institutional setup I study a common institution that implements additional common public spending G^{MU} at $t = 0$, after national government have implemented their national public spending.[10] The common institution issues common debt with a return R_B^{MU} to fund its spending. The common debt will be repaid at $t = 1$ by seniority claims S^j on member states their tax base, so the budget constraint of the common institution equals

$$S^C + S^P = R_B^{MU} G^{MU}. \tag{2.20}$$

The common debt is a safe asset when the claims S^j on the tax base of member states is honored in all states of the world. In practice the credibility of the repayment commitment may be questionable when some government is at risk of default, as discussed in section 2.5.

The revenue from the common debt issuance is used for common public spending targeted at providing public safety goods.[11] I assume that common public spending is equally efficient compared to national public spending, and that its benefits are equally distributed across countries, so that in each country common public spending supports consumption by $V_0(\frac{G^{MU}}{2})$ at $t = 0$ and and by $\frac{\theta}{2} G^{MU}$ at $t = 1$.

[10] I do not consider the impact common public spending has on the national public spending choice. I also do not consider the politics and legal base of the common institution.

[11] If instead of common public spending the common institution would transfer resources to member states, national governments would not use the additional funding to increase public spending as from their national perspective additional spending harms domestic households.

2.4.1 The household portfolio choice with common fiscal policy

Safe asset demand Common public spending contributes directly to $t = 0$ consumption, so households need to use less of their endowment to ensure their minimum consumption requirement at $t = 0$ and have more resources to invest. Common public spending also supports future consumption and results in an increase in the safe asset supply, at the cost of higher expected taxation. Altogether, with common public spending households in country $j \in C, P$ have a $t = 1$ safe asset demand M^j equal to

$$M^j(G^j, G^{MU}) = c^{min} + T^{j,L} - \theta G^j - \frac{\theta}{2} G^{MU},$$

where taxation equals

$$T^j = R_B^j G^j + S^j.$$

Households invest subject to an adjusted safety constraint, which now includes the return on common bond holdings B_{MU}^j

$$R_B^j B_j^j + R_B^i B_i^j + R_B^{MU} B_{MU}^j + R_C^{j,L} C^j \geq M^j. \tag{2.21}$$

Since no country is at risk of default, common bond holdings pay the same interest as the bonds issued by national governments, while by assumption households have a marginal preference for domestic bonds. Market clearing and the indifference pricing of safe assets implies that common bond holdings are equal across member states.

Safe asset portfolio and capital flows Households can acquire common bonds as well as bonds issued by either country to satisfy their safe asset demand. Similar as to without common policy, the binding safety constraint (2.21) determines the safe income obtained from private sector safe assets. By substituting for the safe asset demand in expression (2.21), it shows that the safe income obtained from the private sector safe assets in a safety importing core country and safety exporting periphery country equals

$$\text{Core:} \qquad \lambda(C^C)C^C = c^{min} - \theta G^C - \frac{\theta}{2} G^{MU} - R_B^P B_P^C - R_B^{MU} B_{MU}^C + S^C. \tag{2.22}$$

$$\text{Periphery:} \quad \lambda(C^P)C^P = c^{min} - \theta G^P - \frac{\theta}{2} G^{MU} + R_B^P B_P^C - R_B^{MU} B_{MU}^P + S^P. \tag{2.23}$$

Using expressions (2.22) and (2.23) and using that in equilibrium the return on private safe assets is equal across countries, I can now solve for conservative investment in a monetary union with common fiscal policy as

$$\lambda(C^j)C^j = c^{min} - \frac{\theta}{2}(G^P + G^C + G^{MU}), \tag{2.24}$$

and equilibrium capital flows between member states as

$$B_P^C = \frac{\frac{\theta}{2}(G^P - G^C) + R_B^{MU} B_{MU}^P - S^P}{R_B^P}. \tag{2.25}$$

Conservative investment in a monetary union with common fiscal policy is decreasing in common public spending, while the effect of common policy on capital flows depends how its repayment is shared. Henceforth, I denote conservative investment in case of common fiscal policy as $C^j = C^{CP}$ and the return on core and periphery bonds as $R_B^j = R_B^{CP}$.

Productive investment Productive investment in a monetary union with common fiscal policy is equal to the endowment minus the resources allocated to ensure the subsistence need. It depends not only on the efficiency of safety provision and the subsistence need, but also incorporates a common policy effect. Productive investment is affected by the return on common bond holdings, common public spending, and the country's share of common debt repayment. Productive investment in core and periphery countries respectively is given by

$$I^C = 1 + V_0\Big(\frac{G^{MU}}{2}\Big) \quad \underbrace{-G^C\Big(1 - \frac{\theta}{\lambda(C^{CP})}\Big) + B_P^C\Big(\frac{R_B^{CP}}{\lambda(C^{CP})} - 1\Big)}_{\text{safety provision efficiency}} \quad - \quad \underbrace{\frac{c^{min}}{\lambda(C^{CP})}}_{\text{subsistence need}} \quad \dots$$
$$\underbrace{+ B_{MU}^C\Big(\frac{R_B^{MU}}{\lambda(C^{CP})} - 1\Big) - \frac{S^C - \frac{\theta}{2}G^{MU}}{\lambda(C^{CP})}}_{\text{common policy effect}}, \tag{2.26}$$

and

$$I^P = 1 + V_0\Big(\frac{G^{MU}}{2}\Big) \quad \underbrace{-G^P\Big(1 - \frac{\theta}{\lambda(C^{CP})}\Big) - B_P^C\Big(\frac{R_B^{CP}}{\lambda(C^{CP})} - 1\Big)}_{\text{safety provision efficiency}} \quad - \quad \underbrace{\frac{c^{min}}{\lambda(C^{CP})}}_{\text{subsistence need}} \quad \dots$$
$$\underbrace{+ B_{MU}^P\Big(\frac{R_B^{MU}}{\lambda(C^{CP})} - 1\Big) - \frac{S^P - \frac{\theta}{2}G^{MU}}{\lambda(C^{CP})}}_{\text{common policy effect}}. \tag{2.27}$$

2.4.2 The common institution's provision of public safety

Common fiscal policy implies an increase in the public safety supply, so households rely less on the private sector safe assets (expression 2.24). This substitution comes at the cost of the national contributions to the common debt repayment. The net effect of common fiscal policy on productive investment in country j is given by the difference of expressions (2.12) and (2.26), and expressions (2.13) and (2.27). The productive impact in country $j \in C, P$ equals:

$$\Delta I^j = V_0\Big(\frac{G^{MU}}{2}\Big) - \frac{c^{min} - \theta G^{NE} - \frac{\theta}{2}G^{MU}}{\lambda(C^{CP})} + \frac{c^{min} - \theta G^{NE}}{\lambda(C^{NE})} - \frac{S^j}{R_B^{MU}}, \tag{2.28}$$

where $\lambda(C^{CP}) > \lambda(C^{NE})$, and where I used that national governments choose equal spending and market clearing implies that $R_B^{MU} = R_B^{CP}$.

From expression (2.28), it follows that whether common fiscal policy benefits production in both member states depends on the amount of common spending, and how its repayment is shared. Each country benefits from the common provision of safety when its share of common debt repayment is below a maximum repayment $S^j < \bar{S}(G^{MU})$, defined as

$$\bar{S}(G^{MU}) = R_B^{MU}\Big(V_0\Big(\frac{G^{MU}}{2}\Big) + \frac{c^{min} - \theta G^{NE}}{\lambda(C^{NE})} - \frac{c^{min} - \theta G^{NE} - \frac{\theta}{2}G^{MU}}{\lambda(C^{CP})}\Big). \tag{2.29}$$

For production, and thus welfare, in both countries to benefit simultaneously, it must be that the sum of the maximum payment exceeds the total required repayment, or $2\bar{S}(G^{MU}) \geq R_B^{MU} G^{MU}$. This is the case when common public spending is below an upper bound $G^{MU} < \bar{G}$, defined as

$$\bar{G} = \frac{2\Big(V_0(\frac{G^{MU}}{2}) + (c^{min} - \theta G^{NE})\Big(\frac{1}{\lambda(C^{NE})} - \frac{1}{\lambda(C^{CP})}\Big)}{1 - \frac{\theta}{\lambda(C^{CP})}}. \tag{2.30}$$

Proposition 3 summarizes these results, whose formal proof follows from expressions (2.28), (2.29) and (2.30).

Proposition 3. *Common fiscal policy benefits welfare in both member states when (i) their repayment is less than their maximum repayment* $S^j < \bar{S}(G^{MU})$*, (ii) their repayment add up to full repayment* $S^P + S^C = G^{MU} R_B^{MU}$*, and (iii) common public spending is not too high* $G^{MU} < \bar{G}$.

An intergovernmental agreement to introduce a common fiscal institution de facto allows governments to commit simultaneously and credibly to fund a larger provision of public safety with their tax revenues. When the repayment is equally shared, common fiscal policy is identical to a simultaneous and equal increase in national public spending. However, as the common policy creates additional surplus, the repayment does not have to be equally shared for both countries to benefit.

2.5 Sovereign defaults

This section extends the baseline model to allow for sovereign defaults. It includes two modifications. First, whereas in the baseline model countries $j \in C, P$ were ex ante identical, now they differ in their political fixed cost $\beta^j \in [0, \infty]$, where $\beta^C < \beta^P$. A government in a core country has a lower fixed cost compared the government in the periphery country. The political fixed costs reflects that any politician is required to spend a minimum amount to remain in power or to avoid anarchy, and it may choose for additional public spending. Political fixed costs may be lower in countries with high governance efficiency, or in more homogeneous societies due to easier consensus on public decisions (Alesina and La Ferrara, 2000).

For simplicity, I assume that when a government spends less than its fixed costs, countries descent into anarchy and households are infinitely harmed. Thus, the modified public spending technology is given by

$$V_t(G) = \begin{cases} V_t(G), & \text{if } G \geq \beta^j \\ -\infty, & \text{else} \end{cases}$$

The second modification to the model is that I assume massive tax evasion occurs when tax rates are high, which determines a maximum tax rate $\bar{\tau}$.[12] Thus, the government's ability to tax ex post ensures the full repayment of public debt, only up to a limit. If the maximum tax rate constraint is binding, a government can only

[12] The threshold tax rate may be endogenized by a choice between paying tax and costly tax evasion.

avoid a total loss of tax revenue by partially defaulting and forcing a haircut h on its outstanding bonds.

Due to a possible default, taxation and the return on government bonds in the extended model is state dependent. We denote the return on bonds as $R_B^{j,s}$ in state s, which includes the interest rate and a possible haircut. I do not consider reputational costs of default, and governments do not discriminate between domestic and foreign bond holders during a partial default.

I first solve for the social planner and national government's fiscal policy choice without common fiscal policy, before studying the implications of common fiscal policy when the periphery country is at risk of default.

2.5.1 Fiscal solvency and bond returns

A government may default in the low state if it cannot collect sufficient tax revenue to repay its debt. The required tax rate in the low state is given by the lump sum taxation over the taxable household income. The taxable household income in a downturn consists of household income from bond holdings plus the income obtained from private sector safe asset. Thus, the required tax rate for debt repayment is given by

$$\tau^{j,L}(G^j) = \frac{T_B^{j,L}}{R_B^{j,L} B_j^j + R_B^{i,L} B_i^j + R_C^{j,L} C^j}. \tag{2.31}$$

Governments' tax policy is subject to a maximum tax rate constraint, or $\tau^{j,L} \leq \bar{\tau}$. The required tax rate (expression 2.31) is increasing in public spending as a government that spends more has more outstanding debt and pays a higher interest rate. Thus, at public spending $G^j > G_{CON}$ the required tax rate will exceed the maximum tax rate, where G_{CON} equals

$$G_{CON}(r^j) = \frac{c^{min}}{\theta + (1 + r^j)(\frac{1}{\bar{\tau}} - 1)}.$$

If $G^j > G_{CON}$ the government enters a solvency crisis in a downturn. It must enforce a haircut on its bonds to avoid a total loss of tax revenues, which lowers the safe income obtained by its bond holders. The required haircut is determined by equalizing the required debt repayment (including the haircut) and the maximum tax revenue that can be collected in the low state. Note that G_{CON} is decreasing in the interest rate r^j, so when the interest rate is low a government can spend more without being at risk of default.

To ensure market clearing, sovereign debt is priced to make households indifferent between obtaining safe income from private sector safe assets or from bonds, anticipating a possible haircut. The indifference sovereign interest rate with an anticipated haircut is given by

$$r^j(C^j) = \frac{\lambda(C^j) R_H + h^j \Delta R}{\Delta R + \lambda(C^j)} - 1.$$

Sovereign interest rates now not only depend on the minimum return $\lambda(C)$ of domestic conservative investment, but also on the expected haircut. When a country is expected to default, investors are compensated for the anticipated haircut by a higher interest rate. Although the interest rate is higher when a country defaults, the total return, $R_B^{j,L}$, on its government bonds including the haircut is decreasing in public spending as higher spending requires a larger haircut.

2.5.2 A diverse monetary union

In the remainder of this section, I study a diverse monetary union (DMU) in which only the periphery government is at risk of default. To do so, I define bounds on the political fixed cost. First, the fixed costs of the periphery government is sufficiently high, $\beta^P > \beta_{CON}$, such that when it only spends its fixed cost it is already constraint by the maximum tax rate in the low state and will default, where β_{CON} is given by

$$\beta_{CON} = \frac{c^{min}\Big(\Delta R + \lambda(C)\Big)}{\theta + \lambda(C) R_H (\frac{1}{\bar{\tau}} - 1)}.$$

Second, in Section 2.3.1 I assumed that $R_B^{j,L} > \theta$ so that the safe asset demand is increasing in public spending. Now, I derive an upper bound on the political fixed cost of the periphery government, $\beta^P < \bar{\beta}$, such that the minimum return on periphery government bonds indeed provides more safety than public spending, also in case of default, where $\bar{\beta}$ is given by

$$\bar{\beta} = \frac{\bar{\tau} c^{min}}{\theta}.$$

Lemma 2 defines a diverse monetary union as a monetary union in which the core government never defaults while the periphery government certainly defaults, but its political fixed cost is not extreme.[13]

Lemma 2. *A diverse monetary union has* $\beta^C < \beta_{CON} < \beta^P < \bar{\beta}$.

2.5.3 The social planner's fiscal policy

The social planner sets public spending in each country to maximize the sum of household utility in the diverse monetary union. Also in the extended model, this maximization problem can be restated as expression (2.15), subject to the additional constraint that public spending in each country must exceed the political fixed costs, or $G^j \geq \beta^j$.

Proposition 4 characterized the social planner's fiscal policy choice in a diverse monetary union. In the core country, the social planner sets the amount of public spending that optimally trades off its price and quantity effects, as in Proposition 1. In the periphery country the social planner sets public spending as low as possible, equal to the high political fixed cost.

[13] I do not consider the intermediate case where the fixed cost is a binding spending constraint, but the government does not default, but it can easily be studied by setting $h = 0$ in the analysis that follows. The other possible case where one country defaults while its spending constraint does not bind is never an equilibrium outcome.

Proposition 4. *A constrained social planner implements the following fiscal policy in a diverse monetary union*

$$G^{SP-j} = G^{GE} \qquad\qquad G^{SP-P} = \beta^P$$

where spending G^{GE} satisfies

$$\frac{\theta}{\lambda(C^{GE})} + \frac{\partial\lambda(C^{GE})}{\partial G^{GE}} \frac{2c^{min} - G^{GE}\theta}{\lambda(C^{GE})^2} = 1,$$

and conservative investment C^{GE} solves expression (2.10).

By definition, in a diverse monetary union the periphery country has a high political fixed costs, so even the (constrained) social planner cannot avoid a default in the low state. Due to its high fixed costs, the periphery government supplies a high amount of bonds. As a result, the social planner sets lower public spending in the core country compared to the baseline model. Also, equilibrium conservative investment decreases in both countries compared to the baseline model due to the high bond issuance by the periphery government (expression 2.10).

As opposed to the social planner equilibrium of the baseline model, there are net capital flows as households in the low-debt core country acquire bonds issued by the high-debt periphery government. Interestingly, while there are net capital flows between countries, the social planner's fiscal policy choice still does not depend on capital flows as on aggregate they have no impact on the supply of public safety. An implication of this results is that also the required haircut does not alter optimal fiscal policies from the perspective of a social planner. A haircut lowers the minimum return on bonds, but the net safety effect is zero as it equally lowers the required taxation. A haircut does affect capital flows, but capital flows do not affect the social planner's spending choice.[14]

2.5.4 National fiscal policy

National governments set public spending to maximize the utility of domestic households (expression 2.18), subject to the additional constraint that that public spending in each country must exceed the political fixed costs, or $G^j \geq \beta^j$.

The periphery government is subject to a binding minimum public spending constraint. Thus, as compared to the baseline model, only the national fiscal policy in the core country differs from the social planner's fiscal policy choice. Proposition 5 characterized the optimal national fiscal policy choices.

[14] I study countries that are identical except for their political fixed cost. In reality the private sector ability to produce safe assets may also differ across countries, for instance because of different regulatory quality, protection of property right, or rule of law efficiency. When one country has a more efficient private safety technology (higher λ) domestic conservative investment will increase relative to the other country. Net capital flows will decrease if the safety importing country has the superior private safety technology, and vice versa. The main results are unchanged, unless the difference is large. For instance, a large downward shock of the minimum return on private sector safe assets in the periphery country can reverse capital flows in a flight to safety. This may reflect part of what happened during the global financial crisis in the euro area.

Proposition 5. *Governments in a diverse monetary union implement the nationally optimal fiscal policy*

$$G^C = G^{NE-C} \qquad\qquad G^P = \beta^P,$$

where public spending G^{NE-C} *maximizes household utility in the safety importing core country given that* $G^P = \beta^P$*, where* G^{NE-C} *satisfies*

$$\frac{\theta}{2\lambda(C^{NE})} + \frac{\partial\lambda(C^{NE})}{\partial G^{NE-C}} \frac{c^{min} - \frac{\theta}{2}(\beta^P + G^{NE-C})}{\lambda(C^{NE})^2} + \frac{\theta}{2R_B^{P,L}} = 1,$$

and conservative investment C^{NE} *solves expression (2.10). Public spending in the core country is lower than the social planner's spending choice, so* $G^{NE-C} < G^{SP-C}$*.*

The periphery government is unable to lower spending beyond its political fixed cost β^P. Thus, the core government is certain its households are net importers of foreign bonds when it spends less than the periphery government. The core government responds by spending G^{NE-C}, the optimal amount of public spending as a net importer of foreign bonds. This fiscal policy optimally trades-off of the benefits for domestic households of lowering public spending and larger holdings of foreign bonds with its cost of less direct consumption support by the government.

In contrast to the social planner's choice, the required haircut on bonds issued by the periphery government matters for the optimal fiscal policy of the core government. The larger the required haircut, the lower the minimum safe income from periphery bonds, so the lower the safety benefit of acquiring foreign bonds for households in the core country. This in turn lowers the benefits for the core government of unilaterally lowering spending and thus incentives the government to provide more public safety itself. If the minimum return on periphery bonds is very low (a very high haircut), the spending choice of core governments will be close to the social planner's choice.

Households in the periphery country are better off under the social planner's choice with higher foreign public spending and the same domestic public spending. The foreign bond holdings of core country households force periphery households to rely too much on private sector safe assets. In fact, in the periphery country the net financial safety benefit from domestic public debt is negative as foreign households receive some safe income while only periphery households are taxed. This is in stark contrast to in the baseline model (expression 2.17).

Interestingly, households in the core country benefit from the national fiscal policy choices compared to the social planner's choice. In case of the social planner's fiscal policy choice, households in the core country are also a net acquirer of periphery bonds, while the nationally optimal fiscal policy maximizes domestic welfare when importing foreign public safety. The lower domestic public spending under the national fiscal policy choice allows to benefit more from foreign safety spillovers, at the expense of foreign households who pay the fiscal cost to repay bonds held by core households and who need to rely more on private sector safe assets. Thus, in diverse monetary union the nationally optimal fiscal policy result in a welfare redistribution from the periphery to the core country compared to the social planner's fiscal policy choice.

2.5.5 Common fiscal policy

In the baseline model without default risk, common fiscal policy could benefit all members states as all governments set lower public spending compared to the social planner's choice. As discussed, in a diverse monetary union households in the core country actually are better off under national fiscal policy with lower public spending compared to the social planner's choice, at the expense of periphery households. Thus, in a diverse monetary union additional common public spending may not necessarily lead to a Pareto improvement. I now derive conditions under which households in both, the core and periphery country benefit from common fiscal policy.

Safe asset portfolio and capital flows Common fiscal policy has quantity and price effects on the household safe asset portfolio. First, equilibrium capital flows are affected. In a diverse monetary union, common bonds pay the same interest as the bonds issued by the core country. In a market clearing equilibrium, and since periphery households have a marginal preference for domestic bonds, core households substitute periphery bonds for common bonds, while periphery households substitute private sector safe assets for domestic bonds (a quantity effect).[15]

The return on governments bonds of both the core and periphery country is also affected by common fiscal policy (price effects), albeit differently. The safety premium on government bond decreases as common public spending increases the supply of public safety. As a result, the return on core country bonds increases. In the periphery country, common fiscal policy additionally increases the required haircut, for two reasons. First, ceteris paribus, common fiscal policy lowers the $t = 1$ safe asset demand as it directly supports consumption at $t = 1$, so it lowers the taxable household income in the low state, resulting in a higher required haircut. Second, when the periphery country contributes to common debt repayment, the available tax revenues for domestic debt repayment decreases. The haircut with common fiscal policy is given by

$$h(G^P) = R_H - \Big[\frac{\bar{\tau}}{1-\bar{\tau}}\Big(\frac{c^{min} - \frac{\theta}{2}G^{MU}}{G^P} - \theta\Big) + \frac{S^P}{G^P}\Big]\Big(\frac{\Delta R + \lambda(C^{CP})}{\lambda(C^{CP})}\Big),$$

which is increasing in common public spending

$$\frac{\partial h(G^P)}{\partial G^{MU}} > 0.$$

When combining the lower safety premium and the larger haircut, the total effect of common spending on the minimum return of periphery bonds is negative, and given by

$$\frac{\partial R_B^{CP-P,L}}{\partial G^{MU}} = -\frac{1}{G^P}\Big(\frac{\bar{\tau}}{1-\bar{\tau}}\frac{\theta}{2} + \frac{\partial S^P}{\partial G^{MU}}\Big) < 0.$$

Thus, while common fiscal policy increases the return on core bonds, it lowers the return on periphery bonds.

[15] The decrease in foreign bond holdings of core country households depends on the net safety effect of common bond holdings, which in turn depends on the core country's share of common debt repayment. In the extreme case in which core household repay all common bonds in a downturn, the net safety benefit of the additional common bond holdings is zero and foreign bond holdings are unaffected.

Productive implications Common fiscal policy affects productive investment not only by inducing households to substitute private sector safe assets for public safety, but also via its impact on the safety premium and capital flows, and its impact on the required haircut on periphery bonds. As a result, common fiscal policy has different effects on production in the core compared to the periphery country.

The common fiscal policy effect on productive investment in the core country is given by the difference between expressions (2.12) and (2.26) when including that the periphery bond return in the low state includes a haircut that is affected by common fiscal policy. The impact on productive investment in the core country equals

$$\Delta I^C = V_0\Big(\frac{G^{MU}}{2}\Big) - \frac{c^{min} - \frac{\theta}{2}(G^{NE-C} + \beta^P + G^{MU})}{\lambda(C^{CP})} + \frac{c^{min} - \frac{\theta}{2}(G^{NE-C} + \beta^P)}{\lambda(C^{NE})}\dots$$
$$- \frac{\frac{\theta}{2}(\beta^P - G^{NE-C}) + S^C - G^{MU} R_B^{MU,L}}{R_B^{CP-P,L}} + \frac{\frac{\theta}{2}(\beta^P - G^{NE-C})}{R_B^{NE-P,L}} - G^{MU}, \quad (2.32)$$

and in the periphery country it is given by the difference between expressions (2.13) and (2.27), and equals

$$\Delta I^P = V_0\Big(\frac{G^{MU}}{2}\Big) - \frac{c^{min} - \frac{\theta}{2}(G^{NE-C} + \beta^P + G^{MU})}{\lambda(C^{CP})} + \frac{c^{min} - \frac{\theta}{2}(G^{NE-C} + \beta^P)}{\lambda(C^{NE})}\dots$$
$$+ \frac{\frac{\theta}{2}(\beta^P - G^{NE-C}) - S^P}{R_B^{CP-P,L}} - \frac{\frac{\theta}{2}(\beta^P - G^{NE-C})}{R_B^{NE-P,L}}, \quad (2.33)$$

where I used that in diverse monetary union households in the core country with a low supply of domestic public safety will hold all common debt in equilibrium, or $B^P_{MU} = 0$ and $B^C_{MU} = G^{MU}$, and where conservative investment with common fiscal policy is lower that without common fiscal policy, or $\lambda(C^{CP}) > \lambda(C^{NE})$.

Taking all the effects of common fiscal policy on productive investment together (increase in the bond supply, increase in public consumption support, increase in the required taxation, increase in core bond returns, and a decrease in periphery bond returns), expression (2.32) implies that productive investment in the core country benefits from common fiscal policy in a diverse monetary union if its share S^C of common repayment is such that

$$S^C < \bar{S}^C = R_B^{CP-P,L}\Big[V_0\Big(\frac{G^{MU}}{2}\Big) - \frac{c^{min} - \frac{\theta}{2}(G^{NE-C} + \beta^P + G^{MU})}{\lambda(C^{CP})} + \frac{c^{min} - \frac{\theta}{2}(G^{NE-C} + \beta^P)}{\lambda(C^{NE})}\dots$$
$$- \frac{\frac{\theta}{2}(\beta^P - G^{NE-C}) - G^{MU} R_B^{MU,L}}{R_B^{CP-P,L}} + \frac{\frac{\theta}{2}(\beta^P - G^{NE-C})}{R_B^{NE-P,L}} - G^{MU}\Big]. \quad (2.34)$$

From expression (2.33) I find that productive investment in the periphery country benefits if its share S^P of common repayment is such that

$$S^P < \bar{S}^P = R_B^{CP-P,L}\Big[V_0\Big(\frac{G^{MU}}{2}\Big) - \frac{c^{min} - \frac{\theta}{2}(G^{NE-C} + \beta^P + G^{MU})}{\lambda(C^{CP})} + \frac{c^{min} - \frac{\theta}{2}(G^{NE-C} + \beta^P)}{\lambda(C^{NE})}\dots$$
$$+ \frac{\frac{\theta}{2}(\beta^P - G^{NE-C})}{R_B^{CP-P,L}} - \frac{\frac{\theta}{2}(\beta^P - G^{NE-C})}{R_B^{NE-P,L}}\Big]. \quad (2.35)$$

Common fiscal policy can benefit production, and thus welfare, in both countries simultaneously when the sum of the maximum repayments at which production in each country benefits exceed the total required common repayment. This is the case when

$$G^{MU} < \bar{G}^{DMU} = \frac{2\Big(V_0(\frac{G^{MU}}{2}) + \Big(c^{min} - \frac{\theta}{2}(G^{NE-C} + \beta^P)\Big)\Big(\frac{1}{\lambda(C^{NE})} - \frac{1}{\lambda(C^{CP})}\Big)\Big)}{1 - \frac{\theta}{\lambda(C^{CP})}}. \tag{2.36}$$

Proposition 6. *In a diverse monetary union common fiscal policy benefits welfare in both member states when (i) their repayment is less than their maximum repayment* $S^j < \bar{S}^j$*, (ii) their repayment add up to full repayment* $S^P + S^C = G^{MU} R_B^{MU,L}$*, and (iii) common public spending is not too high* $G^{MU} < \bar{G}^{DMU}$

The formal proof of Proposition 6 follows from expressions (2.34), (2.35), and (2.36). Proposition 6 does not specify exact repayment shares as there are many repayment combinations that result in productive benefits in both countries. It includes equally shared repayment if common public spending is not too high and the political fixed cost of the periphery country, and thus its public spending, is also not too high. In that case, the core country benefits from an increase in the public safety supply at a limited increase in its tax burden and with only a small increase of the required haircut on periphery bonds.

2.5.6 How to ensure common debt repayment in a diverse monetary union?

I assumed that the common debt is repaid by a claim on member states' tax revenue, so that each country credibly commits a share of its tax revenues to the common institution. In practice this promise may not be credible in a downturn when the periphery country simultaneously has to force a (larger) haircut on national bondholders. Next, I discuss how a commitment to transfer some of the repayment liability to the solvent core country in case the periphery country defaults can ensure common debt repayment in all states.

To ensure that common debt has no default risk, the core country may accept to repay a larger share of the required repayment. Such a commitment increases the tax burden in the core country exactly when households face a binding safety constraint. However, it also facilitates an increase in the public safe asset supply and limits the increase of the required haircut on periphery debt due to common fiscal policy. This latter effect benefits core country households as it increases the safe income obtained from their periphery bond holdings. De facto, part of the additional common debt repayment is returned to core households via a higher return on foreign bond holdings.

The maximum repayment the core country may accept while sustaining productive benefits is given by expression (2.34). I show that the maximum (unequal) repayment by the core country that satisfies Proposition 6 can indeed be larger than the maximum repayment of the periphery country. The difference $\bar{S}^P - \bar{S}^C$ is given by

$$\bar{S}^P - \bar{S}^C = \theta(\beta^P - G^C)(1 - \frac{R_B^{CP-P,L}}{R_B^{NE-P,L}}) - G^{MU}(R_B^{MU-L} - R_B^{CP-P,L}). \tag{2.37}$$

The first part of this expression implies that in order for common fiscal policy to benefit households in the core country, they must be compensated for a lower minimum return on their holdings of periphery debt (a higher haircut, see Section 2.4.3). The second part of expression (2.37) work in the opposite direction: Core households benefit from common fiscal policy as the minimum return on their common debt holdings is larger than what they obtained from periphery debt subject to a haircut. Whether the second effect dominates the first, in which case core households benefit from common fiscal policy even when accepting a larger share of repayment, depends on the spending by the periphery government. The core country can benefit from common fiscal policy even when it repays more of the common debt than the periphery country when $\beta^P < \beta^*$, where β^* solves

$$\bar{S}^P(\beta^*) - \bar{S}^C(\beta^*) = 0. \tag{2.38}$$

Proposition 7. *When the core country repays a larger share of common debt, both countries benefit from common fiscal policy if its repayment satisfies conditions (i), (ii) and (iii) of Proposition 6, and $\beta^P < \beta^*$.*

The proof of Proposition 7 solves expression (2.38) for β^*.

2.5.7 Moral hazard

An important concern regarding shared fiscal responsibilities in the euro area is that it may lead to moral hazard. In the context of this model, I interpret this concern as meaning that high-debt periphery countries may be tempted to issue even more debt at the expense of taxpayers in the low-debt core countries who as a result must be liable for a larger share of the common debt repayment. With the proposed common fiscal policy this is not an issue, for two reasons. First, note that in the model there is no reason for politicians to choose excessive spending. It is not in the interest of the periphery government to issue more national debt as part of the safety supply benefits will be captured by foreign households. Rather, domestic households would be better off if the periphery government was able to lower public spending below its political fixed cost to limit the public safety spillovers to the core country.

More interestingly, the proposed common fiscal policy keeps national public debt and spending decisions entirely separate from common public debt and spending decisions. National governments remain responsible for domestic fiscal choices, and the effects of public spending and defaults are no different in case of common fiscal policy. The crucial element of the proposed common fiscal policy is that the common institution directly provides public safety goods that were not provided by the core and periphery governments.

However, note that in the (static) model there are no political economy considerations, for instance regarding strategic public defaults. It is also implicitly assumed that it is costly for a government to not honor its share of common debt repayment, for instance because there is a credible threat of having to leave the monetary union.

2.6 Conclusion

This paper studies public safety provision in a monetary union in which households have a clearly defined safety demand. I show that national policy choices lead to a lower supply of public safety compared to the choice of a social planner, providing a rationale for common public safety provision. A degree of common public spending funded by common debt can benefit all monetary union member states by increasing the total supply of public safety, avoiding an inefficient dependence on private sector safe assets. This result does not rely on fiscal transfers and also holds when some member states may default.

My model shares some key characteristics with the euro area, such as a large demand for safety and member states that may be at risk of default. There are three main conclusions which are relevant for the debate on the common fiscal policy in the euro area. First and foremost, common fiscal policy does not need to involve fiscal transfers to be mutually beneficial. Second, it could be in the self-interest of core countries to fund a larger share of common fiscal policy. Third, common fiscal policy can have additional benefits when it involves the common provision of certain essential public goods, otherwise insufficiently provided by national governments. Examples of such public goods may relate to healthcare, law and order, social security, or climate policy.

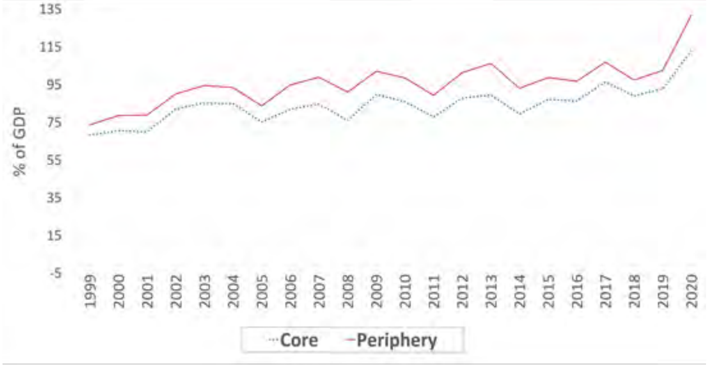
The analysis in this paper has three main limitations that future work may address. First, the model is an entirely real model, so it is not suited to study the implications of diverging inflation rates across member states that may drive a wedge between real and nominal safety. Second, the model does not include a central bank while (unconventional) central bank operations may have important effects on the supply of safe assets. Third, the model does not consider the safe asset demand and supply of the rest of the world. Future work may focus on providing the empirical evidence for the results in this paper, especially in light of the ongoing common debt issuance in the euro area. Examples of results that can be studied using euro area data include the predicted effect of common debt issuance on safe asset portfolios across countries, on the direction and magnitude of safety seeking capital flows, and the predicted holders of common debt.

To conclude, this paper suggests that there may be economic benefits of common public spending when economic activity in a monetary union suffers from a low supply of public safety. As highlighted in the literature, common fiscal policy could come with moral hazard concerns. While such concerns can be avoided based on the common policy design and implementation, common fiscal policy could support an efficient allocation of capital by increasing the supply of public safety, facilitating economic growth, and preparing the euro area for the next crisis.

2.7 Appendix A: figures

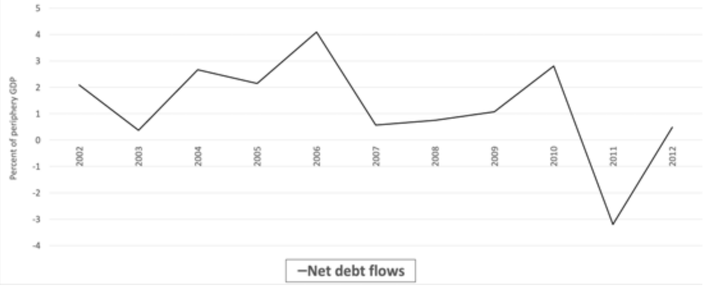
This appendix contains the figures referred to in the text.

Figure 2.3: Safe asset holdings



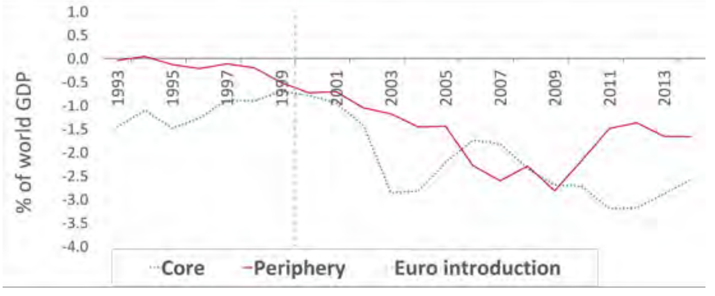
The figure shows the sum of currency and deposits, short term debt and money market fund securities holdings of households and non-financial business over GDP. Core countries include Germany, Netherlands, Austria, and Finland. Periphery countries include Italy, Spain, Portugal, and Greece. *Source:* OECD

Figure 2.4: Net financial flows to debt instruments



The figure shows the net financial flows from core countries (Germany, Netherlands, Austria, Finland and France) to debt instruments in periphery countries (Italy, Spain, Portugal and Greece) in 2002-2012. The direction of safety seeking capital flows outside of crisis times matches the model results. *Source:* Hobza and Zeugner (2014)

Figure 2.5: Net safe asset position



The figures shows the sum of official foreign exchange reserves, minus gold and portfolio debt assets, minus portfolio debt liabilities. Compared to Caballero et al. (2020), it leaves out the addition of other investment and subtraction of other investment liabilities. Core countries include Germany, Netherlands, Austria, Finland ,and France. Periphery countries include Italy, Spain, Portugal and Greece. Since the introduction of the euro in 1999 which removed barriers and costs to capital flows, periphery countries have become net suppliers of safe assets with a magnitude similar to core countries when scaled by world GDP. *Source:* Lane and Milesi-Ferretti (2018) update of the External Wealth of Nations.

2.8 Appendix B: proofs

2.8.1 Proposition 1

The social planner sets public spending G^{GE} in each country to maximize total household welfare $E[U^{MU}]$, where

$$\frac{\partial E[U^{MU}]}{\partial G^{GE}} = \frac{\theta}{\lambda(C)} + \frac{\partial \lambda(C)}{\partial G^{GE}} \frac{2c^{min} - G^{GE}\theta}{\lambda(C)^2} - 1.$$

At zero public spending the effect of an increase in public spending is positive as by Condition 2 it holds that

$$\frac{\theta}{\lambda(\bar{C})} + \frac{\partial \lambda(\bar{C})}{\partial G^{GE}} \frac{2c^{min}}{\lambda(\bar{C})^2} > 1.$$

Furthermore, household expected utility is strictly concave in public spending:

$$\frac{\partial^2 E[U^{MU}]}{\partial (G^{GE})^2} = -\frac{2\theta}{\lambda(C)^2} \frac{\partial \lambda(C)}{\partial G^{GE}} - \frac{2(\frac{\partial \lambda(C)}{\partial G^{GE}})^2 (2c^{min} - G^{GE}\theta)}{\lambda(C)^3} < 0,$$

where I used that

$$\frac{\partial^2 \lambda(C)}{\partial (G^{GE})^2} = \lambda'' \frac{\partial C}{\partial G^{GE}} \frac{\partial^2 C}{\partial (G^{GE})^2} = 0.$$

Thus, there exist some unique spending $G^{GE} > 0$ at which $\frac{\partial E[U^{MU}]}{\partial G^{GE}} = 0$, which solves

$$\frac{\theta}{\lambda(C^{GE})} + \frac{\partial \lambda(C^{GE})}{\partial G^{GE}} \frac{2c^{min} - G^{GE}\theta}{\lambda(C^{GE})^2} = 1.$$

2.8.2 Proposition 2

Suppose that households in the core country import public safety. The government in country $j \in C, P$ sets public spending to maximize domestic household welfare $E[U^j]$, where

$$\frac{\partial E[U^j]}{\partial G^j} = \delta E[R_I] \frac{\partial I^j}{\partial G^j},$$

with

$$\frac{\partial I^C}{\partial G^C} = \frac{\theta}{2\lambda(C)} + \frac{\partial \lambda(C)}{\partial G^C} \frac{c^{min} - \frac{\theta}{2}(G^P + G^C)}{\lambda(C)^2} + \frac{\theta}{2R_B^P} + \frac{\partial R_B^P}{\partial G^C} \frac{\frac{\theta}{2}(G^P - G^C)}{(R_B^P)^2} - 1.$$
$$\frac{\partial I^P}{\partial G^P} = \frac{\theta}{2\lambda(C)} + \frac{\partial \lambda(C)}{\partial G^P} \frac{c^{min} - \frac{\theta}{2}(G^P + G^C)}{\lambda(C)^2} + \frac{\theta}{2R_B^P} - \frac{\partial R_B^P}{\partial G^P} \frac{\frac{\theta}{2}(G^P - G^C)}{(R_B^P)^2} - 1.$$

where I will use Ψ^j to refer to

$$\Psi^j = \frac{\partial \lambda(C)}{\partial G^j} \frac{c^{min} - \frac{\theta}{2}(G^P + G^C)}{\lambda(C)^2},$$

and where

$$\frac{\theta}{2R_B^P} + \frac{\partial R_B^P}{\partial G^C}\frac{\frac{\theta}{2}(G^P - G^C)}{(R_B^P)^2} = -\frac{\partial B_P^C}{\partial G^C},$$

and

$$\frac{\theta}{2R_B^P} - \frac{\partial R_B^P}{\partial G^P}\frac{\frac{\theta}{2}(G^P - G^C)}{(R_B^P)^2} = \frac{\partial B_P^C}{\partial G^P}.$$

Core country Consider the core government's spending choice. At zero domestic public spending the effect of an increase in public spending in the core country is positive as by Condition 2 it holds that

$$\frac{\theta}{2\lambda(\bar{C})} + \frac{\partial\lambda(\bar{C})}{\partial G}\frac{c^{min} - \frac{\theta}{2}G^P}{\lambda(\bar{C})^2} + \frac{\theta}{2R_B^P} + \frac{\partial R_B^P}{\partial G^C}\frac{\frac{\theta}{2}G^P}{(R_B^P)^2} > 1,$$

where

$$\bar{C} = \frac{c^{min}}{\lambda(\bar{C})}$$

Furthermore, household expected utility in the core country is also strictly concave in public spending:

$$\frac{\partial^2 E[U^C]}{\partial(G^C)^2} = \delta E[R_I]\frac{\partial^2 I^C}{\partial(G^C)^2} < 0,$$

which is negative since

$$\frac{\partial^2 I^C}{\partial(G^C)^2} = \frac{\partial\Psi^C}{\partial G^C} - \frac{\partial^2 B_P^C}{\partial(G^C)^2} - \frac{\theta}{2\lambda(C)^2}\frac{\partial\lambda(C)}{\partial G^C},$$

with

$$\frac{\partial\Psi^C}{\partial G^C} = -\frac{\frac{\partial\lambda(C)}{\partial G^C}\frac{\theta}{2}}{\lambda(C)^2} - \frac{2(\frac{\partial\lambda(C)}{\partial G^C})^2(c^{min} - \frac{\theta}{2}(G^P + G^C))}{\lambda(C)^3} < 0,$$

and where

$$\frac{\partial^2 B_P^C}{\partial(G^C)^2} = \theta\Big(\frac{1}{2(R_B^P)^2}\frac{\partial R_B^P}{\partial G^C} - \frac{\Big(\frac{\partial^2 R_B^P}{\partial(G^C)^2}(G^P - G^C) - \frac{\partial R_B^P}{\partial G^C}\Big)2(R_B^P)^2 - 4R_B^P(\frac{\partial R_B^P}{\partial G^C})^2(G^P - G^C)}{4(R_B^P)^4}\Big),$$

which I rewrite as

$$\frac{\partial^2 B_P^C}{\partial(G^C)^2} = \frac{\frac{\partial\lambda(C)}{\partial G^C}\theta\Delta R}{R_H\lambda(C)^2} + \frac{\theta}{2}(G^P - G^C)\Big(\frac{2(\frac{\partial R_B^P}{\partial G^C})^2 - R_B^P\frac{\partial^2 R_B^P}{\partial(G^C)^2}}{(R_B^P)^3}\Big),$$

where

$$\frac{\partial^2 R_B^P}{\partial(G^C)^2} = -\frac{2(\frac{\partial\lambda(C)}{\partial G^C})^2 R_H\Delta R}{(\Delta R + \lambda(C))^3} < 0,$$

so that

$$\frac{\partial^2 B_P^C}{\partial (G^C)^2} = \frac{\frac{\partial\lambda(C)}{\partial G^C}\theta\Delta R}{R_H\lambda(C)^2} + \theta(G^P - G^C)\Big(\frac{(\frac{\partial R_B^P}{\partial G^C})^2 + R_B^P \frac{(\frac{\partial\lambda(C)}{\partial G^C})^2 R_H \Delta R}{(\Delta R + \lambda(C))^3}}{(R_B^P)^3}\Big) > 0.$$

Thus, given foreign public spending G^P, there exist a unique spending choice $G^C > 0$ at which $\frac{\partial E[U^C]}{\partial G^C} = 0$. This spending choice is implicitly defined as:

$$\frac{\theta}{2\lambda(C^C)} + \frac{\partial\lambda(C^C)}{\partial G^C}\frac{c^{min} - \frac{\theta}{2}(G^P + G^C)}{\lambda(C^C)^2} + \frac{\theta}{2R_B^P} + \frac{\partial R_B^P}{\partial G^C}\frac{\frac{\theta}{2}(G^P - G^C)}{(R_B^P)^2} = 1. \tag{2.39}$$

Periphery country The periphery government sets the optimal amount of spending G^P given that the core governments spends G^C that solves (2.39). Repeating the calculations from above, I find that there exist a unique spending choice $G^P > 0$ at which $\frac{\partial E[U^P]}{\partial G^P} = 0$, and which is implicitly defined as:

$$\frac{\theta}{2\lambda(C^P)} + \frac{\partial\lambda(C^P)}{\partial G^P}\frac{c^{min} - \frac{\theta}{2}(G^C + G^P)}{\lambda(C^P)^2} + \frac{\theta}{2R_B^P} - \frac{\partial R_B^P}{\partial G^P}\frac{\frac{\theta}{2}(G^P - G^C)}{(R_B^P)^2} = 1. \tag{2.40}$$

Now, since

$$\frac{\partial R_B^P}{\partial G^P}\frac{\frac{\theta}{2}(G^P - G^C)}{(R_B^P)^2} = \frac{\partial R_B^P}{\partial G^C}\frac{\frac{\theta}{2}(G^P - G^C)}{(R_B^P)^2} > 0,$$

this means that expressions (2.39) and (2.40) result in a spending choice where

$$G^P < G^C,$$

which contradicts with the core being a net public safety importer. Thus, there can be no capital flows in equilibrium, which implicitly defines spending in both countries as defines $G^j = G^{NE} > 0$ where G^{NE} solves

$$\frac{\theta}{2\lambda(C^{NE})} + \frac{\partial\lambda(C^{NE})}{\partial G^{NE}}\frac{c^{min} - \theta G^{NE}}{\lambda(C^{NE})^2} + \frac{\theta}{2R_B^{E,L}} = 1.$$

The national choice spending is lower than the planners choice The welfare benefit Π when a government in country j marginally decreases spending $G^j < G^{GE}$, holding foreign spending $G^i = G^{GE}$ constant, is given by

$$\Pi = -\delta E[R_I]\Big[\frac{\theta}{2\lambda(C^{GE})} + \frac{\partial\lambda(C^{GE})}{\partial G^j}\frac{c^{min} - \theta G^{GE}}{\lambda(C^{GE})^2} + \frac{\theta}{2R_B^i} - 1\Big].$$

Substituting for the social planner's first order condition and for the bond return in Π, I find that it is indeed positive:

$$\Pi = -\delta E[R_I]\Big[\frac{\theta}{2}\frac{\lambda(C^{GE}) - R_L}{\lambda(C^{GE})R_H} - \frac{\partial\lambda(C^{GE})}{\partial G^{GE}}\frac{c^{min}}{\lambda(C^{GE})^2}\Big] > 0,$$

which is positive since $R_L > \lambda(C^{GE})$.

2.8.3 Lemma 2

The tax rate in the low state is given by

$$\tau^{j,L}(G^j) = \frac{R_B^{j,L} G^j}{c^{min} + T^{j,L} - \theta G^j}.$$

Its derivative with respect to public spending equals

$$\frac{\partial \tau^{j,L}}{\partial G^j} = \frac{(\frac{\partial R^{j,L}}{\partial G^j} G^j + R^{j,L})\Big(c^{min} - \theta G^j\Big) + \theta R^{j,L} G^j}{\Big(c^{min} + (R^{j,L} - \theta) G^j\Big)^2} > 0,$$

which is positive as when a country does not default

$$\frac{\partial R_B^{j,L}}{\partial G^j} = \frac{\partial \lambda(C^j)}{\partial G^j}\Big(\frac{R_H \Delta R}{(\Delta R + \lambda(C^j))^2}\Big) > 0.$$

Thus, a country with $\beta^j = \beta_{CON}$ that sets public spending $G^j = \beta_{CON}$ sets the maximum tax rate, where

$$\beta_{CON} = \frac{c^{min}\Big(\Delta R + \lambda(C)\Big)}{\theta + \lambda(C) R_H (\frac{1}{\bar{\tau}} - 1)}.$$

The upper bound on the political fixed costs ensures that $R_B^{j,L} > \theta$, so that the minimum return on government bonds including a haircut provides more consumption than public spending. This is rearranged as

$$G^j < \frac{\bar{\tau} c^{min}}{\theta} = \bar{\beta}.$$

It can be shown that $\bar{\beta} > \beta_{CON}$ when $\beta^j < \bar{\beta}$.

2.8.4 Proposition 4

As in Proposition 1, the social planner sets public spending G^{GE} in the core country to maximize total household welfare $E[U^{MU}]$, where

$$\frac{\partial E[U^{MU}]}{\partial G^{GE}} = \frac{\theta}{\lambda(C)} + \frac{\partial \lambda(C)}{\partial G^{GE}} \frac{2c^{min} - G^{GE}\theta}{\lambda(C)^2} - 1.$$

The difference is that $\frac{\partial \lambda(C)}{\partial G^{GE}}$ is smaller since $G^{SP-P} = \beta^P > G^{GE}$, and thus G^{GE} is lower in the extended model.

2.8.5 Proposition 5

The periphery government cannot lower spending beyond β^P. The government in the core country knows that its households will import public safety when it spends less than the periphery government. Similar to in the proof of Proposition 2, spending G^{NE-C} that maximizes domestic welfare is implicitly defined as

$$\frac{\theta}{2\lambda(C^{NE})} + \frac{\partial\lambda(C^{NE})}{\partial G^{NE-C}} \frac{c^{min} - \frac{\theta}{2}(G^{NE-P} + G^{NE-C})}{\lambda(C^{NE})^2} + \frac{\theta}{2R_B^{P,L}} = 1,$$

where $G^{NE-P} \geq \beta^P$ and where I used that since the periphery country must enforce a haircut it is the case that

$$\frac{\partial R_B^{P,L}}{\partial G^C} = 0.$$

Knowing that it will certainly be a safety exporter, the government in the periphery country will choose the optimal amount of spending $G^{NE-P} \geq \beta^P$ given that the core governments spends G^{NE-C}. However, similar to in the proof of Proposition 2, since

$$\frac{\partial R_B^{P,L}}{\partial G^P} \frac{\frac{\theta}{2}(G^{NE-P} - G^{NE-C})}{(R_B^{P,L})^2} > 0,$$

this would result in an optimal spending choice where

$$G^{NE-P} < G^{NE-C},$$

which cannot be the case as $G^{NE-C} < G^{GE} \leq \beta^P$. Thus, the periphery government optimally sets $G^{NE-P} = \beta^P$.

2.8.6 Interest rate determination

Sovereign debt is priced to make households indifferent between obtaining safe income from bonds or from private sector safe assets. To obtain one unit of safe income, a household can either invest $\frac{1}{\lambda(C)}$ conservative or $\frac{1}{R_B^{j,L}}$ in public debt to obtain safety, where $R_B^{j,L} = 1 + r^j - h^j$. Investing in public debt leaves $\frac{1}{\lambda(C)} - \frac{1}{R_B^{j,L}}$ extra for productive investment. The indifference condition allows to solve for r^j as

$$\begin{aligned}(pR_L + (1-p)\lambda(C))\frac{1}{\lambda(C)} &= ... \\ &(p(1+r^j) + (1-p)(1+r^j-h)\frac{1}{1+r^j-h} + pR_H(\frac{1}{\lambda(C)} - \frac{1}{1+r^j-h}),\end{aligned}$$

or

$$r^j = \frac{\lambda(C^j)R_H + h(R_H - R_L)}{R_H - R_L + \lambda(C^j)} - 1.$$

The haircut is solved for as

$$\begin{aligned}(1 + r^j - h^j)G^j &= \bar{\tau}(c^{min} + T^{j,L} - \theta G^j), \\ h &= (1 + r^j) - \frac{\bar{\tau}}{1-\bar{\tau}}(\frac{c^{min}}{G^j} - \theta).\end{aligned}$$

After substituting in for the interest rate (with haircut) and the lump sum taxation, this can be rearranged as

$$h(G^j) = R_H - \frac{\bar{\tau}}{1-\bar{\tau}}(\frac{c^{min}}{G^j} - \theta)(\frac{\Delta R + \lambda(C^j)}{\lambda(C^j)}).$$

The derivative of the interest rate with respect to public spending equals

$$\frac{\partial r^j}{\partial G^j} = \frac{\frac{\partial \lambda(C^j)}{\partial G^j}\Delta R(R_H - h^j) + \frac{\partial h^j}{\partial G^j}\Delta R\Big(\Delta R + \lambda(C^j)\Big)}{(\Delta R + \lambda(C^j))^2} > 0,$$

and also $\frac{\partial h^j}{\partial G^j} > 0$, where

$$\frac{\partial h^j}{\partial G^j} = \frac{\bar{\tau}}{1-\bar{\tau}}\Big[\frac{c^{min}}{(G^j)^2}\Big(\frac{\Delta R + \lambda(C^j)}{\lambda(C^j)}\Big) + \frac{\partial \lambda(C^j)}{\partial G^j}\frac{\Delta R}{\lambda(C^j)^2}(\frac{c^{min}}{G^j} - \theta)\Big] > 0.$$

Additionally, the required haircut is increasing in foreign spending,

$$\frac{\partial h^j}{\partial G^i} = \frac{\bar{\tau}}{1-\bar{\tau}}\Big[\frac{\partial \lambda(C^j)}{\partial G^i}\frac{\Delta R}{\lambda(C^j)^2}(\frac{c^{min}}{G^j} - \theta)\Big] > 0.$$

The total return on government bonds in the low state is written as

$$R_B^{j,L} = \frac{\lambda(C^j)R_H}{\Delta R + \lambda(C^j)} - \frac{h^j\lambda(C^j)}{\Delta R + \lambda(C^j)},$$

where its change in domestic public spending equals

$$\frac{\partial R_B^{j,L}}{\partial G^j} = -\frac{\bar{\tau}}{1-\bar{\tau}}\frac{c^{min}}{(G^j)^2} < 0,$$

and its change in foreign public spending equals

$$\frac{\partial R_B^{j,L}}{\partial G^i} = \frac{\partial \lambda(C^j)}{\partial G^i}\Big(\frac{\frac{\bar{\tau}}{1-\bar{\tau}}(\frac{c^{min}}{G^j} - \theta)(\frac{\Delta R}{\lambda(C^j)})}{\Delta R + \lambda(C^j)}\Big) - \frac{\lambda(C^j)}{\Delta R + \lambda(C^j)}\frac{\bar{\tau}}{1-\bar{\tau}}\frac{\partial \lambda(C^j)}{\partial G^i}\frac{\Delta R}{\lambda(C^j)^2}(\frac{c^{min}}{G^j} - \theta) = 0.$$

Finally, when a country at risk of default spends more, the total return on its bonds decreases:

$$\frac{\partial(R_B^{j,L}G^j)}{\partial G^j} = -\frac{\bar{\tau}}{1-\bar{\tau}}\theta < 0$$

Chapter 3

Public money as a store of value, heterogeneous beliefs, and banks: Implications of CBDC

3.1 Introduction

In recent years, the use of digital payment methods for transactions has been increasing at the expense of cash, a pattern that has become more pronounced since the outbreak of the Covid-19 crisis (see, e.g., Auer et al. (2020b); Zamora-Pérez (2021)). Despite this fact, the cash-to-GDP ratio has continued to steadily increase, which is suggestive of a strong demand for cash as a store of value.

In response to this shift, central banks have started to investigate the benefits and implications of issuing central bank digital currencies (CBDCs) (Auer et al., 2020a). The ultimate goal of a CBDC is to ensure that individuals operating in an increasingly digitalized economy continue to have access to public money as a means of payment. However, there are concerns that from a store of value perspective, CBDCs may also partially replace bank deposits (see e.g. ECB (2020); FED (2022)).

This paper develops a banking model a la Diamond and Dybvig (1983) with public money as a store of value and studies the effects of CBDC. In the model, banks provide insurance for idiosyncratic liquidity shocks, which exposes the bank to the possibility of a bank run. As in Cooper and Ross (1998); Ennis and Keister (2006), we use an equilibrium selection rule that builds on an exogenous probability of a bank run, which is assumed to capture the state of the economy. Our results rely on the introduction of heterogeneous beliefs about the probability of a bank run. This allows to model how consumers choose between bank deposits and cash holdings, which are safe but subject to storage costs, and how banks adjust their lending in response. Thus, we focus on ex ante portfolio choices, not on actions during a bank run.

The introduction of a CBDC that is a more attractive store of value compared to cash leads to bank disintermediation as it increases the demand for public money at the expense of bank deposits. Interestingly, as the demand for public money increases, the average depositor is more optimistic about bank stability. Consequently, the bank optimally re-balances its portfolio towards a larger share of long-term lending. Thus, while in absolute terms the issuance of CBDC as a store of value leads to a decline in bank funding and lending, in relative terms it translates into more maturity transformation. By adequately calibrating CBDC remuneration and quantity limits, the regulator can affect consumer preferences on whether to hold cash or CBDC and the extent to which CBDC is used as a store of value, respectively.

Our analysis is motivated by evidence on the demand for cash as a store of value in the euro area. We de-trend the cash-to-GDP ratio, and decompose aggregate cash holdings into an estimated transactions demand and a store of value component. The evidence suggests that: (i) the bulk of cash is held for store of value purposes; (ii) cash holdings have a prominent cyclical component and due to their role as a safe haven markedly increase in times of uncertainty and economic downturn; (iii) only a fraction of the population holds cash as a store of value.

Our baseline model is based on the Ennis and Keister (2006) version of the Diamond and Dybvig set-up, augmented with a private choice on a store of value. The central bank issues cash and reserves that serve as safe storage technologies. To capture their technological difference, we assume that cash holdings imply a storage cost whereas (digital) reserves do not.[1] Only banks have access to central bank reserves. They invest in reserves and long-term loans.

The representative bank offers the contract that maximizes the expected utility of its depositors. We study consumers' choice between cash and deposits.[2] For consumers to prefer cash over deposits, the expected utility derived from holding cash must exceed that obtained from deposits. Given the technological superiority of reserves, the bank never chooses to offer a deposit contract inferior to cash. That is, in the baseline model there is no demand for cash regardless of the probability of a bank run. These findings are sharply at odds with the empirical evidence on cash demand.

We modify the baseline model to introduce heterogeneous beliefs about the probability of a bank run. Consumers no longer agree on the probability of the bank run equilibrium and draw their prior beliefs from a distribution function. The belief dispersion indirectly captures the level of uncertainty in the economy. Consistent with the literature, the bank offers a single deposit contract that maximizes the expected utility of its depositors, which depends on their average beliefs.[3]

The model accounts for the main empirical observations on demand for cash as a store of value. First, only some consumers hold cash as a store of value as they are more pessimistic about bank stability. Second, when the dispersion in beliefs (i.e., uncertainty) increases, demand for cash soars at the expense of bank deposits. This suggests that, in a dynamic arrangement with shocks to belief dispersion, the model captures the patterns of demand for cash as a safe asset over time.

The model is applied to study the main implications of allowing the central bank to issue - along with cash and reserves - a central bank digital currency (CBDC). Compared to cash, CBDC is a superior public storage technology, captured by lower storage costs. Additionally, CBDC holdings can be calibrated by the regulator by setting the corresponding interest rate and/or by applying a quantity limit.

[1] In particular, the net exchange value of reserves is normalized to unity while cash is subject to storage costs and, hence, its net exchange of value is below one.

[2] The baseline model does not explicitly consider mixed portfolios. For an extension of this model that allows for consumers to simultaneously hold cash and bank deposits, see Appendix B.

[3] Heterogeneous prior beliefs are commonly used in the field of behavioral finance (Hong and Stein, 2007) to capture disagreement among agents. In practice the objective probability of a state of the world is hard to estimate. Thus, individuals have their corresponding subjective beliefs on which they base their investment decisions (Giglio et al., 2021; Meeuwis et al., 2022).

Our analysis predicts that, under certain conditions, the issuance of a non-interest bearing CBDC introduces a trade-off. On the one hand, and due to its technological superiority, the efficiency of holding public money increases. Those consumers who were already holding public money benefit by fully replacing cash with CBDC. On the other hand, CBDC amplifies the distortion induced by heterogeneous beliefs as it makes public money holdings more attractive. By lowering the subjective probability of a bank run above which consumers opt for holding public money instead of deposits, aggregate public money holdings (and the proportion of public money holders) increase and deposit funding declines. Thus, CBDC leads to bank disintermediation. As remaining depositors are, on average, more optimistic about bank stability, the bank optimally increases the share of long-term lending in its portfolio. That is, while CBDC partially replaces deposits, long-term lending decreases less than proportionally to deposits due to increased relative maturity transformation.

Related literature

Our paper connects to three main strands of the literature. A first strand models the demand and supply of safe liquid assets (Stein, 2012; Gorton and Ordonez, 2022). Our model contributes by explicitly modelling the lasting implications of demand for cash as a safe store of value on bank intermediation. It is the first to explicitly model cash as a storage technology alternative to bank deposits in a context of heterogeneous beliefs about bank stability. Allen et al. (2014) introduce fiat money in a canonical bank-run model as a nominal means of payment (rather than as a store of value). Peck and Setayesh (2022) also explicitly model an alternative investment option next to bank deposits, but their alternative is a productive technology rather than cash.

This paper also relates to the literature on heterogeneous beliefs and disagreement. Giglio et al. (2021) use survey data to provide robust evidence on: (i) the link between beliefs and portfolio allocations, both across retail investors and over time, and (ii) a persistent heterogeneity in beliefs across individuals. It is well documented that different views on interpreting signals lead to persistent disagreement over economic variables (Harris and Raviv, 1993; Kandel and Pearson, 1995; Meeuwis et al., 2022). Patton and Timmermann (2010) shows that even professional forecasters persistently disagree with a belief dispersion that is counter-cyclical and highest in times of economic recession and uncertainty.

Heterogeneous prior beliefs are commonly used in behavioral finance and asset pricing to interpret empirical findings on trading and disagreement (Hong and Stein, 2007; Chand et al., 2021). Papers in the macro-finance literature that assume heterogeneous prior beliefs include Geanakoplos (2010); Scheinkman and Xiong (2003); Martin and Papadimitriou (2021); Caballero and Simsek (2020). We consider heterogeneous beliefs to explain why some consumers prefer cash rather than bank deposits as a store of value.

Finally, our paper contributes to the growing literature on the implications of CBDC for bank intermediation and the real economy. Brunnermeier and Niepelt (2019) show that, under certain conditions, public and private monies are equivalent and, thus, introducing a CBDC does not have any allocative or macroeconomic consequences.[4] Papers that study the effects of CBDC on the banking sector by making one or various

[4] Niepelt (2020) shows that the required conditions are very restrictive and unlikely to hold in practice.

assumptions that impede the equivalence result to hold include Piazzesi and Schneider (2020); Williamson (2022); Bacchetta and Perazzi (2021); Adalid et al. (2022); Ahnert et al. (2022); Keister and Sanches (2022); Abad et al. (2022), among others. In most models, the equivalence result does not hold due to the presence of a market imperfection or a regulatory constraint. Such frictions include imperfect competition in the bank deposit market (see, e.g., Andolfatto (2021); Chiu et al. (2021)), central bank collateral requirements (Assenmacher et al. (2021); Burlon et al. (2022); Williamson (2022)), and liquidity regulation (Meller and Soons, 2022). In our model, it is incomplete information that undermines the equivalence result, through two channels. First, the central bank and consumers face an adverse selection problem which precludes them from investing in long-term loans. Second, consumers do not know the true probability of a bank run.

From a modelling perspective, our paper connects with the CBDC literature that builds on the Diamond and Dybvig framework. Fernández-Villaverde et al. (2021) find that, under certain assumptions, CBDC leads to a central bank deposit monopoly. In contrast to us, they crucially assume that depositors ex ante do not expect any bank run, and the central bank can indirectly engage in long-term lending by signing contracts with investment banks. Skeie (2020); Tercero (2022) show that the usage of CBDC as a nominal means of payment requires its rate of return to be higher for bank deposits. Schilling et al. (2020) present a CBDC trilemma according to which the central bank can only achieve two out of the three goals of efficiency, financial stability (i.e., absence of runs), and price stability. Similar to ours, Keister and Monnet (2022) find that the issuance of a CBDC induces a re-balancing effect in the bank asset portfolio towards more long-term lending. In our model, this relative increase in maturity transformation is attributed to the fact that the average bank depositor becomes more optimistic about bank stability.

The rest of the paper is structured as follows. Section 2 documents some empirical facts on the demand for cash as a store of value. Section 3 presents the baseline model. Section 4 develops the model by introducing heterogeneous prior beliefs about the probability of a bank run. Section 5 extends the model by allowing for CBDC as a store of value. Section 6 concludes.

3.2 Empirical evidence

Some empirical observations help motivate the paper. Figure 1(a) plots the ratio of aggregate cash holdings defined as the value of euro-denominated banknotes in circulation to GDP for the period 2003 - 2021 at annual frequency. The cash ratio has steadily increased over the last decades, even though (digital) transaction efficiency has risen.

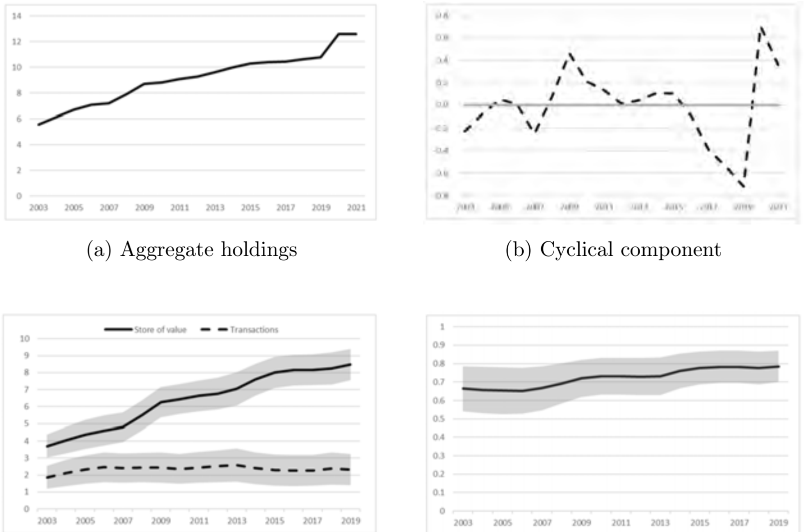
According to recent studies, the use of cash for transactions has decreased, a pattern that has become particularly pronounced in the euro area (and elsewhere) since the onset of the COVID-19 crisis (see, e.g., Auer et al. (2020b); Zamora-Pérez (2021)). Despite this fact, the upward trend in cash holdings has not been reversed. On the contrary, Figure 1(b) suggests that cash holdings jumped in response to the COVID-19 shock and have stayed well above their historical trend since then. More generally, Figure 1(b) shows that cash holdings have only significantly deviated from their trend and remained well above it around the Great Recession (2009) and the COVID-19 crisis (2020-2021). This finding is in line with the empirical studies that show the strong dependence of cash demand as a store of value on uncertainty and the state of the economy (Jobst and Stix, 2017; Rösl and Seitz, 2021). Arguably, as perceived bank stability decreases, a flight-to-safety by depositors from bank deposits to cash takes place (Baubeau et al., 2021). Interestingly, Esselink and Hernández (2017) document that in 2016, 24% of euro area survey respondents reported to hold cash outside a bank account as a precautionary store of value, which suggests that only a fraction of the population holds cash as a store of value arguably as individuals differ in their perceptions about bank stability. According to Zamora-Pérez (2021), in 2019 the amount of cash reserves per-adult in the euro area lied between €1,270 and €2,310.

Similar to the seasonal method applied in Assenmacher et al. (2019); Zamora-Pérez (2021), we decompose the annual series of euro-denominated cash holdings into two estimated components: (i) cash holdings for transaction purposes, and (ii) cash holdings as a store of value. Figure 1(c) displays the two estimated components of total cash holdings. Decomposition estimates are produced by comparing the seasonality of total banknote circulation with the seasonality of a purely transactional benchmark variable. While the estimated value of banknotes for transactions (dotted line) has not significantly changed over the last two decades, the estimated value of cash holdings as a store of value (solid line) has steadily increased over the same period, suggesting that the upward trend and cyclical deviations in the cash ratio is mostly to be attributed to the demand for cash as a store of value.

Figure 1(d) confirms the increasing relative importance of cash holdings as a store of value as opposed to that of cash as a means of payment. In particular, the estimated value of banknotes held as a store of value in 2003 already stood at around 65 percent of total cash holdings; a fraction that has been increasing since then until reaching roughly 80 percent of total banknotes in circulation in 2021.

Our paper offers a modification of the canonical bank-run model that accounts for the main empirical observations on demand for cash as a store of value.

Figure 3.1: Euro denominated cash holdings



(a) Aggregate holdings

(b) Cyclical component

(c) Estimated components

(d) Estimated store of value holdings

Cash holdings are defined as the value of euro-denominated banknotes in net circulation as a percent of annual GDP. Figures (a) and (c) are in percentage points. Figure (b) is in percentage deviations from the HP trend with a standard smoothing parameter of 100. Figure (d) is expressed as the ratio of total cash holdings. Data: ECB and own calculations.

3.3 The baseline model

The baseline model extends the Diamond and Dybvig-type banking model of Cooper and Ross (1998); Ennis and Keister (2006) to allow for cash as a store of value.

3.3.1 Environment

There are three dates $t = 0, 1, 2$ and a single good per date which works as a numeraire and can be used for investment at $t = 0$ and consumption at $t = 1$ and $t = 2$. A unit continuum of ex ante identical consumers indexed by $i \in [0, 1]$ has an endowment normalized to one at $t = 0$. Consumer preferences are given by

$$U(c_1, c_2, \theta_i) = u(c_1 + \theta_i c_2),$$

where c_t is consumption at date t and the utility function u is strictly increasing, strictly concave, continuously differentiable, and satisfies the Inada conditions. The idiosyncratic liquidity shock $\theta_i \in \{0, 1\}$ is realized at $t = 1$ and privately observed by each consumer. If $\theta_i = 0$, consumer i is impatient and wishes to consume at the interim date only; otherwise, she is patient and values consumption at either the interim or final date. The probability of each consumer becoming impatient is a constant λ.

Consumers can invest in two types of assets at $t = 0$ to transfer wealth to future dates: retail central bank money ("cash") and bank deposits. To simplify, we do not allow for mixed portfolios in the main analysis, i.e. consumers choose between cash or

CBDC as if their endowment is non-divisible. Appendix B contains an extended model solution.

There is a central bank that exchanges endowment for cash at $t = 0$ and $t = 1$ and repays consumption goods on demand at $t = 1$ and $t = 2$. While the central bank faces no direct storage costs, holding cash comes with a proportional cost $f > 0$ incurred whenever the cash is exchanged for consumption or any other asset, so a unit of cash has a net exchange value of $1 - f$ whenever used.[5]

Second, consumers can pool resources to form a bank that invests their endowments on their behalf. At $t = 0$ the bank invests an amount x of its deposit funding D_0 received from consumers in a long-term investment technology, and $D_0 - x$ in wholesale central bank money ("reserves"). Reserves can only be accessed by the bank and the net exchange value per unit of reserves is normalized to one.

The long-term investment technology (long-term lending) can be of two types, good and bad. The good type yields a return of R units upon maturity at $t = 2$ and has no liquidation value at $t = 1$.[6] This technology offers a higher long-term return than cash or reserves, but it is less liquid. The bad type —a lemon—never generates any return, similar to Dang et al. (2017).

Only a bank can screen potential borrowers and prevent investment in the bad technology, as in Holmstrom and Tirole (1997). As in Allen and Gale (1998), we assume that the implied adverse selection problem precludes the consumers and the central bank from investing directly or indirectly (via lending to the bank) in the long-term technology.[7] Thus, the bank has two functions in this economy: (i) it serves as a conduit for investment in good long-term technologies, while screening bad ones, and (ii) it provides insurance against idiosyncratic liquidity risk by offering demand deposits to consumers, as in Diamond and Dybvig (1983). Specifically, at $t = 0$ the bank offers a contract that promises a payment of c_1^B if a consumer withdraws at $t = 1$ and c_2^B if she does not. However, such promises are only fulfilled if the consumers withdrawing at $t = 1$ are the proportion λ of impatient ones. As in Allen and Gale (1998), we assume that if the proportion of early withdrawers exceeds λ, the bank "defaults" and makes a liquidation payment c_R^B to all consumers attempting to withdraw at $t = 1$ (and zero to the rest).[8]

The timing of events in the baseline model is as follows. First, each consumer chooses between holding cash or depositing with the bank. The bank, on behalf of its depositors, invests x in the long-term technology and $D_0 - x$ in reserves. At date $t = 1$, the liquidity shock hits and all impatient consumers attempt to withdraw their bank deposits. The actions of patient consumers depend on: (i) what she expects other patient consumers will do, and (ii) the deposit contract. To simplify the discussion, we will focus on the case in which consumers play symmetric pure strategies. If a patient

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[5] This cost could correspond to resources spent to prevent theft before its conversion or on other storage and transportation costs.

[6] Jacklin and Bhattacharya (1988); Haubrich and King (1990) also assume that the long-term asset yields a zero payoff when liquidated early. In contrast, Diamond and Dybvig (1983) assume that the liquidation value is equal to the initial investment, while Ennis and Keister (2006); Cooper and Ross (1998) include a liquidation cost $\tau \in [0, 1]$.

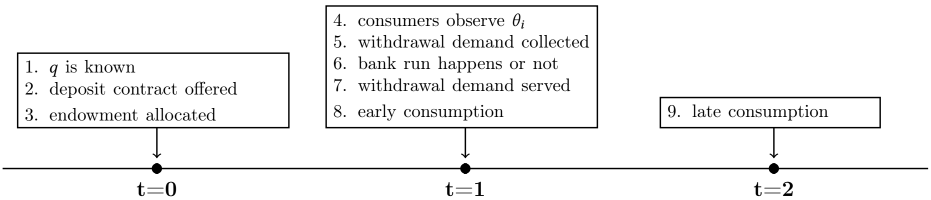
[7] Arguably, in practice, adverse selection explains, among others, why central bank lending and asset purchases are subject to strict risk management frameworks.

[8] Consumers cannot trade at dates $t = 1$ and $t = 2$. Jacklin (1987) and Wallace (1988) consider a credit market at date $t = 1$.

consumer believes other patient consumers will not withdraw and the deposit contract is incentive compatible, ($c_2^B \geq c_1^B$), she will optimally decide not to withdraw her bank deposits. If all patient consumers follow this behavior, a "good" non-run equilibrium can be sustained. However, if she expects all other patient consumers to withdraw and the bank does not have enough resources to pay c_1^B to all depositors, she will optimally decide to withdraw. If all patient consumers follow this behavior, a "bad" bank run equilibrium emerges. When the bank cannot cover the required repayment in case all patient depositors withdraw at $t = 1$, the deposit contract is said to be run-prone.[9] In contrast, if the bank has enough reserves to meet all of its short-term obligations, waiting to withdraw is a dominant strategy as the payment at $t = 2$ is larger than the payment at $t = 1$. In that case, the deposit contract is said to be run-proof.

In order to describe the ex-ante optimal deposit contract anticipating the possibility of multiple equilibria, we follow Cooper and Ross (1998) and Ennis and Keister (2006) and assume a sunspots-based equilibrium selection rule: if both equilibria exist, a bank run occurs with an exogenous probability q. The probability q is constant and does not depend on actual bank reserves, and we have that $qR > 1$. Figure 3.2 summarizes the timeline of the game.

Figure 3.2: Timeline of the baseline model



3.3.2 Optimal demand for cash

To determine the demand for cash, we specify the problem of a bank that behaves competitively in the sense that it offers the contract that maximizes the expected utility of its depositors. Let $\bar{\lambda}$ denote the fraction of depositors that can be served at the interim date under the underlying contract. Variable y represents reserves that are needed to repay impatient depositors whereas y^l represents excess liquidity, i.e. reserves in excess of what is required to repay impatient depositors only. The bank's problem solves

$$\max_{c_1^B, c_2^B, c_R^B, x, y, y^l} (1 - q\mathbb{1}_{\bar{\lambda}<1})\left[\lambda u(c_1^B) + (1-\lambda)u(c_2^B)\right] + q\mathbb{1}_{\bar{\lambda}<1}u(c_R^B) \tag{A}$$

[9] Given the assumption that the long-term investment technology has no liquidation value at $t = 1$, these resources amount to the reserves held by the bank.

subject to

$$x + y + y^l = D_0, \quad (3.1) \qquad \lambda c_1^B = y, \quad (3.2)$$

$$(1 - \lambda)c_2^B = Rx + y^l, \quad (3.3) \qquad c_R^B = y + y^l, \quad (3.4)$$

$$0 \le c_1^B \le c_2^B, \quad (3.5) \qquad c_1^B, c_2^B, x, y, y^l \ge 0, \quad (3.6)$$

The indicator function $\mathbb{1}_{\bar{\lambda}<1}$ reflects the equilibrium selection rule. A bank run only occurs with probability q if $\bar{\lambda} < 1$ and otherwise occurs with probability zero. The maximum fraction of depositors that can be served at the interim date without a default is given by

$$\bar{\lambda} = \frac{y + y^l}{c_1^B}. \tag{3.7}$$

Problem A states that the bank maximizes the expected utility of its depositors subject to the following constraints. Expression 3.1 stipulates that the bank invest all its deposit funding. The bank is a deposit taker. According to expression 3.2, the bank must hold enough reserves to cover the promised interim return. Since there is no aggregate uncertainty, the bank knows that a fraction λ of depositors will have liquidity needs. Expression 3.3 states that the final payment equals the sum of the return on long-term lending and the remaining reserves after having serviced early withdrawals. Expression 3.4 dictates that the payment in case of a bank run is equal to the liquidation value of the bank. Expression 3.5 is the incentive compatibility constraint, which ensures that patient consumers have no incentive to withdraw at the interim date in absence of a bank run.[10]

The optimal deposit contract solves Problem A for payments (c_1^B, c_2^B, c_R^B), the bank asset allocation (x, y), subject to the level of deposit funding, D_0. Therefore, it also implicitly includes the demand for cash ($M_0 = 1 - D_0$). A consumer chooses cash over deposits only if the expected utility derived from holding cash exceeds that obtained with the optimal bank deposit contract. Proposition 1 shows that regardless of the terms of the optimal deposit contract, there is never a positive demand for cash in the baseline model.

Proposition 1: *In the baseline model,* $M^0 = 0$, $\forall\, q \in (0, 1)$.

The reasoning for Proposition 1 is as follows. A bank, whose objective is to maximize depositor utility, can always offer the best run-proof contract for any realization of q. The expected utility obtained from the best run-prone is certainly as high as the expected utility obtained from the run-prone contract that includes only reserve holdings. In turn, the utility obtained from cash holdings is strictly lower than that from a run-proof deposit contract with only reserve holdings due to the storage costs (and the lack of liquidity insurance). Thus, the bank never chooses to offer a deposit contract inferior to cash holdings and a consumer never prefers to hold cash instead of bank deposits.

[10] Without loss of generality and for the sake of tractability, we have assumed that at $t = 0$ each individual places her endowment either in cash or in deposits. See Appendix B for the general version of the consumer's problem which allows each consumer to simultaneously allocate a positive proportion of her endowment in both, deposits and cash (i.e. a mixed portfolio).

To further characterize the solution to the baseline model, we assume a utility function of the constant-relative-risk-aversion form

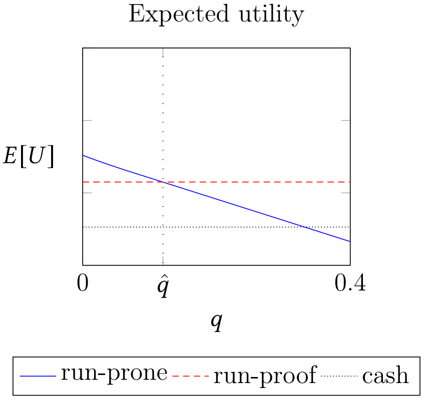
$$u(c) = \frac{c^{1-\gamma}}{1-\gamma} \quad \text{with } \gamma > 1, \tag{3.8}$$

Corollary 1 states a cut-off value $\hat{q}$ that determines whether the solution to Problem (A) is a run-prone or a run-proof contract, similar to Proposition 5 in Cooper and Ross (1998).

Corollary 1: *There exists a $\hat{q} \in (0, 1)$ such that if $q > \hat{q}$ the optimal deposit contract is run-proof whereas if $q < \hat{q}$ it is run-prone. Regardless of the probability of a bank run, there is no demand for cash in the baseline model.*

The intuition of the proof contained in the Appendix is as follows. When $q = 0$, clearly the optimal contract is the run-prone contract that maximizes expected return by lending long-term. The bank optimally responds to a higher q by substituting long-term loans for additional reserves to increase its liquidation value and thus the payment case of a bank run. This substitution lowers the expected utility obtained from the run-prone contract. As an alternative, the bank can offer the best run-proof contract, in which case the expected utility is independent from q. When $q > \hat{q}$, the expected utility from the best run-proof contract exceeds that from the best run-prone contract, while when $q < \hat{q}$ a run-prone contract results in higher expected utility. Figure (3.3) illustrates this intuition by means of a simulation.

Figure 3.3: Optimal deposit contract



The simulation uses $R = 1.5$, $\lambda = 0.3$, $f = 0.2$, and $\gamma = 1.5$.

To summarize, the baseline model fails to explain any of the empirical facts on cash holdings as a store of value presented in section 2. Notably, in the baseline model there is no demand for cash regardless of the state of the economy. The next section extends the baseline model to account for the empirical findings on demand for cash as a safe store of value.

3.4 The model

This section extends the baseline model to allow for individual heterogeneous prior beliefs about the probability of a bank run.

3.4.1 Heterogeneous beliefs

The baseline model assumes that if multiple equilibria exist, a bank run occurs with an exogenous probability q that is known ex ante by all consumers at $t = 0$ and before they decide on how to allocate their endowment. Consider instead that consumers do not have such information but have heterogeneous beliefs (at $t = 0$) about the probability of a bank run.

Formally, a consumer i has belief q_i at $t = 0$ about the probability of a bank run at $t = 1$, if it exists. At $t = 0$ each consumer draws her belief q_i from a cumulative distribution $F(q, \sigma)$ with support $[0, 1]$ and density $f(q, \sigma)$. We assume that a greater σ correlates with greater aggregate belief dispersion in the sense of a mean preserving spread (see Stiglitz and Weiss (1981)), i.e. for $\sigma_1 > \sigma_2$ it holds that

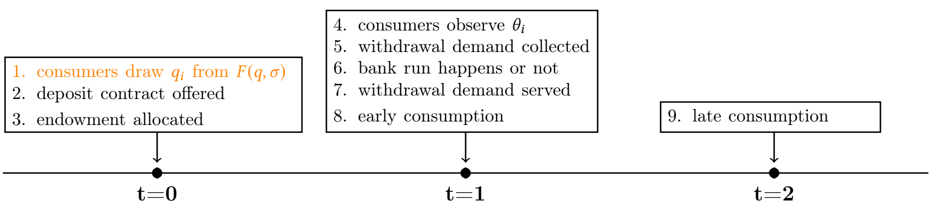
$$\int_0^1 q_i f(q, \sigma_1) dq = \int_0^1 q_i f(q, \sigma_2) dq,$$

while for any $t > 0$ it holds that

$$\int_0^t F(q, \sigma_1) dq \geq \int_0^t F(q, \sigma_2) dq.$$

Figure 3.4 presents the timeline. Importantly, in this set-up consumers make their portfolio choice at $t = 0$ based on their belief q_i about the probability of a bank run at $t = 1$. Note that the baseline model can be interpreted as the case for which $\sigma = 0$ as all consumers agree on the probability q of a bank run.

Figure 3.4: Timeline of the model



3.4.2 Optimal demand for cash

We turn our attention to the banks' problem and the household's portfolio choice, asking under what conditions the optimal demand for cash as a store of value is positive. If the chosen deposit contract is run-proof, individual beliefs q_i are irrelevant and the results presented in section 3 apply.

If the chosen deposit contract is run-prone, a bank run may occur. Consistent with the literature and the baseline model, we assume that the bank offers a single deposit contract that maximizes the expected utility of its depositors.[11] In other words, the bank offers a deposit contract based on the average individual belief of its depositors.

Consumers who are sufficiently pessimistic about bank stability (sufficiently high q_i) believe to be better off with cash than with the run-prone deposit contract. Proposition 2 states that if the deposit contract that solves the bank's problem is run-prone and the depositor is sufficiently pessimistic, or $q_i > \tilde{q}$, consumer i prefers to hold cash rather than bank deposits. The threshold value $\tilde{q}$ is

$$\tilde{q} = \frac{\lambda u(\frac{c_1^B}{D_0}) + (1-\lambda)u(\frac{c_2^B}{D_0}) - u(1-f)}{\lambda u(\frac{c_1^B}{D_0}) + (1-\lambda)u(\frac{c_2^B}{D_0}) - u(\frac{c_R^B}{D_0})},$$

which is the subjective probability of a bank run for which a consumer is indifferent between placing her endowment in bank deposits and placing it in cash.[12]

Proposition 2: *Given a certain run-prone deposit contract: (i) consumers with $q_i > \tilde{q}$ place their endowment in cash, (ii) a proportion $(1-\tilde{q})$ of consumers holds cash, and (iii) $M_0 = \int_{\tilde{q}}^{1} f(q,\sigma)dq$.*

Provided that the deposit contract offered by the bank is run-prone, consumers who are sufficiently pessimistic about bank stability hold cash. Aggregate demand for cash is given by the sum of individual cash holdings for all consumers with $q_i > \tilde{q}$.

Despite the fact that the bank cannot observe individual beliefs about the probability of a bank run, the bound $\tilde{q}$ and, thus, the fraction of consumers who optimally place their endowment in deposits is known to the bank and depends on the chosen deposit contract. Consequently, the bank solves

$$\max_{c_1^B, c_2^B, c_R^B, x, y} \left[1 - \int_0^{\tilde{q}} q_i f(q,\sigma_1)dq\right]\left[\lambda u(c_E) + (1-\lambda)u(c_L)\right] + \left[\int_0^{\tilde{q}} q_i f(q,\sigma_1)dq\right]u(c_R), \quad \text{(B)}$$

subject to the same constraints as Problem (A). Importantly, the beliefs q_i are assumed to be unaffected by the chosen deposit contract.

Denote the belief of the average depositor as $\int_0^{\tilde{q}} q_i f(q,\sigma_1)dq = \bar{q}$. Problem (B) results in the following optimality condition

$$(1-\bar{q})\left[Ru'(c_B^2) - u'(c_1^B)\right] = \bar{q}u'(c_R^B). \quad (3.9)$$

As illustrated in Figure (3.5) for the case of a Gaussian distribution of individual beliefs with mean q and dispersion σ, it follows that - on average - depositors are

[11] In theory, even when beliefs are private information, the bank could offer a continuum of deposit contracts, permitting each depositor to self-select her preferred option based on her subjective beliefs. Allowing for such a technology would translate into a lower but still positive demand for cash as long as the deposit contracts offered by the bank are run-prone. Note that a representative bank cannot simultaneously offer run-prone and run-proof contracts.

[12] Without loss of generality and for the sake of tractability, we have assumed that at $t = 0$ each individual places her endowment either in cash or in deposits. See Appendix B for the general version of the consumer's problem which allows each consumer to simultaneously allocate a positive proportion of her endowment in both deposits and cash (i.e. a mixed portfolio). A simulation shows how consumers with an interior belief choose a mixed portfolio.

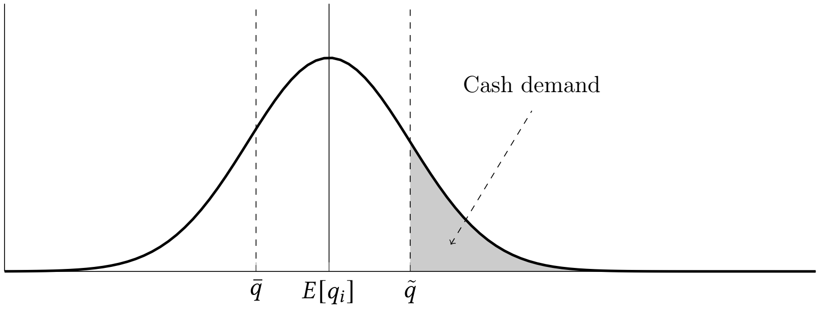
relatively optimistic about the probability of a bank run, or $\bar{q} < q$. Consumers with $q_i > \tilde{q}$ are cash holders as they believe they are better off holding cash. Aggregate cash holdings are given by the shaded area. Note that $\bar{q}$ is the average belief of those consumers that deposit with the bank, so it must be that $\bar{q} < \tilde{q}$.

Similar to Corollary 1, Corollary 2 defines a cut-off value $\hat{\hat{q}}$ that determines whether the solution to Problem (B) is a run-prone or a run-proof contract under the assumption that expression (3.8) applies.[13] The bank offers a run-prone contract when the average beliefs of its depositors $\bar{q}$ is sufficiently low.

Corollary 2: *There exists a $\hat{\hat{q}} \in (0,1)$ such that if $\bar{q} > \hat{\hat{q}}$ the solution to Problem (B) is a run-proof contract and if $\bar{q} < \hat{\hat{q}}$ it is a run-prone contract.*

Corollary 2 follows from the proof of Corollary 1, which applies for all D_0. The difference between $\hat{\hat{q}}$ and $\hat{q}$ is due to the difference between $\bar{q}$ and q in the bank's objective function, which relates to the existence of a demand for cash and, ultimately, to the presence of heterogeneous beliefs about bank stability.

Figure 3.5: Aggregate demand for cash



3.4.3 Uncertainty and demand for cash

The dispersion in individual beliefs, σ, can be interpreted as a measure of aggregate uncertainty. This section investigates the main implications of an exogenous shift in σ (mean-preserving spread) for the demand for cash and the deposit contract offered by the bank. We assume here that the contract offered by the bank is run-prone (thus $\bar{q} < \hat{\hat{q}}$, see Corollary 2).

We obtain two results. First, for any given run-prone deposit contract, an increase in beliefs' dispersion (mean-preserving spread) leads to an increase in aggregate demand for cash as the mass of consumers in the tails of the distribution increases (see Figure 3.6a).[14]

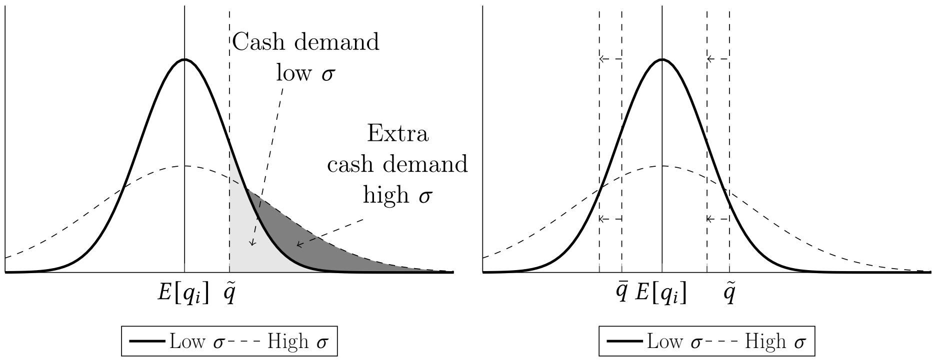
The second effect is particularly interesting. Since the average depositor is now comparatively more optimistic about bank stability ($\bar{q}$ declines, see Figure 3.6b), the

[13] The remainder of the analysis continues assuming that this specification of the utility function applies.

[14] Recall from section 4.1 that a greater value of σ implies a greater dispersion in beliefs but does not affect the mean of the distribution.

bank adjusts its own liquidity risk profile. As depositors on average perceive a bank run to be less likely, the bank increases long-term lending as a share of its portfolio.[15] As a result, the liquidation value of the bank decreases and so does the bound $\tilde{q}$ since the return on bank deposits increases. Proposition 3 summarizes the main implications of an increase in beliefs' dispersion, σ, for the optimal run-prone contract.

Figure 3.6: Impact of CBDC



(a) cash demand (b) q-values

Proposition 3: *Assume $\bar{q} < \hat{\hat{q}}$ so that banks offer a run-prone deposit contract. As σ increases: (i) cash demand increases, (ii) bank deposits and the average belief of depositors $\bar{q}$ decrease, (iii) the bank reduces reserve holdings and long-term lending, (iv) the bank reduces the share of reserves in its portfolio $\frac{y}{D_0}$, (v) the bound $\tilde{q}$ decreases.*

The interpretation of Proposition 3 is as follows. In times of high uncertainty, more consumers prefer cash rather than bank deposits, similar to a flight-to-safety. As a result, the remaining depositors are - on average - more confident about bank stability. The bank optimally responds to this shift in the belief of its average depositors by offering a relatively higher payment in the good equilibrium and a relatively lower payment in case of a bank run. It does so by re-balancing its asset portfolio towards more long-term lending, which increases maturity transformation.[16]

In a nutshell, the model accounts for key empirical findings on cash holdings as a safe liquid asset: (i) at the aggregate level there is a demand for cash as a store of value, (ii) only a certain proportion of consumers hold cash (i.e., those who are sufficiently pessimistic about bank stability and the future state of the economy), and (iii) aggregate demand for cash and the proportion of consumers who hold public money for safety reasons increase with uncertainty.

This modification of the Diamond and Dybvig model offers a suitable set-up to study the implications of introducing a CBDC for banks and the demand for public money as a store of value. The next section investigates these issues in the context of the proposed model.

[15] Optimality condition (3.9) indicates that the share of bank reserves, y, is strictly decreasing in $\bar{q}$.

[16] Note that we ignore any feedback effects of bank's portfolio choices on the probability of a bank run, which is beyond the scope of this paper.

3.5 The model with CBDC

This section extends the model to allow for the central bank to issue central bank digital currency (CBDC) along with cash and reserves.

3.5.1 CBDC vs cash

As for the case of cash, the central bank exchanges endowment for CBDC at $t = 0$ and $t = 1$ and repays consumption goods on demand at $t = 1$. When compared to cash, CBDC is characterized by three key distinctive features. From a technological perspective, CBDC is a superior store of value compared to cash, captured by lower storage costs, $f^{DC} < f$. From a regulatory perspective, the interest rate on CBDC holdings, r^{DC}, may differ from zero. In addition, the authority could impose a quantity limit on CBDC supply.

For any given run-prone contract offered by the bank, a consumer prefers to hold cash or CBDC depending on the exchange of value of each of the two forms of public money. Proposition 4 summarizes this choice.

Proposition 4: *For any given run-prone contract offered by the bank, a consumer strictly prefers to hold CBDC rather than cash if* $(1 - f^{DC} + r^{DC}) > (1 - f)$.

Under a run-prone deposit contract, Proposition 4 has several implications. First, by adequately calibrating r^{DC}, the regulator can determine whether consumers prefer cash or CBDC as a store of value. Second, by introducing a limit on CBDC supply $\bar{M}^{DC} < M_0$, where $\bar{M}^{DC}$ denotes the CBDC quantity limit, the regulator can calibrate the amount of CBDC held as a store of value. Consequently, if the only difference between CBDC and cash is given by $f > f^{DC}$ (i.e., no binding limits on CBDC supply and $r^{DC} = 0$) CBDC fully replaces cash as a safe store of value.

3.5.2 CBDC vs deposits

The introduction of a CBDC may also affect the run-prone contract offered by the bank and, ultimately, the store of value choice made by consumers. In other words, the issuance of a CBDC may affect both, the demand for cash as well as bank intermediation.

Consider, again, the reference CBDC case in which $f > f^{DC}$, $r^{DC} = 0$, and there are no binding limits on CBDC supply. Then, the threshold for q above which a consumer prefers to hold public money is no longer given by $\tilde{q}$ since now it depends on f^{DC} rather than on f (recall expression 13). We find that $\tilde{\tilde{q}} < \tilde{q}$, where $\tilde{\tilde{q}}$ is the threshold with CBDC. Proposition 5 summarizes the main implications of this result.

Proposition 5: *Assume* $\bar{q} < \hat{\hat{q}}$, *so that banks offer a run-prone deposit contract, and* $f > f^{DC}$. *Then, the introduction of a CBDC leads to a decline in the threshold above which consumers prefer to hold public money* ($\tilde{\tilde{q}} < \tilde{q}$). *The effect is: (i) an increase in the demand for public money,* M_0, *(ii) a decline in bank deposits,* D_0, *and in the average belief of depositors,* $\bar{q}$, *(iii) a decrease in reserves and long-term lending, and (iv) a reduction in the share of reserves in the bank's portfolio,* $\frac{y}{D_0}$.

Intuitively, the introduction of a superior public storage technology leads to an increase in the fraction of consumers who hold public money. That is, there is a positive fraction of consumers who switch from bank deposits to CBDC. The resulting decline in bank deposit funding is proportional to the magnitude of the reduction in the threshold above which consumers prefer to hold public money. The corresponding decrease in long-term lending is less than proportional (i.e., increased maturity transformation); remaining depositors are - on average - more optimistic about bank stability and, hence, the representative bank optimally increases the share of long-term lending.

3.5.3 Efficiency and redistributive considerations

What are the efficiency and redistributive implications of augmenting the baseline model with heterogeneous beliefs about the probability of a bank run? And those of introducing CBDC in the model? This section addresses these questions assuming that the optimal deposit contract is run-prone and the only difference between CBDC and cash is given by $f > f^{DC}$ (i.e., no binding limits on CBDC supply and $r^{DC} = 0$).

Figure 3.7a illustrates the solution to the bank's problem in the c_1^B - c_2^B diagram for the baseline model (point a), the model (point b), and the model with CBDC (point c). As the incentive compatibility constraint has to hold, each of the three points lie to the left of the 45° line.

For the bank, the introduction of heterogeneous beliefs about bank stability results in disintermediation and, thus, a reduction of the feasibility set of depositors (the resource constraint shifts to the left). A certain proportion of consumers opts for holding cash instead of deposits based on their perception of bank instability rather than on objective risk-return considerations.

The introduction of CBDC also leads to a reduction of depositors feasibility set. By making public money holdings more attractive, it leads to an increase in aggregate demand for public money and, thus, amplifies the market distortion induced by heterogeneous beliefs.

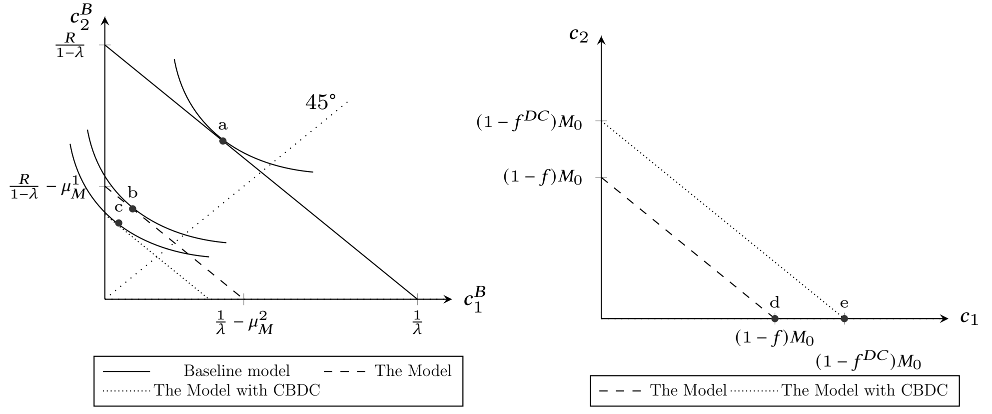
Qualitatively, both modifications have the same implications since the origin of the efficiency loss compared to the baseline model is the same (i.e., incomplete information). In both, the proportion of consumers that opts for holding public money rather than bank deposits increases. Consequently, long-term lending decreases but less than proportionally relative to bank funding as the bank optimally re-balances its asset portfolio towards more productive investment.

Quantitatively, the magnitude of the efficiency loss due to disintermediation may differ. The size of the efficiency loss induced by augmenting the baseline model with heterogeneous beliefs about bank stability is determined by constants $\mu_M^1 = \frac{M_0 R}{1-\lambda}$ and $\mu_M^2 = \frac{M_0}{\lambda}$. Not surprisingly, the efficiency loss is increasing in the return on long-term lending, R, and in public money holdings, M_0. [17] The additional impact on the feasibility set triggered by the model with CBDC is proportional to the difference between f and f^{DC}.

For public money holders, the introduction of CBDC expands the feasibility set, as illustrated in Figure 3.7b. Those consumers that already opted for cash due to their pessimistic beliefs about bank stability now incur lower storage costs. Their consumption bundle shifts from point d to point e.

[17] Note that the value of constants μ_M^1 and μ_M^2 depends on public money holdings, M_0, which depend on cash storage costs f.

Figure 3.7: Feasibility set and optimal consumption



(a) Depositors

(b) Public money holders

With regards to the redistributive implications of CBDC, on the one hand it is clear that those consumers who switch from cash to CBDC are better-off as they benefit from lower storage costs. On the other hand, the impact on all other consumers is more uncertain and depends on how their beliefs compare to the true probability of a bank run.

Suppose that the mean of the distribution of beliefs, $E[q_i]$, equals the true probability of a bank run; an application of the "wisdom of the crowds" (Ray, 2006). In that case all other consumers are worse off due to CBDC. Depositors are worse-off since the deposit contract that is offered to them is further away from the true optimal deposit contract (i.e., the one that solves the bank's problem for the true probability of the bank run equilibrium). Also those consumers who now opt for holding public money (rather than deposits) are worse-off as their shift attends to a change in their subjective perceptions about bank stability rather than to objective risk - return considerations. In other words, bank disintermediation is certainly inefficient.[18]

3.6 Conclusion

This paper develops a banking model a la Diamond and Dybvig (1983) with public money as a store of value and heterogeneous beliefs about bank stability. The assumption of heterogeneous beliefs allows to rationalize how different consumers choose between bank deposits and cash holdings, which are safe but subject to storage costs. Our model accounts for the key empirical observations on public money as a store of

[18] If the true probability of a bank run is sufficiently high and higher than the mean of the distribution of beliefs, those consumers who switch from bank deposits to CBDC may be better-off based on objective risk-return considerations. If the true probability of a bank run is sufficiently low and lower than the mean of the distribution of beliefs, bank depositors may objectively be better-off due to CBDC since the deposit contract that is offered to them is closer to the true optimal deposit contract.

value and is consistent with empirical findings highlighted in the behavioral finance literature.

According to the model, the introduction of CBDC as a store of value implies a trade-off. On the one hand, and due to its technological superiority, the efficiency of holding public money increases and those consumers who were already holding cash are better off. On the other hand, it amplifies the distortion induced by heterogeneous beliefs about bank stability and leads to a certain degree of bank disintermediation. While in absolute terms bank funding and lending decline at the expense of an increase in public money holdings, in relative terms maturity transformation increases. The reason is that remaining depositors are, on average, more optimistic about bank stability, so banks optimally re-balance their asset portfolio. By adequately calibrating CBDC remuneration and quantity limits, the competent authority can determine whether consumers prefer cash or CBDC and to what extent CBDC is used as a store of value.

Our analysis hints at additional considerations that are important for understanding the implications of introducing a CBDC as a store of value but which are beyond the scope of this paper. We show how perceived bank stability affects demand for public money as a store of value. Throughout the analysis, we assume no endogenous feedback effects of bank's portfolio choices on the probability of a bank run. Future work may endogenize the probability of a bank run, possibly by adopting a global-games approach as in Goldstein and Pauzner (2005) or by following the approach of Rochet and Vives (2004). Our analysis could also be extended to include regulatory or policy options that may affect the demand for public money as a store of value and its implications for banks, such as central bank lending or deposit insurance.

3.7 Appendix A: proofs

3.7.1 Proposition 1

For any value for q, the deposit contract with the lowest possible expected return offered by the bank is a run-proof contract that includes no long-term lending ($x = 0$). In that case, Problem (A) reduces to

$$\max_y \lambda u(\frac{y}{\lambda}) + (1-\lambda)u(\frac{y^l}{1-\lambda}),$$

subject to

$$y + y^l = D_0, \tag{3.11}$$
$$0 \leq c_1^B \leq c_2^B. \tag{3.12}$$

The first order condition that characterizes the solution is given by

$$u'(\frac{y^l}{1-\lambda}) - u'(\frac{D_0 - y^l}{\lambda}) = 0. \tag{3.13}$$

This defines $y^l = (1-\lambda)D_0$ and $y = \lambda D_0$.

If a single atomistic consumer with endowment ϵ invests in deposits, her expected utility is

$$E[U^{deposit}] = u\Big[\epsilon\Big].$$

If she instead holds cash, her expected utility is

$$E[U^{cash}] = u\Big[\epsilon(1-f)\Big].$$

Since $f > 0$, she will not hold any cash. Any chosen deposit contract yields at least as high expected returns and, thus, there is never any demand for cash.

3.7.2 Corollary 1

The proof consists of three parts: i) the run-proof solution to Problem (A); ii) the run-prone solution to Problem (A); iii) the conditions under which each contract is offered. We will use that there is no cash demand (Proposition 1), but we include deposit funding D_0 in the bank's problem as it is useful for the proof of Corollary 2.

First, an optimal run-proof contract solves Problem (A) where the indicator function is zero and subject to an additional constraint that allows only for run-proof contracts:

$$y^l = c_1^B - y. \tag{3.14}$$

Let η_E and η_L be the Lagrange multipliers on constraints (3.2) and (3.3) of Problem (A), respectively, and η_R the multiplier on the additional constraint (3.14). Let γ and β be the multipliers on the non-negativity constraints for x and y^l, respectively.

When first ignoring the incentive compatibility constraint, the first order conditions that characterize the solution are given by

$$c_1^B : \lambda u'(c_1^B) - \eta_E \lambda - \eta_R = 0, \tag{3.15}$$
$$c_2^B : (1-\lambda)u'(c_2^B) - \eta_L(1-\lambda) = 0, \tag{3.16}$$
$$x : -\eta_E + \eta_L R - \eta_R + \gamma = 0, \tag{3.17}$$
$$y^l : -\eta_E + \eta_L + \beta = 0. \tag{3.18}$$

Rewriting (3.15) gives

$$\eta_E = u'(c_1^B) - \frac{1}{\lambda}\eta_R,$$

and rewriting (3.16) gives

$$\eta_L = u'(c_2^B).$$

Since $y^l > 0$ must hold for any run-proof contract, $\beta = 0$ and thus expression (3.18) implies that $\eta_L = \eta_E$. This allows to solve for η_R as

$$\eta_R = \lambda\Big[u'(c_1^B) - u'(c_2^B)\Big].$$

Substituting for η_E, η_L, and η_R into expression (3.17) gives the following optimality condition

$$u'(c_1^B) = u'(c_2^B)\frac{R-1+\lambda}{\lambda}. \tag{3.19}$$

Since $R > 1$ and u is concave, the optimal run-proof contract is indeed incentive compatible.

The optimality condition (3.19) is restated as

$$u'\Big[\frac{y}{\lambda}\Big] = \frac{R-1+\lambda}{\lambda}u'\Big[\frac{R(D_0-y)}{1-\lambda} - (R-1)\frac{y}{\lambda}\Big], \tag{3.20}$$

and when $D_0 = 1$ this results in a solution $y = y^{proof}$. We denote the resulting expected utility of a single consumer with endowment ϵ who deposits with the bank as

$$E[U^{proof}] = \lambda u\Big[\frac{\epsilon}{D_0}\frac{y^{proof}}{\lambda}\Big] + (1-\lambda)u\Big[\frac{\epsilon}{D_0}\Big[\frac{R(D_0-y^{proof})}{1-\lambda} - (R-1)\frac{y^{proof}}{\lambda}\Big]\Big].$$

Second, an optimal run-prone contract solves Problem (A) where the indicator function is equal to one. Let η_E and η_L be the Lagrange multipliers on constraints (3.2) and (3.3) of Problem (A), and let γ and β be the multipliers on the non-negativity constraints for x and y^l, respectively. When first ignoring the incentive compatibility constraint, the first order conditions that characterize the solution are given by

$$c_1^B : (1-q)\lambda u'(c_1^B) + q\lambda u'(c_R^B) - \eta_E\lambda = 0, \tag{3.21}$$
$$c_2^B : (1-q)(1-\lambda)u'(c_2^B) + q(1-\lambda)u'(c_R^B) - \eta_L(1-\lambda) = 0, \tag{3.22}$$
$$x : -qRu'(c_R^B) - \eta_E + \eta_L R + \gamma = 0, \tag{3.23}$$
$$y^l : -\eta_E + \eta_L + \beta = 0. \tag{3.24}$$

We will first show that any optimal run-prone contract has no excess liquidity. To do so, suppose the opposite, so that $y^l > 0$. Then $\beta = 0$ must hold. From (3.23) and (3.24), it follows that $\eta_E = \eta_L = \frac{qR}{R-1}u'(c_R^B)$, while from (3.22) we find that $\eta_L = (1-q)u'(c_2^B) + qu'(c_R^B)$. Combining these two expressions for η_L gives:

$$(R-1)(1-q)u'(c_2^B) = qu'(c_R^B).$$

From expressions (3.21) and (3.22), we also find that $c_1^B = c_2^B$. Thus, this implies the following relationship between c_1^B, c_2^B and c_R^B

$$c_1^B = c_2^B = Ac_R^B,$$

where the constant A equals

$$A = [\frac{q}{(R-1)(1-q)}]^{-\frac{1}{\gamma}} > 0.$$

We can now rewrite the objective function as

$$max_{c_1^B}(1-q)u(c_1^B) + qu(\frac{1}{A}c_1^B).$$

At the optimum, the following first order condition must apply

$$(1-q)u'(c_1^B) + q\frac{1}{A}u'(\frac{1}{A}c_1^B) = 0,$$

which is never satisfied since $A > 0$. Thus, we must have that $y^l = 0$ at the solution. Now, using that $y^l = 0$, the first order conditions reduce to

$$c_1^B : (1-q)\lambda u'(c_1^B) + q\lambda u'(c_R^B) - \eta_E\lambda = 0, \tag{3.25}$$
$$c_2^B : (1-q)(1-\lambda)u'(c_2^B) - \eta_L(1-\lambda) = 0, \tag{3.26}$$
$$x : -qRu'(c_R^B) - \eta_E + \eta_L R = 0. \tag{3.27}$$

Rewriting expression (3.25) gives

$$\eta_E = (1-q)u'(c_1^B) + qu'(c_R^B),$$

and rewriting expression (3.26) gives

$$\eta_L = (1-q)u'(c_2^B).$$

Substituting for η_E and η_L into expression (3.27) gives

$$-qu'(c_R^B) - (1-q)u'(c_1^B) + (1-q)Ru'(c_2^B) = 0,$$

which can be rewritten into the optimality condition

$$(1-q)\Big[Ru'(c_2^B) - u'(c_1^B)\Big] = qu'(c_R^B). \tag{3.28}$$

When $q = 0$, and since $R > 1$, the contract that satisfies the optimality condition (3.28) is incentive compatible as $u'(c_2^B) < u'(c_1^B)$ and hence $c_2^B > c_1^B$. When $q > 0$, the optimality condition (3.28) is restated as

$$u'(\frac{y}{\lambda}) = Ru'(\frac{R(D_0 - y)}{1-\lambda}) - \frac{q}{1-q}u'(y).$$

Using the assumed utility function, y is solved for as

$$y = \frac{\frac{RD_0}{1-\lambda}}{R^{\frac{1}{\gamma}}\left[\frac{1}{\lambda^{-\gamma}} + \frac{q}{1-q}\right]^{-\frac{1}{\gamma}} + \frac{R}{1-\lambda}}. \tag{3.29}$$

It follows that $\frac{\partial y}{\partial q} > 0$, and so $\frac{\partial c_1^B}{\partial q} > 0$ and $\frac{\partial c_2^B}{\partial q} < 0$. Thus, a critical bound q' exists such that when $q > q'$ it holds that the solution to the optimality condition (3.28) includes $c_2^B < c_1^B$ and when $q < q'$ it holds that $c_2^B > c_1^B$.

Since the solution to the optimality condition (3.28) when $q > q'$ contradicts with the incentive compatibility constraint, it cannot be an equilibrium contract. Instead, if $q > q'$ and the bank wishes to offer a run-prone contract, the best incentive compatible run-prone contract it could offer is the solution to optimality condition (3.28) when $y^* = y|_{c_1^B = c_2^B}$: the run-prone incentive compatible contract with the highest early repayment. Utility under this run prone contract with $y = y^*$ of a single consumer who deposits her endowment ϵ with the bank is given as

$$E[U^{prone}|y = y^*] = (1-q)\left[\lambda u(\frac{\epsilon}{D_0}\frac{y^*}{\lambda}) + (1-\lambda)u(\frac{\epsilon}{D_0}\frac{R(D_0 - y^*)}{1-\lambda}\right] + qu(\frac{\epsilon}{D_0}y^*). \tag{3.30}$$

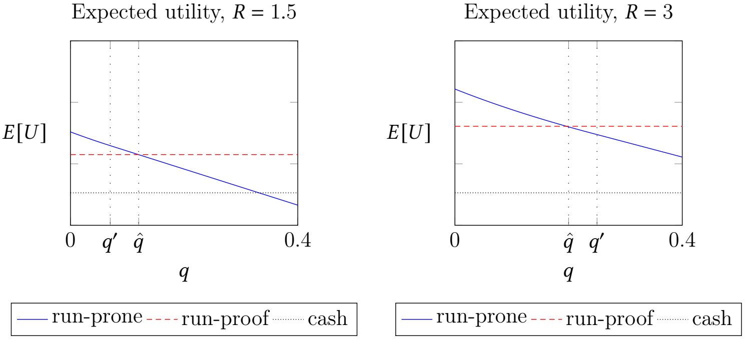
Finally, we solve for the unique equilibrium contract. From expressions (3.29) and (3.30) it follows that an optimal run-prone contract is such that $\frac{\partial U^{prone}}{\partial q} < 0$, both when $q < q'$ and when $q > q'$. Thus, we can derive a second critical bound $\hat{q}$ such that when $q = \hat{q}$ the utility obtained from the run-prone deposit contract is equal to the utility obtained from the run-proof contract. The cut-off value $\hat{q}$ is equal to

$$\hat{q} = \frac{\lambda u(\frac{1}{D_0}\frac{y}{\lambda}) + (1-\lambda)u(\frac{1}{D_0}\frac{R(D_0-y)}{1-\lambda})}{\lambda u(\frac{1}{D_0}\frac{y}{\lambda}) + (1-\lambda)u(\frac{1}{D_0}\frac{R(D_0-y)}{1-\lambda}) - u(\frac{1}{D_0}y)} - \dots$$
$$\frac{\lambda u\left[\frac{1}{D_0}\frac{y^{proof}}{\lambda}\right] + (1-\lambda)u\left[\frac{1}{D_0}\left[\frac{R(D_0-y^{proof})}{1-\lambda} - (R-1)\frac{y^{proof}}{\lambda}\right]\right]}{\lambda u(\frac{1}{D_0}\frac{y}{\lambda}) + (1-\lambda)u(\frac{1}{D_0}\frac{R(D_0-y)}{1-\lambda}) - u(\frac{1}{D_0}y)}.$$

where when $\hat{q} < q'$, y is the solution to optimality condition (3.28) using $q = \hat{q}$, and when $\hat{q} > q'$, y is the solution to (3.28) using $q = q'$ and $c_1^B = c_2^B$.

Figure (3.8) illustrates the relative cut-off values by plotting the simulated expected utility of each type of contract as a function of q, using that $D_0 = 1$ and under different values for R.

Figure 3.8: Optimal deposit contract



The simulation uses $\lambda = 0.3$, $f = 0.2$, and $\gamma = 1.5$.

3.7.3 Proposition 2

The run-prone contract offered by the bank satisfies expression (3.9). A consumer's expected utility when depositing its endowment ϵ with the bank depends on its belief q_i and equals

$$E[U^{deposits}] = (1-q_i)\Big[\lambda u(\frac{\epsilon}{D_0}c_1^B) + (1-\lambda)u(\frac{\epsilon}{D_0}c_2^B)\Big] + q_i u(\frac{\epsilon}{D_0}c_R^B).$$

If a consumer instead holds cash, her expected utility is

$$E[U^{cash}] = u\Big[\epsilon(1-f)\Big].$$

From here it follows that positive cash demand requires $E[U^{deposits}] < E[U^{cash}]$, so when

$$q_i > \frac{\lambda u(\frac{c_1^B}{D_0}) + (1-\lambda)u(\frac{c_2^B}{D_0}) - u(1-f)}{\lambda u(\frac{c_1^B}{D_0}) + (1-\lambda)u(\frac{c_2^B}{D_0}) - u(\frac{c_R^B}{D_0})} = \tilde{q}.$$

3.7.4 Proposition 3

Cash demand equals

$$M_0 = \int_{\tilde{q}}^{1} f(q,\sigma)dq.$$

First, when σ increases, all else equal, clearly cash demand increases. Next, cash demand also depends on the bound $\tilde{q}$, given as

$$\tilde{q} = \frac{\lambda u(\frac{c_1^B}{D_0}) + (1-\lambda)u(\frac{c_2^B}{D_0}) - u(1-f)}{\lambda u(\frac{c_1^B}{D_0}) + (1-\lambda)u(\frac{c_2^B}{D_0}) - u(\frac{c_R^B}{D_0})}.$$

At lower deposit funding D_0, the average belief of bank depositors $\bar{q}$ decreases as only relatively optimistic depositors remain, or $\frac{\partial \bar{q}}{\partial \sigma} < 0$. This implies that the optimal $\frac{y}{D_0}$, as determined by expression (3.29) with $q = \bar{q}$, decreases (so $\frac{\partial \frac{y}{D_0}}{\partial \sigma} < 0$), and thus the bound $\tilde{q}$ is affected:

$$\frac{\partial \tilde{q}}{\partial \sigma} = \frac{\partial \frac{y}{D_0}}{\partial \sigma} u'(\frac{c_R^B}{D_0}) \frac{\left[\lambda u(\frac{c_1^B}{D_0}) + (1-\lambda) u(\frac{c_2^B}{D_0}) - u(1-f)\right] - \frac{\bar{q}}{1-\bar{q}}\left[u(1-f) - u(\frac{c_R^B}{D_0})\right]}{\left[\lambda u(\frac{c_1^B}{D_0}) + (1-\lambda) u(\frac{c_2^B}{D_0}) - u(\frac{c_R^B}{D_0})\right]^2}.$$

The sign of this expression depends on $\bar{q}$. When $\bar{q} < \tilde{q}$ it is negative, and when $\bar{q} > \tilde{q}$ it is positive. Clearly, since only consumers with $q_i < \tilde{q}$ hold bank deposits, it must be that $\bar{q} < \tilde{q}$ and $\frac{\partial \tilde{q}}{\partial \sigma} < 0$: an increase in σ decreases the bound $\tilde{q}$, further increasing cash demand.

3.7.5 Proposition 5

Consider $\tilde{q}$:

$$\tilde{q} = \frac{\lambda u(\frac{c_1^B}{D_0}) + (1-\lambda) u(\frac{c_2^B}{D_0}) - u(1-f)}{\lambda u(\frac{c_1^B}{D_0}) + (1-\lambda) u(\frac{c_2^B}{D_0}) - u(\frac{c_R^B}{D_0})}.$$

Holding bank pay-outs and deposits constant, the impact of cash storage cost equals

$$\frac{\partial \tilde{q}}{\partial f} = \frac{u'(1-f)}{\lambda u(c_1^B) + (1-\lambda) u(c_2^B) - u(c_R^B)} > 0.$$

Thus, a decrease in cash storage cost, all else equal, results in a decrease of $\tilde{q}$.

Next, a lower $\tilde{q}$ implies an increase in M_0 and, thus, a decrease in D_0. Lower deposit funding not only implies lower reserves and lower long-term lending, but also a lower share of reserves in the bank's portfolio as $\bar{q}$ decreases (similar to in Proposition 3).

3.8 Appendix B: a mixed portfolio

3.8.1 Baseline model

Let c_E denote the consumption of impatient depositors (who consume at $t = 1$), c_L the consumption of patient depositors (who consume at $t = 1$ or $t = 2$) in case of no bank run, c_R the consumption in case of a bank run. Consider a single atomistic consumer who considers holding a share $d_0 \in [0, 1]$ of her endowment ϵ as deposits and a share $(1 - d_0)$ as cash. Her portfolio allocation problem, given a run-prone deposit contract, is given by

$$\max_{d_0} (1-q)\left[\lambda u(c_E) + (1-\lambda) u(c_L)\right] + q u(c_R),$$

subject to

$$c_E = d_0 \epsilon \frac{c_1^B}{D_0} + (1-d_0)\epsilon(1-f), \qquad c_L = d_0 \epsilon \frac{c_2^B}{D_0} + (1-d_0)\epsilon(1-f),$$

$$c_R = d_0 \epsilon \frac{c_R^B}{D_0} + (1-d_0)\epsilon(1-f).$$

The first order condition for a given deposit contract equals

$$\lambda u'(c_E)\Big[\epsilon(\frac{c_1^B}{D_0}-(1-f))\Big]+(1-\lambda)u'(c_L)\Big[\epsilon(\frac{c_2^B}{D_0}-(1-f))\Big]+...$$
$$q\Big[u'(c_R)\Big[\epsilon(\frac{c_R^B}{D_0}-(1-f))\Big]-\lambda u'(c_E)\Big[\epsilon(\frac{c_1^B}{D_0}-(1-f))\Big]-...$$
$$(1-\lambda)u'(c_L)\Big[\epsilon(\frac{c_2^B}{D_0}-(1-f))\Big]\Big]=0. \tag{3.31}$$

Expression 3.31 can result in either corner solution or an interior choice for d_0, depending on q. Certainly, when q is sufficiently low, consumers only hold deposits.

However, the deposit contract is affected by deposit funding. The bank's problem in the version of the baseline model that allows for mixed portfolios is given by

$$\max_{c_1^B,c_2^B,c_R^B,x,y,y^l}(1-q\mathbb{1}_{\bar{\lambda}<1})\Big[\lambda u(c_E)+(1-\lambda)u(c_L)\Big]+q\mathbb{1}_{\bar{\lambda}<1}u(c_R),$$

subject to

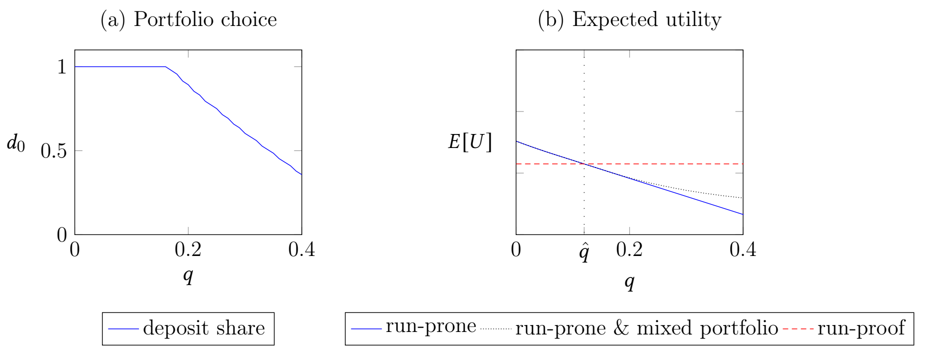
$$x+y+y^l=D_0, \qquad \lambda c_1^B=y,$$
$$(1-\lambda)c_2^B=Rx+y^l, \qquad c_R^B=y+y^l,$$
$$0\le c_1^B\le c_2^B, \qquad c_1^B,c_2^B,x,y,y^l\ge 0,$$

where

$$c_E=c_1^B+(1-f)(1-D_0), \tag{3.32}$$
$$c_L=c_2^B+(1-f)(1-D_0), \tag{3.33}$$
$$c_R=c_R^B+(1-f)(1-D_0), \tag{3.34}$$
$$\bar{\lambda}=\frac{y+y^l}{c_1^B}. \tag{3.35}$$

At an intermediate q, consumers may opt for some cash holdings (a mixed portfolio) in which case aggregate deposit funding D_0 would be lower and the bank could optimally offer adjusted payoffs. In other words, in equilibrium the consumer's problem and the bank's problem are simultaneously determined. Panel (a) of Figure (3.9) uses a simulation to illustrate the run-prone contract consumers may choose for a mixed portfolio at an intermediate q. Panel (b) confirms that at some intermediate q a mixed portfolio results in a higher expected utility, given that the contract is run-prone. Panel (b) also shows that, under this calibration, the run-proof contract is always preferred over a linear combination of the run-prone contract and cash holdings and. That is, in this case, the same results apply regardless of whether mixed portfolios are allowed or not.

Figure 3.9: Baseline model mixed portfolio



The simulation uses $R = 1.5$, $\lambda = 0.3$, $f = 0.2$, and $\gamma = 1.5$.

3.8.2 The model

Consider a single atomistic consumer who considers holding a share d_0 of her endowment ϵ as deposits and a share $(1 - d_0)$ as cash. Her portfolio allocation problem given a run-prone contract depends on her belief, and is given by

$$\max_{d_0}(1 - q_i)\Big[\lambda u(c_E) + (1 - \lambda)u(c_L)\Big] + q_i u(c_R),$$

subject to

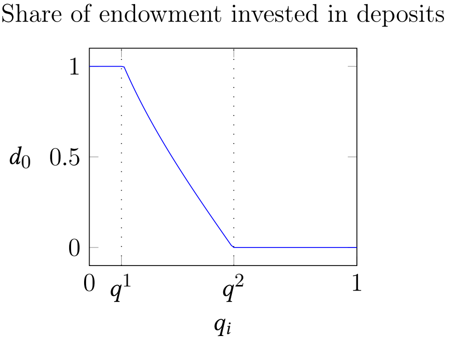
$$c_E = d_0\epsilon\frac{c_1^B}{D_0} + (1 - d_0)\epsilon(1 - f), \qquad c_L = d_0\epsilon\frac{c_2^B}{D_0} + (1 - d_0)\epsilon(1 - f),$$
$$c_R = d_0\epsilon\frac{c_R^B}{D_0} + (1 - d_0)\epsilon(1 - f).$$

The first order condition equals

$$\lambda u'(c_E)\Big[\epsilon(\frac{c_1^B}{D_0} - (1 - f))\Big] + (1 - \lambda)u'(c_L)\Big[\epsilon(\frac{c_2^B}{D_0} - (1 - f))\Big] + \ldots$$
$$q_i\Big[u'(c_R)\Big[\epsilon(\frac{c_R^B}{D_0} - (1 - f))\Big] - \lambda u'(c_E)\Big[\epsilon(\frac{c_1^B}{D_0} - (1 - f))\Big] - \ldots$$
$$(1 - \lambda)u'(c_L)\Big[\epsilon(\frac{c_2^B}{D_0} - (1 - f))\Big]\Big] = 0. \tag{3.36}$$

The first term is positive and increasing in d_0, whereas the second term is negative and decreasing in d_0. Thus, a q^1 exists such that when $q_i < q^1$ it follows that $d_0 = 1$, a $q^2 > q^1$ such that when $q^1 < q_i < q^2$ it follows that $0 < d_0 < 1$ where d_0 solves optimality condition (3.36), and when $q_i > q^2$ it follows that $d_0 = 0$. Figure (3.10) uses a simulation to illustrate how consumers with an interior belief choose a mixed portfolio.

Figure 3.10: Mixed portfolio



The simulation uses $R = 1.5$, $\lambda = 0.3$, $f = 0.2$, $\gamma = 1.5$, $D_0 = 0.7$, $y = 0.37$, and $\bar{q} = 0.05$.

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Samenvatting (summary in dutch)

Dit proefschrift gaat over het verleden, het heden, en de toekomst van de euro. De eerste twee hoofdstukken bestuderen kwetsbaarheden van de euro en hoe de stabiliteit en veerkracht van de gemeenschappelijke munt gewaarborgd kan blijven. Het laatste hoofdstuk bestudeert de gevolgen van een recente euro-ontwikkeling, de mogelijke invoering van een digitale euro, voor commerciële banken.

In het eerste hoofdstuk wordt een politiek-economisch model vormgegeven om de oorzaken en gevolgen van monetaire eenwording tussen landen met een verschillende institutionele kwaliteit te analyseren. Het creëren van een heterogene monetaire unie leidt tot snelle marktaanpassingen waarbij de institutionele verschillen blijven bestaan, zoals binnen de eurozone is gebeurd. Na een monetaire eenwording weerspiegelt de gemeenschappelijke wisselkoers de economieën van alle lidstaten samengenomen. Hierdoor houdt de wisselkoers een revaluatie in voor landen met zwakkere instellingen die een zwakkere munt hadden, en een devaluatie voor landen die een sterkere munt hadden. Deze re- en devaluaties van de wisselkoers voor landen met zwakkere en sterkere economieën respectievelijk hebben blijvende herverdelingseffecten tot gevolg. De productie- en begrotingscapaciteit in landen met sterkere instellingen verbetert door een concurrentievoordeel als gevolg van de devaluatie. In landen met zwakkere instellingen worden de overheidsuitgaven daarentegen niet meer beperkt door wisselkoersonzekerheid, terwijl hun begrotingscapaciteit door de wisselkoers revaluatie juist afneemt. Bedrijven en werknemers in sterkere landen profiteren van een productieve impuls, terwijl spaarders in zwakkere landen profiteren van een sterkere en stabielere munt. Omdat zwakkere landen hun munt niet meer kunnen devalueren in crisistijd vereist de stabiliteit van een heterogene monetaire unie een herbalancerings-mechanisme dat de aanhoudende verschuiving in begrotingscapaciteit compenseert, zoals overdrachten van het sterkere land aan het zwakkere land.

Het tweede hoofdstuk bestudeert de vraag naar en het aanbod van financiële en reële veiligheid in een monetaire unie, zoals het aanbod van veilige staatsobligaties en gezondheidszorg respectievelijk. Dit hoofdstuk biedt een macro-financieel model van een monetaire unie om de veiligheidsvoordelen van (gemeenschappelijk) begrotingsbeleid te bestuderen. In een Nash-evenwicht voorzien nationale overheden in een lagere hoeveelheid financiële en reële veiligheid dan waar een 'social planner' voor kiest. Hierdoor moeten huishoudens te veel op de particuliere sector vertrouwen om aan hun vraag naar veiligheid te voldoen. Dit komt doordat de overheid bij haar uitgavenkeuze alleen rekening houdt met de veiligheidsbaten en belastingkosten voor binnenlandse huishoudens. Echter, overheidsuitgaven hebben ook een positief effect voor buitenlandse spaarders doordat het totale veiligheidsaanbod in de monetaire unie toeneemt. Een social planner daarentegen houdt wel rekening met de kosten en baten voor alle huishoudens in de monetaire unie. Een gemeenschappelijk begrotingsbeleid kan leiden tot een Pareto-verbetering door voor het lager-dan-optimale nationale veiligheidsaanbod te compenseren. Dit theoretische resultaat vereist geen feitelijke begrotingsoverdrachten, zoals bestudeerd in het eerste hoofdstuk van dit proefschrift, en geldt ook wanneer sommige lidstaten in gebreke kunnen blijven.

Het derde hoofdstuk bestudeert de implicaties van Central Bank Digital Currencies (CBDCs). In dit hoofdstuk wordt het klassieke bankmodel van Diamond en Dybvig (1987) uitgebreid met overheidsgeld als waardeopslag en heterogene opvattingen over de kans op een bankrun. De uitgifte van een CBDC, die een aantrekkelijkere waardeopslag is dan contant geld, heeft een uitruil tot gevolg. Enerzijds profiteren consumenten die reeds contant geld als waardeopslag aanhielden van de vervanging van contant geld door CBDC. Anderzijds leidt de uitgifte van CBDC tot de disintermediatie van banken omdat het de subjectieve kans op een bankrun waarbij consumenten liever overheidsgeld dan bankdeposito's aanhouden verlaagt. Opvallend is dat, hoewel een CBDC bankdeposito's gedeeltelijk vervangt, de kredietverlening door banken minder dan evenredig afneemt. Dit komt doordat de resterende depositohouders gemiddeld optimistischer zijn over de stabiliteit van de banken en dus herschikken banken hun activa. In absolute termen leidt de uitgifte van een CBDC dus tot een daling van bankfinanciering en -kredietverlening, maar in relatieve termen vertaalt zij zich in meer looptijdtransformatie door banken. Door een adequate kalibratie van een CBDC-vergoeding en kwantitatieve limieten kan de toezichthouder de mate van uitruil bepalen door de keuze tussen contant geld, CBDC, of bankdeposito's als waardeopslag te beinvloeden.

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The euro as a diverse monetary union
This chapter is co-authored with Enrico Perotti from the University of Amsterdam

The safety demand and common fiscal policy in a monetary union
This chapter is single-authored

Public money as a store of value, heterogeneous beliefs, and banks: Implications of CBDC
This chapter is co-authored with Manuel Muñoz from the European Central Bank

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