The Common Currency Channel of Risk Sharing*

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I propose a new channel of international risk sharing: the common currency channel. I show theoretically that the central bank of a currency union can use the common currency to insure member countries against consumption risk from idiosyncratic productivity shocks. A trade-off between risk-sharing and moral hazard emerges: a central bank which enables risk sharing induces countries to free ride on each other's production efforts. I study this trade-off and derive rules for a central bank striking the optimal balance between insurance and incentives. Monetary policy determines current account imbalances that are financed through the central bank. Optimal policy is contingent on the realization of aggregate production. The central bank should lower its policy rate in response to a decrease in aggregate production to provide insurance through the common currency. Revisiting European Central Bank policies during the Eurocrisis between 2008 and 2014, I interpret the buildup of TARGET2 balances as risk sharing through the common currency. I find that this channel accounts for up to 60% of risk sharing among Eurozone countries in the early stages of the Eurocrisis. I conclude that the common currency can be a substitute for risk sharing through fiscal integration.

JEL Classification: E2, E58, F32, F45

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1 Introduction

The classical doctrine of the Lender of Last Resort (LOLR) holds that a central bank should lend to 'illiquid but solvent' banks without limit, against good collateral and at high rates.[1] However, there is evidence that during crisis times, central banks are not lending against good collateral, and not at high rates. During the Eurocrisis from 2008 to 2014, the European Central Bank (ECB) consistently reduced its collateral requirements and lowered its refinancing conditions for commercial banks from countries hit by crisis. In this paper, I show that a central bank may find it optimal to deviate from the LOLR principles when union members are hit by asymmetric shocks. I argue that the central bank can use the common currency to insure member countries against the adverse impact of heterogeneous productivity shocks on consumption. The amount of risk sharing depends on the real rate at which the central bank refinances net currency flows between member countries. The central bank controls this rate through its choice of collateral requirements in monetary operations. I empirically demonstrate that the ECB was providing insurance through the common currency. Linking the buildup of TARGET balances to the finance of current account deficits, I find that the common currency channel provided up to 60% of total risk sharing among Eurozone countries at the early stages of the Eurocrisis.

The informal description of risk sharing through a common currency goes back to Mundell (1973). My contribution is to provide a theoretical framework which allows me to formally present the common currency channel of risk sharing. Within this framework, I derive rules for a central bank operating this channel. Finally, I use the model to interpret ECB policies during the Eurocrisis as risk sharing through the common currency. In my model, a currency union consists of a finite number of regions or countries. Each region has access to two production technologies. A safe asset delivers a fixed amount of output while a risky production technology delivers stochastic output. Regional firms operate the risky technology. Their output is determined by unobserved regional banker effort and a regional productivity shock. The central bank issues the common currency to regional banks against the safe asset before productivity shocks are realized. Currency in the model is a non-contingent nominal deposit contract. The regional banker forwards the currency to regional firms. Regional firms use the currency to hire labor which is provided by regional consumers. Consumers use the currency to buy output from firms in all regions of the currency union. This implies that the common currency insures regional consumers against the consumption risk arising from regional productivity shocks. The absence of exchange rates means that regional consumers hold claims against all firms in the currency union. This is the insurance value of the common currency.

The absence of flexible exchange rates between members of a currency union leads to currency flows between member countries with different regional production levels. More specifically, countries which produce less than the average country will suffer from net money outflows. Countries which produce more than the average country will receive net money inflows. The real value of these net money flows is given by the trade deficits between the different member regions. Net money flows appear at the central bank which operates the unified payment

[1] See Bagehot (1873) and, more recently, Goodhart (1999).

system of the currency union. The central bank's policy instrument is the real rate at which it refinances net money flows between regions. More specifically, the central bank determines how many units of the safe asset it transfers from a deficit region to a surplus region per unit of net money flow. That is, the central bank decides the rate at which it monetizes the safe asset. If the central bank requires a safe asset transfer whose value is equal to the real value of net money flows between regions, then it refinances net money flows 'at market rate'. The resulting allocation is equal to the allocation obtained if each region had issued its own currency. If, however, the central bank requires a safe asset transfer whose value is less than the real value of net money flows between regions, then it refinances net money flows 'below market rate'. This is the channel through which the common currency provides risk sharing. In the model, *overdraft balances* represent the fraction of current account imbalances which are financed through the central bank's provision of common currency below market rates. Overdraft balances are a symptom of risk sharing through the common currency.

I show that the creation of overdraft balances is equivalent to a situation in which the central bank redistributes seigniorage revenue to regions with production levels lower than the union-wide average.[2] The unequal distribution of seigniorage revenue is the channel through which the central bank's operations have real effects. I show that there is an equivalence between monetary policy and fiscal transfers in my model. Any risk-sharing allocation that can be sustained through the common currency can also be sustained through a fiscal authority that taxes overall production in the economy and transfers the proceeds to regions with low production levels. However, I show that due to the moral hazard problem from unobserved banker effort, Arrow security trades would not implement the efficient risk sharing allocation in this economy.

To study optimal monetary policy, I derive the second best risk sharing allocation of the real economy. I show that the central bank which maximizes the expected utility of member regions can implement this allocation through its choice of real refinance rates. Optimal policy is driven by two considerations. First, moral hazard limits the amount of insurance the central bank can optimally provide. If countries are fully insured against the realization of their idiosyncratic production, then regional bankers will be tempted to free-ride on banker efforts in other countries. As all countries try to do the same, overall production in the currency union will be inefficiently low. The central bank prevents this by setting a real refinance rate which implements an agency wedge such that individual countries are partially exposed to the realization of their individual production. Second, optimal monetary policy is determined by aggregate production in the currency union. The central bank optimally announces a policy rate schedule which depends on aggregate production. This schedule implies that in the event of a decrease in aggregate output, the central bank should lower its real refinance rate to provide the optimal amount of insurance through the common currency. This schedule incentivizes regional bankers to exert effort and implements the second best risk sharing allocation. However, the optimal refinance schedule is generally not time consistent. If the central bank lacks commitment, then it is inclined to fully insure regions against negative production shocks ex post. In an extension of the baseline model, I show that an appropriate design of the governing council of the central bank can overcome this commitment problem. More specifically, if any region can veto devia-

[2] Seigniorage revenue is the profit that occurs to the issuer of currency.

tions from the announced policy schedule, then central bank commitment can be restored.

In an empirical application, I revisit the policies taken by the European Central Bank (ECB) during the Eurocrisis between 2008 and 2014. I document that the ECB adjusted its refinancing policies (collateral requirements, maturity of refinance operations, and interest rates) over the course of the Eurocrisis years such that, in absence of other effective risk sharing channels, large TARGET2 balances arose. TARGET2 balances measure claims and liabilities between national banks within the Eurosystem arising from net cross-border payment flows. They are the real-world equivalent of the overdraft balances arising in my model as a result of risk sharing through the common currency. I follow the literature in analyzing the Eurocrisis as a balance-of-payment crisis within a currency union and interpret TARGET2 balances as a mechanism through which the required adjustments to current account deficits by Periphery countries (Greece, Ireland, Italy, Portugal, Spain) have been delayed. As a result, TARGET2 balances cushioned the otherwise even more dramatic reduction in consumption per capita. Using the balance of payment identity, I quantify *TARGET transfers* from current account and TARGET2 balance data. More specifically, I calculate *adjusted current account balances* for each Euro country by considering a counterfactual in which countries with current account deficits reduce these deficits by an amount equal to the increase in their TARGET2 balances. The so obtained TARGET transfers are of substantial size. They amount to 9% of GDP in 2009 and 11% of GDP in 2010 for Greece, to 5.7% of GDP in 2008 and 4.2% of GDP in 2009 for Ireland, and to 9.6% of GDP in 2010 and 5.4% of GDP in 2011 for Portugal. In a next step, I estimate the contribution of these implicit TARGET transfers to risk sharing during the Eurocrisis following the cross-sectional variance decomposition methodology in Asdrubali et al. (1996). This methodology allows to measure the fraction of shocks to GDP which are smoothed through different channels of international risk sharing. Traditional channels of international risk sharing are factor income flows, savings, and international transfers. I find that none of these channels was particularly effective during the Eurocrisis. Instead, I document that TARGET transfers contributed substantially to risk sharing in the early stages of the Eurocrisis in 2008 and 2009. During those years, TARGET transfers explain 60% of risk sharing in the entire sample of Eurozone countries and 80% for Periphery countries. Between 2010 and 2014, TARGET transfers turn out to be dis-smoothing due to decreasing current account deficits, but still imply substantial transfers from Core to Periphery countries.[3]

Risk sharing through the common currency is a possibility in any currency union. The central bank decides at which rate to refinance net money flows between member regions or countries. If it does so below market rates, then it allows for risk sharing through the common currency. However, two conditions need to be fulfilled for the common currency channel to be quantitatively relevant. First, member regions need to suffer from asymmetric productivity shocks. Second, these shocks must not be smoothed through other risk sharing channels. Both conditions were fulfilled during the Eurocrisis. The lack of fiscal integration in the Euro area shifted the burden of risk sharing to the European Central Bank. In the U.S., for example, productivity shocks are generally more symmetric across states, and, most importantly, asymmetric shocks

[3]Core countries are Belgium, Germany, France, Luxembourg, Netherlands, Austria, and Finland. Periphery countries are Greece, Ireland, Italy, Portugal, and Spain (sometimes also referred to as GIIPS).

are smoothed through fiscal transfers or other risk sharing channels. The unique constitution of the Eurozone as a currency union without fiscal integration and imperfectly correlated shocks to national income after 2008 provided the grounds for the empiricial relevance of the common currency channel of risk sharing.

1.1 Related Literature

Risk sharing through a common currency was first informally discussed by Mundell (1973). He argues that a common currency allows to mitigate shocks across countries as it represents a fixed claim against currency union-wide output. Flexible exchange rates inhibit this risk sharing as an adverse shock to a country's production leads to a devaluation of its currency. This devaluation reduces the currency's purchasing power and prevents the country with an adverse shock from drawing on resources of other countries. A corollary from this argument is that a common currency is particularly beneficial for countries with asymmetric business cycle shocks. This is in contrast with the literature on optimum currency areas (OCA) which was pioneered by Mundell (1961) (see Alesina et al. (2002) for an overview).[4] This literature identifies synchronized business cycle movements to be one of the prerequisites for an optimum currency area. The reason is that a common currency implies the loss of independent monetary policy and, in the presence of nominal rigidities, prevents nominal exchange rate adjustments to act as shock absorbers. In this paper, I abstract from any nominal rigidities. Instead, I formalize the argument in Mundell (1973) to study the common currency channel of risk sharing.

A few other papers have studied risk sharing through a common currency. Most related to my approach are Voss (1998), Ching & Devereux (2003), and Tornell (2018). Voss (1998) studies how the central bank of a currency union can reduce consumption volatility by allowing regional disparities in the growth of money supply. Similar to my work, risk sharing is ultimately achieved through the state-dependent division of seigniorage revenue. However, Voss (1998) abstracts from moral hazard arising from asymmetric information. As a result, he can only derive the risk sharing benefit under the assumption of exogenously incomplete markets. In my model, however, the moral hazard problem implies endogenous market incompleteness in the sense that Arrow security trades will not implement the second best risk sharing allocation (see section 6.3). Furthermore, my model has the advantage that it links risk sharing through the common currency to current account imbalances between countries. This allows a better map to the Eurocrisis than regional disparities in the growth rate of money supply. Ching & Devereux (2003) present a model of optimum currency areas which incorporates the costs from losing independent monetary policy as well as the benefits from enhanced risk sharing. In my model, giving up independent national monetary policies has no direct costs, but rather the insurance through a common currency comes at the cost of moral hazard. The focus of my paper is on the existence and optimal operation of the common currency channel of risk sharing, not on the question of optimum currency areas. Tornell (2018) interprets TARGET2 balances as an automatic loan from the currency union via the central bank and studies the TARGET2 system

[4] Mundell (1961) is sometimes referred to as 'Mundell I' while Mundell (1973) is referred to as 'Mundell II' (see McKinnon (2004)).

as a risk sharing mechanism that smooths the effects of negative shocks.[5] His main focus is on the effect of this implicit bailout guarantee on national debt accumulation which he studies in a dynamic political-economy model. My focus, on the other hand, is on formalizing the notion of risk sharing through a common currency. From this I derive principles how the central bank of a currency union can actively manage the moral hazard arising from risk sharing through a common currency.

Most of the theoretical literature on banking assumes that contracts are written in real terms.[6] Notable exceptions from this are Skeie (2008) and Allen et al. (2014) who build models of banking crises in which contracts are written in nominal terms. The fact that contracts are written in nominal terms is key to my analysis since the central bank can always reprint nominal claims at zero cost. This stands in stark contrast to 'real models' with no explicit reference to the money creation process. In my model, the central bank cannot directly produce output, but redistributes parts of aggregate production through seigniorage. The monetary environment in my model is similar to the one in Allen et al. (2014). In fact, I regard the findings in my paper as complimentary to their finding that a central bank which accommodates the demands of the private sector for fiat money allows full sharing of liquidity risk. The risk to be shared in Allen et al. (2014) is the liquidity risk introduced by Diamond & Dybvig (1983) as a preference shock for early consumption. In contrast, my paper deals with productivity risks and shows that a common currency actively managed by a central bank can achieve the constrained efficient allocation.

The rules derived for optimal monetary policy in my model bear similarity with the literature on deposit insurance, bank risk taking and state-dependent penalties (see Marshall & Prescott (2006), Boyd et al. (2002), and Allen et al. (2015) for an overview). In my model, the central bank implicitly insures all regional deposits as it stands ready to refinance regional net currency outflows. However, to mitigate the moral hazard problem arising from insurance through the common currency, the central bank announces refinancing rates which act as state-dependent penalties. Optimal monetary policy in my model comprises central bank refinancing rates which resemble collateral requirements. This underlines the importance of collateral frameworks in the conduct of monetary policy as discussed in the emerging literature on central bank collateral frameworks (see Nyborg (2017), Koulischer et al. (2015), Choi et al. (2019), Bindseil & Jablecki (2013)). In explicitly modeling the modern two-layered payment system comprising interbank payments through a central bank, I follow the distinction of inside and outside money going back to Gurley & Shaw (1960) which was recently embedded in modern macro models by Piazzesi & Schneider (2018) and Bianchi & Bigio (2014).

Similar to my paper, Chari & Kehoe (2008) study moral hazard within monetary unions. In their model, national governments in a monetary union are tempted to not properly regulate their domestic banks in an attempt to free-ride on other government's regulation efforts. I study how a similar free-riding problem can be addressed through policy decisions by the central bank to implement the second best allocation of risk sharing. Persson & Tabellini (1996) study the trade-off between incentives and insurance in a federal fiscal union. In their model, through

[5] Schelkle (2017) informally develops a similar argument.

[6] See Freixas & Rochet (2008) and Gorton & Winton (2003) for an overview of the literature.

insuring regions against idiosyncratic risks, the federal government induces regions to take less effort in ensuring these negative risks do not materialize. In my model, the central bank faces the same trade-off. In fact, money and monetary policy have real effects without reference to sticky prices or wages. The real effects come from the fact that the refinancing operations of the central bank imply real resource transfers through an uneven distribution of (implicit) seigniorage revenues. This renders monetary policy quasi-fiscal in my model. The broader point here is that in the absence of risk sharing through a fiscal union, a currency union can play a similar role in implementing risk sharing between union members.

There is a vivid debate about TARGET2 balances and their role during the European balance-of-payment crisis. See Sinn (2014) for a comprehensive narrative of the Eurocrisis. Merler & Pisani-Ferry (2012) and Higgins & Klitgaard (2014) summarize the evidence for a 'sudden stop' crisis in the Eurozone and discuss the balance of payment within a monetary union. Sinn & Wollmershäuser (2012) outline the implicit fiscal transfers through TARGET2 balances. I add to this literature by conceptualizing TARGET2 balances as a symptom of risk sharing through a common currency and by studying the trade-offs arising for a central bank operating this channel of international risk sharing. Asdrubali et al. (1996) proposed a methodology to quantify the contribution of different risk sharing channels to overall consumption smoothing. They distinguish between the capital market channel, the credit market channel, and the fiscal channel. While they initially studied the United States, many authors have conducted similar analyses for Europe, both before the introduction of the Euro (Sørensen & Yosha (1998)) as well as after its introduction (Kalemli-Ozcan et al. (2014), Milano et al. (2017), Cimadomo et al. (2018)). My contribution to this strand of literature is to include the common currency channel as a fourth channel into the empirical analysis. Similar to the authors mentioned above, I find that the traditional risk sharing channels have not been particularly effective during the Eurocrisis. However, I find that the common currency channel has been effective during the early stages of the crisis, accounting for up to 60% of risk sharing in the years of 2008 and 2009.

The rest of this paper is organized as follows. Section 2 describes the model setup. In section 3, I derive the constrained efficient risk sharing allocation (second best). Section 4 shows how a common currency allows for risk sharing, and studies how the central bank can achieve the second best allocation through monetary policy. Section 5 establishes the quantitative importance of the common currency channel of risk sharing during the Eurocrisis. Section 6 discusses several extensions to the baseline model. Section 7 concludes. All proofs are relegated to the Appendix.

2 The Real Economy

Agents and preferences. Consider an economy which consists of $N \subset \mathbb{N}$ symmetric regions. There are two dates: $t = 0, 1$. Each region $i \in N = \{1, 2, ..., n\}$ is inhabited by one representative household and a continuum of firms. Similar to Gertler & Kiyotaki (2010) and Gertler & Karadi (2011), the household entails a risk-averse consumer and a risk-neutral banker. At $t = 0$, the consumer is endowed with one unit of labor which he inelastically supplies to firms within the same region. Consumers in region i cannot supply labor to firms in region $j \neq i$. Firms use consumer labor as the sole input factor. At $t = 0$, the banker is endowed with one unit of the consumption good ('safe asset'). He can exert costly effort to enhance the productivity of firms within his region (through monitoring, for example). A banker in region i cannot enhance productivity of firms in region $j \neq i$. The effort level is binary, $e_i \in \{0, 1\}$ and freely observed by the consumer within the same household, but not by consumers in households from different regions. The household only consumes at $t = 1$ and derives utility according to the following utility function:

$$U(c_i, e_i) = \frac{(c_i)^{1-\eta}}{1-\eta} - k \cdot e_i \tag{1}$$

where c_i denotes the consumer's consumption which consists of the banker's endowment and the goods produced by firms. $k > 0$ is an effort cost parameter, and $\eta > 0$ measures the risk aversion of the consumer.

Production technology. Regional firms operate a production technology which requires one unit of labor input at $t = 0$ and produces a stochastic return at $t = 1$. More specifically, each region is subject to a *regional productivity shock* which can be either high or low: $z_i \in \{H, L\}$. The probability of a high shock is given by $q \in (0, 1)$. It is i.i.d. across regions.[7] The regional shock impacts the production of all firms within a region equally. Regional production is given by

$$y_i = \begin{cases} A_H & \text{if } z_i = H \text{ and } e_i = 1 \\ A_L & \text{otherwise} \end{cases} \tag{2}$$

where $A_H > A_L > 0$. If the region is hit by a low shock or if the banker does not exert effort, then regional production is given by A_L. If the region is hit by a high shock and the banker exerts effort, then regional production is given by A_H. Importantly, the incidence of low output might be due to bad luck (low shock) or lacking banker effort. Other regions cannot infer which of the two caused the low output. I assume that if a region is in isolation, the regional banker exerts effort:

$$q\frac{(1 + A_H)^{1-\eta}}{1-\eta} + (1-q)\frac{(1 + A_L)^{1-\eta}}{1-\eta} - k > \frac{(1 + A_L)^{1-\eta}}{1-\eta} \tag{3}$$

The consumption good can be traded between regions at zero cost.[8] As regional shocks are i.i.d. across regions, regional risk sharing is possible. In fact, as consumers are risk-averse, an *insurance scheme* between regions is welfare improving.

Aggregate production risk. As the number of regions, N, is finite, aggregate production in this economy is uncertain. More specifically, there is uncertainty about the number of regions $m \in \{0, 1, ..., N\}$ with high shocks. The random variable m_N follows a binomial distribution with parameters N and q:

$$m_N \sim B(N, q) \tag{4}$$

[7] All results go through if regional shocks are allowed to be correlated across regions. As correlated shocks reduce the tractability of the model, I focus on the benchmark case of i.i.d. shocks.

[8] Introducing trading frictions between regions does not change results qualitatively.

or, equivalently,

$$m_N = \sum_{i=1}^{N} X_i \quad \text{where} \quad X_1, ..., X_n \overset{\text{i.i.d.}}{\sim} Bernoulli(q) \tag{5}$$

If regional bankers exert effort, aggregate production is given by $Y_N = m_N A_H + (N - m_N) A_L$. I refer to the uncertainty over the realization of m_N as *aggregate production risk*.

Timeline and Information. Figure 1 summarizes the timing of the real economy. At $t = 0$, regional bankers are endowed with one unit of the consumption good and choose their effort level e_i. This effort level is unobserved by other regions. Regional shocks are not directly observed by anybody. At $t = 1$, regional firms produce output according to the realized regional productivity shock as well as banker effort exerted at $t = 0$. Regional output is freely observed by everybody. At $t = 1$, the amount of goods in region i is equal to $1 + y_i$ where $y_i \in \{A_H, A_L\}$.

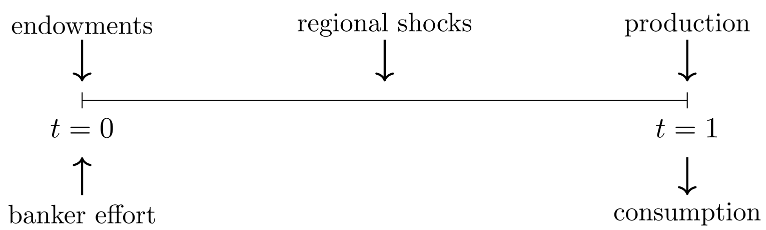

Figure 1: Timeline (real economy)

3 Constrained Efficient Allocation

In this section, I will present the second best risk sharing allocation as the solution to an information-constrained central planning problem. In section 4, I will show how the second best allocation can be implemented in a monetary environment through a central bank.

A risk sharing allocation in the real economy described above is defined as follows.

Definition 1 (Risk Sharing Allocation).
Let aggregate production be given by $m \in \{0, 1, ..., N\}$. A risk sharing allocation is given by consumption levels for regions in low state $\boldsymbol{c_L^{(m)}} = \{c_L^{(0)}, c_L^{(1)}, ..., c_L^{(N-1)}\}$, consumption levels for regions in high state $\boldsymbol{c_H^{(m)}} = \{c_H^{(1)}, c_H^{(2)}, ..., c_H^{(N)}\}$, transfers to regions in high state $\boldsymbol{t_H^{(m)}} = \{t_H^{(0)}, t_H^{(1)}, ..., t_H^{(N)}\}$, transfers to regions in low state $\boldsymbol{t_L^{(m)}} = \{t_L^{(0)}, t_L^{(1)}, ..., t_L^{(N)}\}$, and total transfers between regions $\boldsymbol{T^{(m)}} = \{T^{(0)}, ..., T^{(1)}, ..., T^{(N)}\}$.

In this definition, the element $c_H^{(m)}$ of the vector $\boldsymbol{c_H^{(m)}}$ denotes consumption of a region with high output when a total of m regions produce high output, while $c_L^{(m)}$ denotes consumption of a region with low output. $t_H^{(m)}$ denotes the transfer to a region with high output if m regions have high output levels. This transfer can be positive or negative. Similarly, $t_L^{(m)}$ is the transfer to a region with low output when a total of m regions have high output levels. Note that without the unobservability of regional banker effort, the central planning problem is trivial: The central planner would require all regional bankers to exert effort, and then divide aggregate production equally amongst regions.

Lemma 1 (First Best Allocation)**.**
The first-best allocation is such that each region's consumption is a state-invariant function of aggregate production m. This allocation is given by

$$c_H^{(m)} = c_L^{(m)} = \frac{N + mA_H + (N-m)A_L}{N} \qquad \forall m \in \{0, 1, ..., N\} \tag{6}$$

$$t_H^{(m)} = c_H^{(m)} - (1 + A_H) = \frac{(N-m)(A_L - A_H)}{N} < 0, \quad t_L^{(m)} = c_L^{(m)} - (1 + A_L) = \frac{m(A_H - A_L)}{N} > 0 \tag{7}$$

$$T^{(m)} = (N-m)t_L^{(m)} = -mt_H^{(m)} = \frac{m(N-m)(A_H - A_L)}{N} \tag{8}$$

The first best allocation implies that regions perfectly share the consumption risk arising from idiosyncratic productivity shocks. Risk sharing is achieved through real resource transfers from regions with high output to regions with low output.

With unobservable banker effort, however, any insurance scheme that fully insures a region against consumption risk reduces the regional banker's incentive to exert effort. If no banker exerts effort, any insurance scheme will suffer from an underprovision of effort leading to low output and consumption levels. Thus, the central planner needs to strike the optimal balance between insuring regions against idiosyncratic production risks and providing them with incentives to exert costly effort. The planner solves the following **second best program**:

$$\max_{\boldsymbol{c_H^{(m)}},\, \boldsymbol{c_L^{(m)}}} \quad q \sum_{m=0}^{N-1} \binom{N-1}{m} q^m (1-q)^{N-1-m} \frac{\left(c_H^{(1+m)}\right)^{1-\eta}}{1-\eta} + (1-q) \sum_{m=0}^{N-1} \binom{N-1}{m} q^m (1-q)^{N-1-m} \frac{\left(c_L^{(m)}\right)^{1-\eta}}{1-\eta}$$

s.t.

$$mc_H^{(m)} + (N-m)c_L^{(m)} \leq N + mA_H + (N-m)A_L \;\forall m \in \{0, ..., N\} \tag{RC}$$

$$q \sum_{m=0}^{N-1} \binom{N-1}{m} q^m (1-q)^{N-1-m} \left(\frac{\left(c_H^{(1+m)}\right)^{1-\eta}}{1-\eta} - \frac{\left(c_L^{(m)}\right)^{1-\eta}}{1-\eta} \right) \geq k \tag{IC}$$

$$q \frac{\left(c_H^{(m)}\right)^{1-\eta}}{1-\eta} + (1-q) \frac{\left(c_L^{(m)}\right)^{1-\eta}}{1-\eta} \geq q \frac{A_H^{1-\eta}}{1-\eta} + (1-q) \frac{A_L^{1-\eta}}{1-\eta} \tag{PC}$$

$$c_H^{(m)}, c_L^{(m)} \geq 0 \tag{NNC}$$

(9)

The planner's objective function is the expected utility of a (representative) region which is exerting effort. As there are N regions each of which is subject to a Bernoulli productivity shock, there are 2^N states of the world at the end of the period. Aggregate production risk arises from the fact that there are $N + 1$ distinct aggregate production levels: $m \in [0, N]$. The solution to the planner's problem are the two vectors $\boldsymbol{c_H^{(m)}} = \left(c_H^{(1)}, c_H^{(2)}, ..., c_H^{(N)}\right)$ and $\boldsymbol{c_L^{(m)}} = \left(c_L^{(1)}, c_L^{(2)}, ..., c_L^{(N)}\right)$. With probability q, a region which exerts effort ends up with high output, and with probability $1 - q$ it ends up with low output. Hence, the first term in the expression for the planner's objective function sums over the different consumption levels allocated to a region with high output for all potential realizations of aggregate production. Similarly, the second term sums over the consumption levels allocated to a region with low output for all potential realizations of aggregate production. When maximizing the objective function, the central planner needs to obey four constraints. First, the aggregate resource constraint (RC) restricts the central planner to ex post budget balance. That is, for any aggregate production realization m, the planner cannot allocate more goods than there are goods produced. Effectively, this implies that the central planner cannot produce any goods himself, i.e. he cannot transfer goods between different states of the world. Second, the incentive constraint (IC) ensures that the allocation is such that for every region, the expected utility of exerting effort is higher than the expected utility of not exerting effort. Third, the ex ante regional participation constraint (PC) requires that, in expectation, the insurance scheme is (weakly) welfare impoving for each region. That is, it cannot leave regions worse off than if there was no insurance scheme. Fourth, the non-negativity constraints (NNC) restrict the social planner to allocate non-negative amounts of the consumption good. Proposition 1 summarizes the solution to this program.

Proposition 1 (Second Best Allocation)**.**
$\exists\ \bar{N} \in [1, \infty)$:

1. *If $N \leq \bar{N}$: Planner achieves first best allocation.*
2. *If $N > \bar{N}$: Optimal risk sharing allocation depends on **aggregate production** m and the **agency wedge** γ: For any given $m \in \{1, ..., N-1\}$,*

$$c_H^{(m)} = \gamma \frac{N + mA_H + (N-m)A_L}{N + (\gamma - 1)m}, \quad c_L^{(m)} = \frac{N + mA_H + (N-m)A_L}{N + (\gamma - 1)m} \tag{10}$$

$$t_H^{(m)} = -\frac{(N-m)(1 + A_H - \gamma(1 + A_L))}{N + (\gamma - 1)m}, \quad t_L^{(m)} = \frac{m(1 + A_H - \gamma(1 + A_L))}{N + (\gamma - 1)m} \tag{11}$$

$$T^{(m)} = \frac{m(N-m)(1 + A_H - \gamma(1 + A_L))}{N + (\gamma - 1)m} \tag{12}$$

where $\gamma = \gamma(N, q, A_H, A_L, k, \eta) = \frac{c_H^{(m)}}{c_L^{(m)}} \in \left(1, \frac{1+A_H}{1+A_L}\right]$.

The first part of Proposition 1 shows that for a sufficiently small number of regions in the insurance scheme ($N \leq \bar{N}$), the first best allocation can be achieved even with unobservable banker effort. This is due to the fact that in the presence of only a few other other regions, regional bankers internalize the impact of their regional decision on total production. If, however, the number of regions is sufficiently large ($N > \bar{N}$), then regional bankers try to free-ride on each others' efforts which leads to an underprovision of effort if regions are fully insured. I will focus on this case. The second part of Proposition 1 reveals that the central planner responds to the moral hazard problem by creating an **agency wedge** between the consumption level if the region has high output and the consumption level if the region has low output. This implies that the planner only *partially insures* regions in order to *provide incentives*, thereby mitigating the moral hazard problem. Importantly, the agency wedge is independent of the realized aggregate output m. This implies that the central planner distorts the first best allocation equally in all potential states of the world. The size of this distortion depends on the number of regions N, the banker effort cost k, the probability of a high shock q, production levels A_L and A_H, and the consumer's risk aversion η. Corollary 1 summarizes the comparative statics of the agency wedge with respect to these parameters.

Corollary 1 (Comparative Statics of Agency Wedge)**.**
The agency wedge γ is increasing in $\{N, k, \eta, A_L\}$ and decreasing in $\{q, A_L\}$.

The wedge is increasing in the number of regions N being insured. More regions imply that the effort of an individual regional banker has lower impact on economy-wide income and as a result, the banker is less inclined to exert costly effort. That is, the higher the number of regions, the more inclined are bankers to free ride on each other. The agency wedge is further increasing in effort costs k as higher costs reduce a banker's incentive to exert effort. The agency wedge decreases in the probability of a high regional shock q. If the probability of a high shock is low (low q), there is a high chance that a region will end up with low output despite the regional banker's effort. As a result, it is hard to incentivize the banker to exert effort. The agency wedge increases in the consumer's risk aversion η. The more risk averse the consumer is, the harder it is for the central bank to incentivize the regional banker. This increases the agency wedge. Finally, the agency wedge decreases in the difference $A_H - A_L$ as an increase in this difference makes exerting effort more valuable in expectation which makes it easier for the central planner to incentivize regional bankers.

Apart from the agency wedge γ, the second best risk sharing allocation depends on aggregate production m. More specifically, both $c_H^{(m)}$ and $c_L^{(m)}$ are increasing in aggregate production m. Figure 2 illustrates the first and second best risk sharing allocation as a function of aggregate production m. In the model specification underlying this example, the agency wedge is given by $\gamma = \frac{c_H^{(m)}}{c_L^{(m)}} = 1.147$. That is, for every realization of aggregate production m, the social planner distorts the allocation such that regions with high output consume 14.7% more than regions with low output (compared to a difference of 20% between consumption with high output and consumption with low output in the case of no insurance between regions). The figure illustrates that transfers per high output region are decreasing in m while transfer per low output region are increasing in m. The next corollary shows that total resource transfers implied by the second best allocation are inversely U-shaped in aggregate production m.

Corollary 2 (Second Best Total Resource Transfers)**.**
Total real resource transfers $T = m \cdot t_H^{(m)}$ are increasing for low values of aggregate production m and decreasing for large values of m:

$$\frac{\partial T^{(m)}}{\partial m} = \underbrace{t_H^{(m)}}_{>0} + m \underbrace{\frac{\partial t_H^{(m)}}{\partial m}}_{<0} \tag{13}$$

Ceteris paribus, total resource transfers are decreasing in γ.

The total size of real resource transfers is determined by both the number of regions in high state (extensive margin) and the transfer per region in high state (intensive margin): $T = m \cdot t_H^{(m)}$.

The number of regions in high state is increasing in m while the transfer per region in high state, $t_H^{(m)}$, is decreasing in m. The extensive margin effect of m on total transfers is dominating for small values of m while the intensive margin effect is dominating for large values of m.

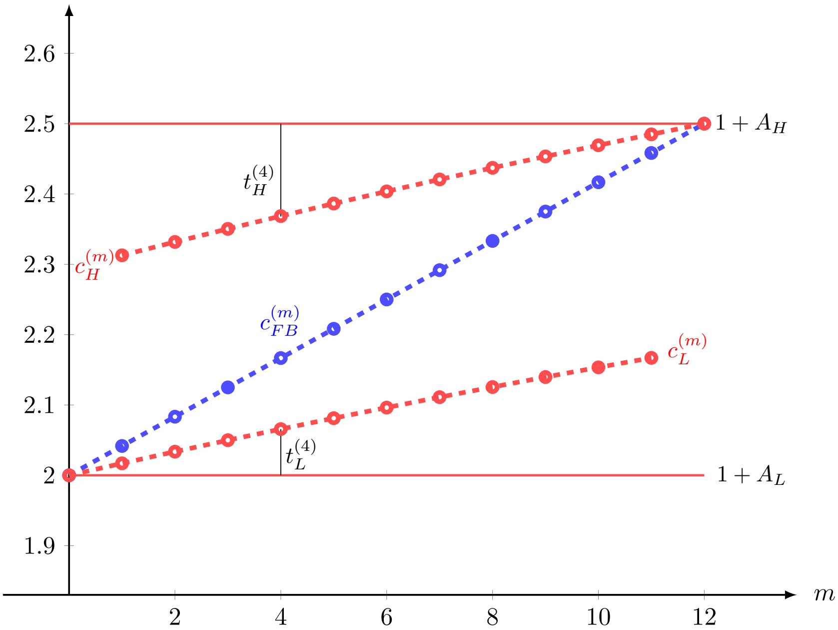

Figure 2: First and second best allocation

Note: First and second best consumption levels as a function of aggregate production m for $N = 12$, $q = 0.8$, $k = 0.05$, $A_L = 1$, $A_H = 1.5$, $\eta = 2$. The agency wedge is given by $\gamma = 1.147$. The first best allocation is depicted in blue. It is such that each region consumes an equal share of total production for all m. The social planner implements the second best allocation by creating a wedge between regional consumption in case of high output and regional consumption in case of low output. Second best transfers per region are given by the vertical distance between production and consumption levels (illustrated here for $m = 4$).

4 Risk Sharing Through Common Currency

In this section, I show how the constrained efficient allocation can be implemented in the decentralized economy through a common currency which is managed by the central bank. In section 4.1, I outline the monetary environment of the decentralized economy. The argument for risk sharing through a common currency then proceeds in three steps. In section 4.2, I discuss the balance of payments within the currency union. This subsection shows that the common currency allows for current account imbalances between member regions which are refinanced through the central bank. The key insight is that the rate at which the central bank monetizes the endowment good determines the amount of real resources transferred between regions through the use of the common currency. In section 4.3, I derive optimal policy rates for a central bank striking the balance between insurance and incentives from the common currency. In section 4.4, I show that real resource transfers through central bank refinance of current account imbalances are equivalent to fiscal transfers in a fiscal union. I conclude that risk sharing through the common currency is based on an unequal distribution of implicit seigniorage revenue.

4.1 Monetary Environment

Similar to Allen et al. (2014), I assume that all transactions in the decentralized economy are intermediated by money.[9] Money is exclusively created by a *central bank*. At $t = 0$, the central bank lends one unit of currency to each regional banker against his endowment good ('safe asset'). This implies that total money supply at $t = 0$ is given by $M \equiv \sum_{i=1}^{N} M_i = N$. Regional bankers lend the money to regional firms. Regional firms use the money to buy labor from the regional consumer. At $t = 1$, after productivity shocks have realized, regional firms sell their output on an *economy-wide* goods market, and forward all revenue to their regional banker. Regional bankers that cannot repay their central bank loans have to refinance their deficit.[10] The central bank sets a real resource price r_{CB} at which it provides additional money at $t = 1$ to cover deficits. More specifically, the central bank requires r_{CB} units of endowment goods per unit of money deficit from a region with net money outflows. This implies that $\frac{1}{r_{CB}}$ is the rate at which the central bank *monetizes the endowment good* at $t = 1$ to cover one unit of net money flows between regions.

Definition 2 (Monetary Policy)**.**
The central bank chooses a real rate r_{CB} at which it provides money at $t = 1$:

$$r_{CB} = \frac{\text{endowment goods}}{\text{unit of deficit with central bank}} \tag{14}$$

Equivalently, $\frac{1}{r_{CB}}$ is the rate at which the central bank monetizes the endowment good.

The central bank transfers the endowment goods obtained from regions with a net money deficit to regions with a net money surplus. That is, the central bank effectively controls the real value (in terms of endowment goods) of a net money flow between any two regions. At the end of $t = 1$, after debt has been settled using endowment goods, the central bank redistributes all remaining endowment goods back to regions in equal shares.

The central bank's objective function is the expected utility of a region at $t = 0$ before productivity shocks are realized. That is, the central bank has a utilitarian welfare criterion which attaches the same welfare weight to all regions:

$$W_{CB} = \mathbb{E}\left[\sum_{i=1}^{N}\left(\frac{c_i^{1-\eta}}{1-\eta} - k \cdot e_i\right)\right] \tag{15}$$

Figure 3 summarizes the timeline of events in the monetary economy.

[9] I use the terms money and currency interchangeably.

[10] This assumption could be rationalized in a dynamic model in which the central bank requires regions to repay their loans to stay in the currency union.

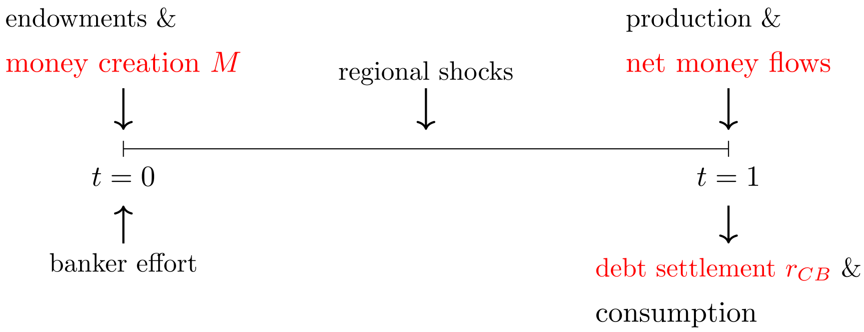

Figure 3: Timeline (monetary economy in red)

4.2 Balance of Payments and Monetary Policy in a Currency Union

At $t = 0$, the central bank creates a total of $\sum_i^N M_i = N$ units of money. These nominal balances are held by regional consumers who exchange their labor endowment against money. Aggregate production in the currency union is given by $Y^{(m)} = mA_H + (N-m)A_L$ where m denotes the number of regions with high banker effort and a high productivity shock. Regional firms sell their output on the economy-wide goods market. The economy-wide goods market clears according to the quantity equation which implies that the equilibrium price level is given by

$$P^{(m)} = \frac{M}{Y^{(m)}} = \frac{N}{\sum_i^n y_i} = \frac{N}{mA_H + (N-m)A_L} \tag{16}$$

As each regional consumer holds the same amount of currency ($M_i = 1$), each consumer obtains the following amount of consumption goods from the goods market:

$$\frac{1}{P^{(m)}} = \frac{Y^{(m)}}{N} = \frac{1}{N}\left(\sum_{i=1}^{n} y_i\right) = \frac{1}{N}\left(mA_H + (N-m)A_L\right) \tag{17}$$

That is, goods market clearing implies that the different regional consumers obtain the same amount of goods from the goods market irrespective of their regional production levels. This implies that there is a flow of goods from regions with high output levels to regions with low output levels which is accompanied by a flow of money in opposite direction. Lemma 2 summarizes these flows.

Lemma 2 (Regional Balance of Payments)**.**
Assume the aggregate state of the economy is given by m. Goods market clearing implies that

$$CA_L^{(m)} = \frac{m(A_L - A_H)}{N} < 0, \qquad NET_L^{(m)} = \frac{m(A_L - A_H)}{mA_H + (N-m)A_L} < 0 \tag{18}$$

$$CA_H^{(m)} = \frac{(N-m)(A_H - A_L)}{N} > 0, \qquad NET_H^{(m)} = \frac{(N-m)(A_H - A_L)}{mA_H + (N-m)A_L} > 0 \tag{19}$$

where $CA_i^{(m)} = \frac{NET_i}{P}$ with $i \in \{L, H\}$ denotes a country's current account balance, and $NET_i^{(m)}$ denotes its net money inflow. It holds that $m \cdot CA_H^{(m)} + (N-m) \cdot CA_L^{(m)} = 0$ as well as $m \cdot NET_H^{(m)} + (N-m) \cdot NET_L^{(m)} = 0$.

Each regional banker obtains $M_i = 1$ units of money from the central bank at the beginning of the period. The regional consumer uses this money on the goods market at $t = 1$ to buy output. This implies that each region has a gross outflow of money equal to $M_i = 1$. This gross outflow of money is met by a gross inflow of money from regional firms selling their output to consumers on the economy-wide goods market. This implies that the net money inflow to region i is given by

$$NET_i^{(m)} = P^{(m)} y_i - M_i = \frac{y_i - \frac{1}{N}\sum_{j=1}^{n} y_j}{\frac{1}{N}\sum_{j=1}^{n} y_j} \tag{20}$$

That is, region i has a net money inflow if its firms produce more output than the average region. On the contrary, the region has a net money outflow if it produces less output than the average region. In the following, it will be convenient to summarize total net money flows in the economy by one variable, $NET^{(m)}$.

Definition 3 (Net Outstanding Claims Between Regions).
Let $NET^{(m)}$ denote the total amount of outstanding nominal claims between regions after the goods market has cleared. It is given by

$$NET^{(m)} \equiv mNET_H^{(m)} = -(N-m)NET_L^{(m)} \tag{21}$$

Proposition 2 shows that net money flows are the result of missing exchange rates between different regions in the currency union.

Proposition 2 (Missing Exchange Rates and Money Flows).
Let P_i (P_j) is the (hypothetical) price level that would have materialized in region i (j) if it was not part of the currency union. A net money flow from region i to region j implies that $P_i > P_j$ or $Y_i < Y_j$, respectively.

If each region had issued its own currency, the equilibrium of the economy would feature exchange rates between different currencies which depend on country-specific production levels (see section 6.2). Net money flows between regions reflect the absence of these exchange rates.

Risk sharing through the common currency crucially depends on how these net money flows are refinanced by the central bank. Net flows appear on the central bank level and imply that regions with a net money outflow will not be able to repay their central bank loan from $t = 0$. Regions can refinance their deficit with the central bank at the real rate r_{CB}. More specifically, the central bank offers to convert r_{CB} units of endowment goods into one unit of currency. Note that in equilibrium, the nominal value of r_{CB} units of endowment goods is given by $P^{(m)} \cdot r_{CB}$. If the central bank offers to refinance a net money deficit of $NET_L^{(m)}$ for a total of $r_{CB} NET_L^{(m)}$ amount of endowment goods, then it refinances a fraction $P^{(m)} \cdot r_{CB}$ 'at market rate', and a fraction $1 - P^{(m)} \cdot r_{CB}$ 'below market rates'. That is, $\left(1 - P^{(m)} \cdot r_{CB}\right) NET_L^{(m)}$ is money created in excess of the nominal value of the endowment good to refinance net money flows. It is the result of monetizing the endowment good 'above market rate' $P^{(m)}$.[11]

[11] Note that refinancing net money flows 'below market rate' $\frac{1}{P^{(m)}}$ is equivalent to monetizing endowment goods 'above market rate' $P^{(m)}$.

Lemma 3 (Market versus Central Bank Refinance).
At the rate r_{CB}, a deficit region refinances a fraction $P^{(m)} \cdot r_{CB}$ of its money deficit through other regions ('at market rate'), and the remaining fraction $1 - P^{(m)} \cdot r_{CB}$ through the central bank ('below market rate'):

$$NET_L^{(m)} = \underbrace{P^{(m)} \cdot r_{CB} \cdot NET_L^{(m)}}_{\text{'market refinance'}} + \underbrace{(1 - P^{(m)} \cdot r_{CB}) \cdot NET_L^{(m)}}_{\text{'central bank refinance'}} \tag{22}$$

If the central bank allows a deficit region to cover its deficit at a real resource price of $r_{CB} \cdot NET_L^{(m)}$, then this implies a transfer of the corresponding amount of endowment goods from deficit regions to surplus regions. At the goods market price level $P^{(m)}$, this resource transfer recovers a fraction $P^{(m)} \cdot r_{CB}$ of a deficit region's net money deficit. The remaining fraction $1 - P^{(m)} \cdot r_{CB}$ of the deficit is covered by the central bank through *overdraft balances*.

Definition 4 (Central Bank Overdraft Balance).
An overdraft balance is created at $t = 1$ to cover net money flows between regions which are not refinanced at market rate $\frac{1}{P^{(m)}}$.

Corollary 3 (Overdraft Balances).
The total amount of overdraft balances created by the central bank is given by

$$B^{(m)} \equiv (1 - P^{(m)} \cdot r_{CB}) \cdot NET^{(m)} \tag{23}$$

If $r_{CB} < \frac{1}{P^{(m)}}$, then a fraction $1 - P^{(m)} \cdot r_{CB}$ of a deficit region's total money outflow $NET_L^{(m)}$ will be financed through an overdraft balance at the central bank. This implies that part of the net inflow of a surplus region will be converted into an overdraft balance. Only the remaining part of net money flows will have to be refinanced at the market rate $\frac{1}{P^{(m)}}$. Note that every positive overdraft balance (of a deficit region) is met with a negative overdraft balance (of a surplus region). As a result, the net amount of overdraft balances is always equal to 0.

Corollary 4 (Current Account Finance through the Central Bank).
The amount of current account imbalances financed through the central bank is given by

$$CA_L^{CB} \equiv \frac{NET_L^{(m)}}{P^{(m)}} - r_{CB} \cdot NET_L^{(m)} = (1 - P \cdot r_{CB})\, CA_L = \frac{B^{(m)}}{mP^{(m)}} \tag{24}$$

$$CA_H^{CB} \equiv \frac{NET_H^{(m)}}{P^{(m)}} - r_{CB} \cdot NET_H^{(m)} = (1 - P \cdot r_{CB})\, CA_H = \frac{B^{(m)}}{(N - m)P^{(m)}} \tag{25}$$

Corollary 4 shows that the real value of overdraft balances represents the fraction of current account imbalances that are refinanced below market rates through the central bank. I conclude this subsection with the following definition of a monetary equilibrium with a common currency.

Definition 5 (Monetary Equilibrium with Common Currency and Monetary Policy).
Given the realization of aggregate production risk m and monetary policy variables $\{M, r_{CB}^{(m)}\}$, a monetary equilibrium with a common currency consists of regional banker effort levels $(e_1, e_2, ..., e_n)$, production levels $(y_1, y_2, ..., y_n)$, price level $P^{(m)}$, net money flows $NET^{(m)}$, overdraft balances $B^{(m)}$, and consumption levels $(c_1^{(m)}, c_2^{(m)}, ..., c_n^{(m)})$ such that regional bankers maximize (ex-ante) household utility and the economy-wide goods markets clears.

4.3 Optimal Risk Sharing Through the Common Currency

If $r_{CB} = \frac{1}{P^{(m)}}$, then a deficit region has to cover its current account deficit resulting from goods market clearing with a corresponding amount of endowment goods. This implies that, at $t = 1$, the central bank monetizes the endowment good at market rates which leaves the individual region fully exposed to its idiosyncratic productivity shock. Hence, the central bank can achieve risk sharing only if $r_{CB} < \frac{1}{P^{(m)}}$, i.e. if it monetizes the endowment good above market rates.

Proposition 3 (Risk-Sharing Monetary Policy).
The central bank allows for risk sharing through the common currency only if it sets $r_{CB} \in \left[0, \frac{1}{P^{(m)}}\right)$ *and* $B^{(m)} > 0$. *The higher the monetary policy rate* r_{CB}, *the lower the risk sharing through the common currency.*

In this model, monetary policy is described by the real refinance rate r_{CB} and the amount of overdraft balances $B^{(m)}$ created. The goods market value of money in equilibrium is given by $P^{(m)}$. If the central bank monetizes endowment goods above the market rate of $P^{(m)}$, then it achieves risk sharing between the member regions of the currency union. The central bank finances part of a region's current account deficits from goods market clearing through the creation of overdraft balances. That is, it devalues the real claims a surplus region holds against a deficit region, thereby enabling a real resource transfer from surplus regions to deficit regions. It is through these real resource transfers that regions within the currency union smooth consumption profiles and thereby share risks. The lower the real rate r_{CB}, the higher the fraction of current account deficits that are financed through the central bank below market rates, and hence, the higher the implied real resource transfers.

Corollary 5 (Full Risk Sharing Monetary Policy).
The central bank implements full risk sharing at $r_{CB} = 0$. *This implies that* $B^{(m)} = NET^{(m)}$.

If the central bank refinances net money flows between regions at zero real cost, then the full risk sharing allocation is achieved. However, as regional banker effort is unobservable, full insurance may lead to the underprovision of banker effort and hence suboptimal levels of aggregate production ($m = 0$). That is, the problem for the central bank is to choose the amount of risk sharing which is compatible with the regional bankers' incentives to exert costly effort. The following Proposition derives the optimal refinancing rate r_{CB} which implements the second best allocation from Proposition 1.

Proposition 4 (Optimal Monetary Policy).
The central bank implements the second best allocation by setting

$$r_{CB}^{(m)} = \frac{1}{P^{(m)}} \frac{c_H^{(m)} - c_L^{(m)}}{A_H - A_L} < \frac{1}{P^{(m)}} \tag{26}$$

where $c_H^{(m)}$ *and* $c_L^{(m)}$ *are the solution from the social planning problem, and* $P^{(m)}$ *is the price level on the goods market. Corresponding overdraft balances are given by*

$$B^{(m)} = P^{(m)} \frac{(N-m)m\left[1 + A_H - \gamma(1 + A_L)\right]}{N + (\gamma - 1)m} \tag{27}$$

The *optimal refinancing rate* r_{CB} is always less than the real value of money on the goods market which is given by $\frac{1}{P^{(m)}}$. That is, the central bank provides insurance through the common currency by refinancing net money flows 'below market rates', or equivalently, by monetizing the endowment good 'above market rates'. Proposition 4 shows that the optimal refinancing rate r_{CB} depends on both the agency wedge γ as well as the realized aggregate production m. Note that if $c_H^{(m)} = c_L^{(m)} \quad \forall m$, then the optimal policy rate is given by $r_{CB} = 0 \quad \forall m$. This implies perfect risk sharing. If $c_H^{(m)} = 1 + A_H \quad \forall m$ and $c_L^{(m)} = 1 + A_L \quad \forall m$, then $r_{CB} = \frac{1}{P^{(m)}}$. This implies no risk sharing.

With N regions in the currency union there are $N + 1$ potential realizations of aggregate production, and optimal monetary policy specifies a policy rate r_{CB} for $N - 1$ of them (there are no money flows between regions for $m = 0$ and $m = N$ and hence no role for monetary policy). Importantly, the central bank will not be able to implement the second best allocation if it commits to one policy rate for all potential states of the world. Corollary 6 summarizes this observation.

Corollary 6 (Optimal Monetary Policy is State-Contingent)**.**
Optimal monetary policy follows a state-contingent schedule: $\boldsymbol{r_{CB}^{(m)}} = \{r_{CB}^{(0)}, r_{CB}^{(1)}, ..., r_{CB}^{(N)}\}$*. That is, for each realization of the aggregate production, the central bank sets a distinct policy rate.*

At $t = 0$, the central bank implements the second best risk sharing allocation by announcing refinancing rates which depend on the realization of aggregate production at $t = 1$. The announced refinance rate schedule is such that regional bankers are incentivized to exert effort. Providing incentives comes at the cost of only partial insurance against production risks. The implementation of the second best allocation in the decentralized economy requires the central bank to have full commitment to its announced refinance rates. In Section 6.1, I analyze how commitment can be guaranteed through the design of decision making within the central bank.

The next Proposition establishes the comparative statics of optimal monetary policy.

Proposition 5 (Comparative Statics of Optimal Monetary Policy)**.**
The optimal monetary policy rate r_{CB} *is increasing in both the agency wedge* γ *and aggregate production* m*.*

Optimal monetary policy is driven by two considerations. First, for any given aggregate output level m, the central bank needs to implement the agency wedge γ in order to provide incentives. The higher the agency wedge γ, the more the central bank distorts the allocation away from perfect risk sharing. As a result, the optimal rate r_{CB} is increasing in the agency wedge γ.[12] Second, for any given agency wedge γ, the central bank changes its policy rate in response to changes in aggregate production m. More specifically, the second best allocation implies that the consumption of a region in low state is increasing in aggregate production m. This requires larger current account finance through the central bank, i.e. a reduction in r_{CB}. As a result, lower values for m imply lower values for r_{CB} in optimum. Corollary 7 summarizes this observation.

[12]The Appendix provides comparative statics with respect to $\{k, q, \eta, A_L, A_H\}$. $\{k, q, \eta\}$ influence optimal policy through the agency wedge only while A_L and A_H influence optimal policy through both the agency wedge and aggregate production.

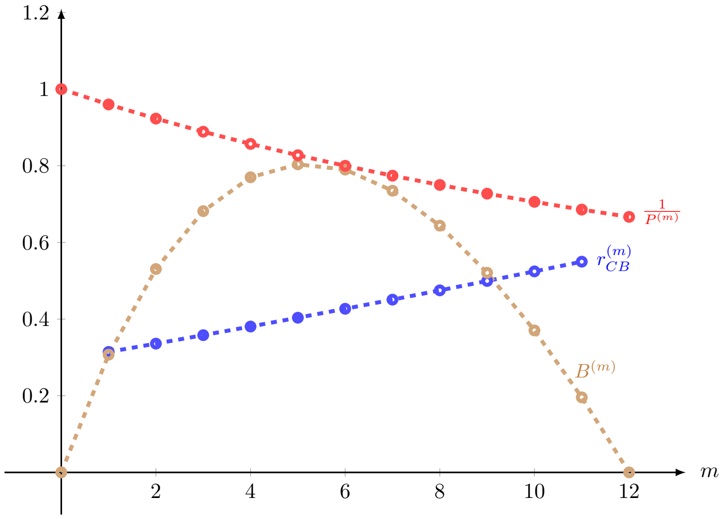

Figure 4: Optimal policy rate $r_{CB}^{(m)}$, optimal overdraft balances $B^{(m)}$, and market rate $\frac{1}{P^{(m)}}$

Note: Model is parameterized with $q = 0.8$, $k = 0.05$, $A_L = 1$, $A_H = 1.5$, $\eta = 2$, and $N = 12$. The optimal policy rate (in blue) is increasing in aggregate production m to provide insurance through the common currency. Optimal overdraft balances (in brown) are inversely U-shaped due to the tension between more balances per region in low states (intensive margin) and the number of regions in low state as m increases (extensive margin). The market rate $\frac{1}{P}$ (in red) is monotonically decreasing in aggregate production m as money supply is independent of m.

Corollary 7 (Optimal Policy over the Cycle)**.**
The optimal policy rate r_{CB} is increasing in aggregate production m. Optimal overdraft balances B are non-monotone in aggregate production m: They increase in m for small values of m, and decrease in m for large value of m.

Figure 4 illustrates both optimal policy rates r_{CB} as well as optimal overdraft balances as a function of aggregate production m. The figure shows that the central bank optimally increases its policy rate as aggregate production increases. Further, the total amount of overdraft balances created, B, is non-monotonic. The non-monotonicity of B with respect to aggregate production m is explained by the tension between fewer regions in need of transfers as m increases, and more transfers per region as m increases. More specifically, lower values of m imply larger balances for each country with low output (intensive margin). However, as the number of countries with low output decreases in m, this increase in balance per country is counteracted by a decrease in the number of countries with a balance (extensive margin). For small values of m, the intensive margin effect dominates the extensive margin effect (and B increases in m), and vice versa for high values of m (and B decreases in m).

4.4 Equivalence between Monetary Policy and Fiscal Transfers

Overdraft balances allow the central bank of the currency union to share consumption risks between different member states. In this subsection, I show that these overdraft balances are the result of the unequal distribution of implicit *seigniorage revenue* created through the central bank's policies at $t = 1$. Further, I demonstrate that any risk sharing allocation obtained through the common currency can be obtained through fiscal transfers.

To see the connection to seigniorage more clearly, note that at $t = 0$, the central bank creates a total of M units of money. The real value of this money at $t = 1$, V_M, depends on its goods market value as well as its refinance value. More specifically, the value on the goods market is equal to $\frac{1}{P^{(m)}}$ while its refinance value is r_{CB}. Thus, the real value of money at $t = 1$ is given by

$$V_M^{(m)} = \frac{M}{P^{(m)}} + r_{CB} NET^{(m)} \tag{28}$$

so that

$$V_M\left(r_{CB} = \frac{1}{P^{(m)}}\right) - V_M\left(r_{CB}^{(m)}\right) = \frac{NET\left(1 - P^{(m)} \cdot r_{CB}^{(m)}\right)}{P^{(m)}} = \frac{B^{(m)}}{P^{(m)}} \tag{29}$$

That is, if $r_{CB} = \frac{1}{P^{(m)}}$, then a net money flow between regions has the same real value as it has on the goods market. If $r_{CB} < \frac{1}{P^{(m)}}$, however, then the value of a net money flow between regions is less than the real value of money on the goods market. Thus, the real value of money balances created at $t = 0$ is reduced by the central bank's refinancing policy at $t = 1$ if $r_{CB} < \frac{1}{P^{(m)}}$. The central bank determines the nominal value of the endowment good at $t = 1$. The market nominal value is given by $P^{(m)}$, but the central bank can attach a value higher than that. The central bank's privilege of being the sole provider of currency in the economy means that it can monetize endowment goods above market rates, thereby devaluing net money flows between regions. The real value of this devaluation is given by the real value of overdraft balances which is $\frac{B^{(m)}}{P^{(m)}}$. I refer to the real value of overdraft balances as implicit *seigniorage* revenue.

Definition 6 (Seigniorage Revenue)**.**
The central bank's seigniorage revenue $S^{(m)}$ from refinancing operations at the end of the period is given by $S^{(m)} = \frac{B^{(m)}}{P^{(m)}} = B^{(m)}\frac{Y^{(m)}}{N}$.

Seigniorage revenue is a fraction $B^{(m)}$ of average output in the economy. Proposition 6 derives the seigniorage revenue required to implement the second best allocation.

Proposition 6 (Optimal Seigniorage Revenue)**.**
The central bank's seigniorage revenue $S^{(m)}$ from implementing the second best allocation is given by

$$S^{(m)} = \frac{B^{(m)}}{P^{(m)}} = \frac{(N-m)m\left[1 + A_H - \gamma(1 + A_L)\right]}{N + (\gamma - 1)m} \tag{30}$$

The total seigniorage revenue accrues to regions in a low state. Total seigniorage revenue is increasing in m for small m and decreasing in m for large m.

The seigniorage proceeds through the buildup of overdraft balances are fully distributed to regions with a net money deficit at $t = 1$. That is, the real resource transfer required to achieve the second best allocation is implemented through an uneven distribution of seigniorage revenue among regions. The required seigniorage revenue is largest for intermediate values of aggregate production m. The reason for this is similar to the logic for total balances. Larger values of m lead to lower real transfers required for each country with low output (intensive margin). At the same time, however, larger values of m imply fewer regions with low output (extensive margin). The first effect dominates the second for low values of m, while the second effect dominates the first for large values of m. This implies that the total amount of seigniorage revenue is largest for an intermediate value of m.

To shed further light on the quasi-fiscal effects of monetary policy in this model, consider the case of a fiscal union without any monetary transactions. Assume that the fiscal authority can transfer real resources between different regions through taxes and transfers.

Definition 7 (Fiscal Policy)**.**
The fiscal authority sets a tax rate $t \in (0, 1)$ on output produced in the economy, and redistributes the tax revenue $T \equiv t\,[N + mA_H + (N - m)A_L]$ back to regions. A fraction θ of total tax revenue goes to regions with low output, and a fraction $1 - \theta$ to regions with high output.

The fiscal union effectively sets up an ex post risk-sharing arrangement. The following Proposition shows that the fiscal authority can achieve the same allocation through taxes and transfers as the central bank through its choice of the real refinancing rate.

Proposition 7 (Equivalence to Fiscal Transfers)**.**
The fiscal authority implements the second best allocation by taxing all output at rate

$$t^{(m)} = \frac{(N - m)\,[1 + A_H - \gamma(1 + A_L)]}{(1 + A_H)\,[N + (\gamma - 1)m]} \tag{31}$$

and redistributing all revenue to regions with low output. It holds that $t^{(m)} \cdot m(1 + A_H) = S^{(m)}$.

Optimal fiscal policy is described by a tax rate which depends on the realization of aggregate production risk, m. That is, just like optimal monetary policy, optimal fiscal policy is state dependent. Importantly, Proposition 7 shows that the second best allocation can be achieved through a fiscal authority that effectively taxes regions in high state and transfers the tax revenue to regions in low state. The so-obtained real resource transfer between regions is exactly equal to the seigniorage revenue $S^{(m)}$ generated through the central bank in a currency union.

Thus, a fiscal authority in a fiscal union is able to use the tax-transfer system to achieve the same allocation achieved by the central bank in a monetary union through monetary policy. I conclude that the central bank's refinancing decisions are quasi-fiscal. They imply real resource transfers between different regions as they distribute implicit seigniorage revenue to regions with low output.

5 TARGET Balances: The Common Currency Channel in Action

Section 4 established three main results. First, a common currency is able to insure union members against idiosyncratic production risks, thereby achieving consumption risk sharing. Second, potential moral hazard problems of such an insurance scheme can be addressed through a central bank which strikes the balance between insurance and incentives through its policy decisions. Third, the central bank sets the policy rate according to a schedule $\boldsymbol{r_{CB}^{(m)}} = (r_{CB}^{(0)}, r_{CB}^{(1)}, ..., r_{CB}^{(N)})$ which depends on aggregate production m. As the number of regions with high output decreases (lower m), the central bank responds with a decrease in its policy rate r_b, i.e. $r_{CB}^{(m-1)} < r_{CB}^{(m)}$. This reduction in refinancing rates leads to a buildup of overdraft balances B. These balances are a symptom of risk sharing through the common currency.

In this section, I argue that the European Central Bank (ECB) provided risk sharing through the common currency during the Eurocrisis from 2008 to 2014. Section 5.1 interprets the accumulation of TARGET debt within the Eurosystem as risk sharing through the common currency.[13] TARGET balances are equivalent to central bank overdraft balances B in my model. In section 5.2, I construct a counterfactual exercise to calculate the real resource transfers between the different Eurozone countries achieved through TARGET flows. Section 5.3 follows the approach pioneered in Asdrubali et al. (1996) to estimate the contribution of "TARGET transfers" to total risk sharing within the Eurosystem.

5.1 Balance of Payment and TARGET Balances

The balance of payment identity for an individual country is given by

$$CA + FA + OB = 0 \tag{32}$$

where CA denotes the current account balance, FA is the financial account balance, and OB is the official settlement balance. The latter represents the change in a country's foreign reserves (foreign currency and gold), and it is close to zero if a country is part of a flexible exchange rate regime (like the Eurozone with the rest of the world). Therefore, in the Eurozone, it holds that $OB \approx 0$. The balance of payment for each member country equals[14]

$$CA + FA + T = 0 \tag{33}$$

where T denote TARGET flows. TARGET stands for "**T**rans-European **A**utomated **R**eal-time **G**ross Settlement **E**xpress **T**ransfer System" which is the real-time gross settlement (RTGS) system for the Eurozone. That is, current account deficits of a Eurozone country are either financed through private capital flows (FA) or through the TARGET system. The TARGET system allows any Eurozone country to borrow from their national central bank to wire funds to another Eurozone country using eligible collateral.[15] Collateral requirements allow the ECB to monetize assets above market rates. Financing current account deficits through the financial

[13] TARGET2 replaced TARGET in 2007. I use the terms interchangeably.

[14] See Merler & Pisani-Ferry (2012) and Higgins & Klitgaard (2014) for a description of balance of payments within a currency union.

[15] See Bindseil & König (2011), Whelan (2014), and Tornell (2018) for a more detailed description of the TARGET system.

account, on the other hand, implies selling assets at market prices. Using the notation from my model it holds that, for an individual Eurozone country with a current account deficit, $CA_L = \frac{NET_L}{P}$, $T = -(1 - P \cdot r_{CB})NET_L$, and $FA = -P \cdot r_{CB} \cdot NET_L$ where $NET_L < 0$.

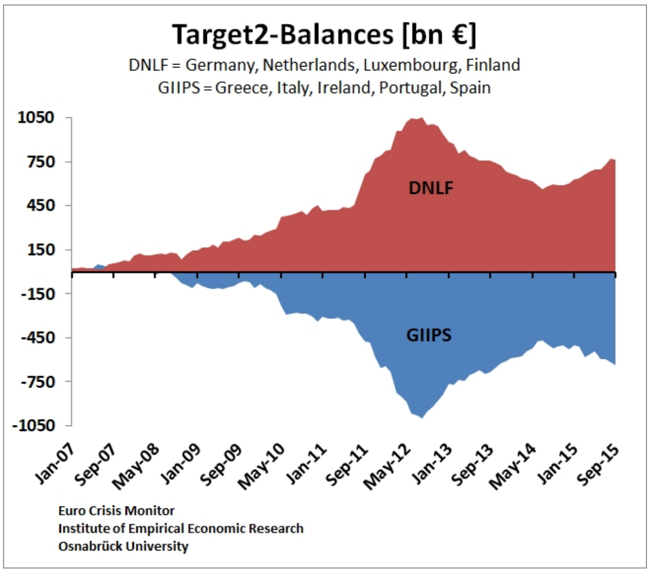

Figure 5: TARGET Balances in the Eurosystem

Note: TARGET balances measure intra-Eurozone net currency flows. If a country has a positive TARGET balance, this country had more inflow of currency from other countries than currency outflow to other countries. Similarly, negative TARGET balances indicate a net outflow of the common currency. TARGET balances represent the overdraft balances introduced in the theoretical section.

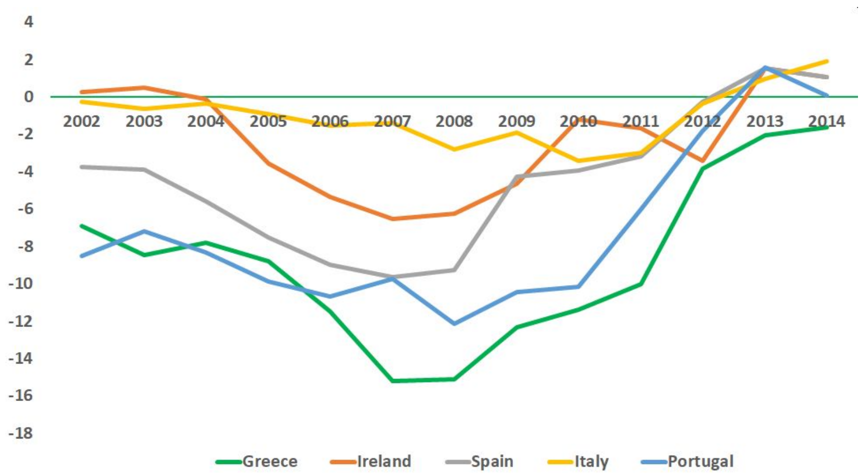

Figure 6: Current Account Balances of Periphery Countries (in % of GDP)

Note: All periphery countries had current account deficit at the onset of the Eurocrisis in 2008. During the following years, these countries adjusted their current account imbalances and, apart from Greece, had reverted a current account deficit into a surplus by 2013. I argue that TARGET balances allowed for a gradual adjustment of current account imbalances instead of an abrupt adjustment which would have been likely without the common currency. Data from the OECD.

Figure 5 shows that during the Eurocrisis between 2008 and 2014, TARGET balances within the Eurozone grew substantially. Periphery countries (Greece, Ireland, Italy, Portugal, Spain) accumulated large negative TARGET balances with Core countries (Germany, Netherlands, Luxembourg, Finland).

Furthermore, as Figure 6 shows, these TARGET balances arose while at the same time Periphery countries maintained current account deficits. Contrasting the official settlement balance in eq. (32) with the TARGET flows in eq. (33) suggests that, without the common currency, Periphery countries would have run down their foreign reserves in order to maintain current account deficits with Core countries. However, eventually the national central banks would have run out of foreign reserves, and the current account would have had to adjust. The TARGET system prevented this rundown of foreign reserves as it gave Periphery countries potentially unlimited access to foreign reserves. The limits to this access were defined by the ECB which enabled the buildup of these large TARGET balances through its policy decisions as Table 1 demonstrates.

Date	Policy measure
15 October 2008	Full allotment policy
25 October 2008	Minimum rating of collateral reduced from single A to triple B
30 October 2008	Maturity of LTROs[a] extended to six months
1 February 2009	Acceptance of government guaranteed own-use bonds as collateral
23 June 2009	First of three LTRO tenders with a maturity of 12 months
6 May 2010	Rating requirement waived for bonds issued or guaranteed by Greece
1 April 2011	Rating requirement waived for bonds issued or guaranteed by Ireland
7 July 2011	Rating requirement waived for bonds issued or guaranteed by Portugal
21 December 2011	First of two LTRO tenders with a maturity of 3 years
29 June 2012	Lowering of rating requirement to triple B for all ABS[b]

Table 1: Changes in ECB Refinancing Policy (taken from Sinn (2014))

Note: The table shows some of the most important changes in refinancing policies taken by the European Central Bank during the period 2008-2013. The ECB moved away from a policy of lending against good collateral towards lending against low quality collateral. In the language of the model presented earlier, I interpret these changes as a decrease in the real refinancing rate r_{CB}.

[a] Long-Term Refinancing Operations
[b] Asset-backed securities

Table 1 summarizes some of the most important changes in the ECB's refinancing policy during the Eurocrisis. Before the onset of the financial crisis in 2008, the ECB auctioned *limited amounts* of central bank money *short-term* to commercial banks against *high-quality collateral.* During the course of the Eurocrisis, the ECB gradually changed its refinancing policies towards unlimited amounts of central bank money ('full allotment policy') which were lent long-term (LTRO operations) against low-quality collateral (reduced rating requirements). All in all, the measures taken by the ECB provided cheap refinancing credit to banks in Periphery countries that suffered from a reversal of private capital flows.

Sinn (2014) refers to the policy measures taken by the ECB as "help from the printing press" (p. 153). In light of the analysis presented in section 4, I interpret these measures as the ECB providing risk sharing through the common currency. In the absence of effective traditional risk sharing channels (credit market, capital market or fiscal transfers), the ECB partially insured Periphery countries against the adverse effects of their negative shocks on consumption.[16] In the language of my model, the change in ECB refinancing policies in Table 1 reflect a decrease in the real refinancing rate r_{CB}. This decrease of the real refinancing rate resulted in large TARGET balances which mirror overdraft balances in my model. That is, the ECB monetized assets at a higher than market rate, and thus provided money to Periphery countries through the TARGET system which helped to refinance current account deficits at a real rate lower than the market rate.[17]

5.2 Quantifying "TARGET Transfers"

To quantify the amount of real resource transfers through the TARGET system, I conduct the following counterfactual exercise for Eurozone countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain) from 2002 - 2014.[18]

1. For each country, I determine the amount of current account deficit financed through TARGET flows using the balance of payment identity. That is, if $CA < 0$, then $\min\{1, \frac{\Delta T}{CA}\}$ measures the fraction of current account deficits financed through an increase in TARGET imbalances.
2. Assume that without the TARGET flows, the country's current account balance would have improved one for one.[19]
3. Assume that if a country reduces its current account deficit, it does so by cutting back on its imports. This leads to a reduction of exports for each import partner. Trade partners are affected proportionally to their import trade share.[20]
4. Calculate *adjusted current account balances* for all countries in the panel. "TARGET transfers" are the difference between actual current account balances and adjusted current account balances.

[16] In addition to these refinancing policy changes by the ECB, national central banks within the Eurosystem were allowed to grant assistance to commercial banks within the ELA ('Emergency Liquidity Assistance') program. This program has been used mostly by Greece, Ireland, and Cyprus. See Sinn (2014).

[17] Strictly speaking, TARGET balances are credit between countries secured by collateral used in the central bank's refinancing operations. In my model, this decrease in collateral requirements is a real resource transfer between countries. Technically, the real resource transfer only materializes if a country defaults on its debt and the creditor country seizes the collateral. Imposing probabilities of default would allow to interpret the decrease in collateral requirements as an (expected) real resource transfer between countries.

[18] See Appendix B.1. for data source description.

[19] It is not straightforward to predict how current account balances of Periphery countries would have evolved without the TARGET system. Edwards (2004) shows in a cross-country panel that capital account reversal are typically accompanied by instant current account reversal. See also Cecchetti & Schoenholtz (2018) who show that during the Asian crisis, the current account balance of the ASEAN-5 (Indonesia, Malaysia, Philippines, Singapore, and Thailand) increased from about -3% of GDP in 1997 to around +7% of GDP in 1998.

[20] That is, if country A has to reduce its current account deficit by €x and y% of its imports stem from country B, then country B will see a reduction of its exports by € $y/100 \cdot x$.

Country	Year	CA financed through TARGET (% of CA)	Implied TARGET Transfer (% of GDP)
Portugal	2008	23.5%	2.1%
Portugal	2009	23.3%	2%
Portugal	2010	100%	9.6%
Portugal	2011	100%	5.5%
Portugal	2012	100%	1.7%
Italy	2010	55.7%	1.6%
Italy	2011	100%	2.8%
Italy	2012	100%	0.2%
Ireland	2008	100%	5.7%
Ireland	2009	100%	4.3%
Ireland	2010	100%	0.6%
Ireland	2011	100%	1.1%
Greece	2008	18.3%	2.7%
Greece	2009	78.5%	9.7%
Greece	2010	100%	11.2%
Greece	2011	70.6%	6.9%
Greece	2012	100%	3.8%
Spain	2008	35.6%	3.0%
Spain	2009	40.1%	1.5%
Spain	2010	57%	1.4%
Spain	2011	45.8%	0.8%
Spain	2012	100%	0.09%

Table 2: Implied TARGET Transfer for Periphery during Eurocrisis

Note: The table shows the fraction of current account deficits that were refinanced through changes in TARGET balances for Periphery countries between 2008 and 2012. These fractions are calculated using the Balance-of-Payments identity: $CA + FA + T = 0$. *If a country has a current account deficit* ($CA < 0$) *and an increase in TARGET deficits at the same time* ($T > 0$), *then refinance of current account deficits through TARGET balances account for a fraction* $\min\{1, \frac{T}{CA}\}$ *of current account deficits. Implied TARGET transfers are calculated by reducing the current account deficit by the fraction which is financed through TARGET balances.*

Table 2 presents the fraction of the current account deficit financed through TARGET balances and the implied TARGET transfers (in % of GDP) for the Periphery countries during selected years of the Eurocrisis. Effectively, the current account adjustments lead to a redistribution of consumption between the different Eurozone countries in each period. Since it holds that

$$\text{current account balance} = \text{domestic saving} - \text{domestic investment}$$

a decrease in the current account deficit implies an increase in (net) domestic savings, while an increase in the current account deficit implies a decrease in (net) domestic savings. This implies that, in this counterfactual exercise, a country with a current account deficit partly financed by TARGET flows will see a reduction in consumption while a country with a current account surplus which is partly paid for via TARGET will see an increase in consumption. That is, some countries will see positive TARGET transfers while others will see negative TARGET transfers.

As Table 2 illustrates, the implicit consumption transfers through TARGET balances during the peak of the Eurocrisis (2008-2012) were substantial. For example, Greece obtained an implicit transfer through TARGET flows of €2741 per person in 2009 and of €2302 in 2010. These are 9.7% and 11.2% of GDP per capita, respectively. Similarly, Ireland obtained a consumption transfer per person equal to €2374 in 2008 and €1663 in 2009 (5.7% and 4.2% of GDP per capita, respectively). Portugal enjoyed a consumption transfer through TARGET of €1742 per person in 2010 and €941 in 2011 (9.6% and 5.4% of GDP per capita, respectively).[21]

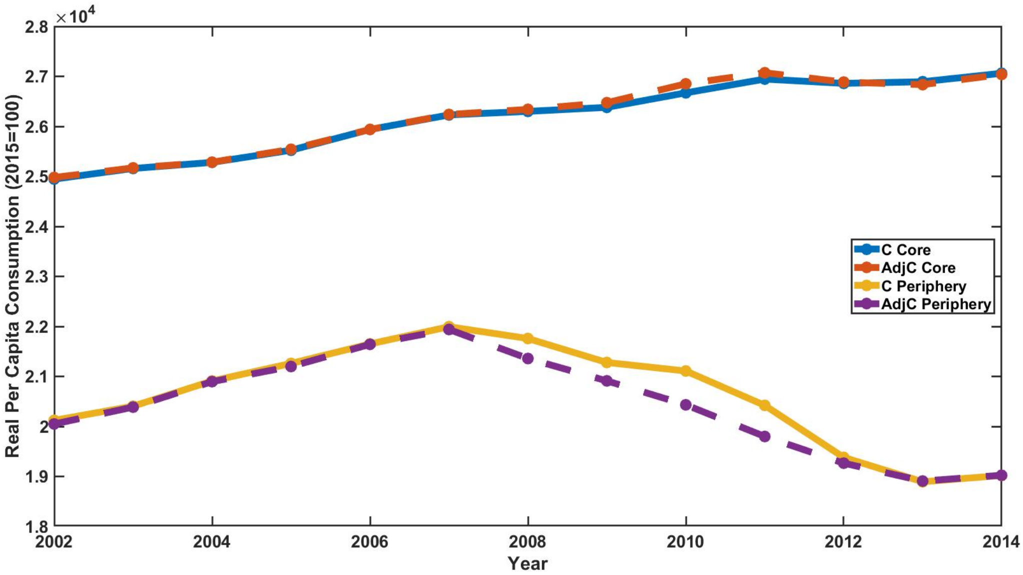

Figure 7: Resource Transfers through TARGET

Note: The figure shows the actual real per-capita consumption levels of Core countries (blue) and Periphery countries (yellow). Subtracting the implied TARGET transfers in each year gives the adjusted consumption series for Core countries (red) and Periphery countries (violet). The figure shows that between 2008 and 2012, implied TARGET transfers cushioned the otherwise strong decline in consumption levels for Periphery countries.

Figure 7 illustrates the significance of TARGET transfers for consumption smoothing in Periphery countries. It contrasts the difference between real per capita consumption with the actual current account balances and real per capita consumption with the adjusted current account balances. Countries are grouped into 'Core' and 'Periphery' countries, and the figure shows the average real per capita consumption levels for these two groups.[22] The solid lines in the figure represent the average real per capita consumption levels during the years 2002 and 2014 as they appear in the data, and the dashed lines represent the adjusted consumption levels without TARGET transfers obtained through the counterfactual exercise described above. It

[21] TARGET transfers for Core countries are reported in Appendix B.2.

[22] Core countries are Austria, Belgium, Finland, France, Germany, Luxembourg, Netherlands. Periphery countries are Portugal, Ireland, Italy, Greece, Spain.

is apparent that until 2007, TARGET transfers played virtually no role in financing current account imbalances. Between 2008 and 2012, however, the TARGET system implied significant resource transfers from Core to Periphery countries. TARGET transfers allowed Periphery countries to maintain higher current account deficits than would have otherwise been the case, thereby smoothing the negative effects of the financial crisis and the implied economic slowdown on consumption. The figure shows that TARGET transfers turned insignificant again after 2012. This is the case since Periphery countries had reduced their current account deficits by then and the TARGET system was no longer used to finance current account deficits.[23]

Again, the TARGET system allowed for a smoother reversal in current account deficits than is usually the case in balance of payment crisis in which a (sudden) reversal of capital inflows implies an instant reversal in current account deficits.[24] In the following subsection, I will quantify the contribution of the common curreny channel of risk sharing to total risk sharing among Eurozone countries during the Eurocrisis from 2008-2014.

5.3 Risk Sharing through "TARGET Transfers"

The literature on international risk sharing distinguishes three channels of risk sharing. First, countries can share risk via the cross-ownership of productive assets which is facilitated by a well-developed capital market (capital market channel). Second, countries can share risk if they are part of a fiscal union in which a central government can redistribute consumption through the tax-transfer system (fiscal channel). Third, countries may smooth their consumption though adjusting their asset portfolio, i.e. through lending and borrowing on credit markets (credit market channel). The academic consensus is that traditional risk sharing channels are less well-developed in the Eurozone than in the United States (see Ioannou & Schäfer (2017) for an overview). Previous literature has established the role of European institutions in improving risk sharing during the Eurocrisis (Milano et al. (2017) and Cimadomo et al. (2018)) and the role of austerity programs in reducing the amount of risk sharing (Kalemli-Ozcan et al. (2014)). My contribution to this literature is to quantify the contribution of the common currency channel to total risk sharing.

To test for the quantitative relevance of "TARGET transfer" in providing risk sharing, I follow the methodology developed in Asdrubali et al. (1996). They decompose the cross-sectional variance of shocks to GDP as follows:

$$GDP_t^i = \frac{GDP_t^i}{GNI_t^t}\frac{GNI_t^i}{NI_t^i}\frac{NI_t^i}{DNI_t^i}\frac{DNI_t^i}{C_t^i}C_t^i \tag{34}$$

where GNI=GDP+net factor income (capital market channel), NI = GNI-capital depreciation (capital depreciation channel),[25] DNI = NI+international transfers (fiscal channel),

[23] Between 2007 and 2013, Portugal turned its current account deficit of 9.7% of GDP into a surplus of 1.18% of GDP, Italy turned its deficit of 1.37% of GDP into a surplus of 0.94% of GDP, Ireland turned its deficit of 6.54% of GDP into a surplus of 1.5% of GDP, Greece reduced its current account deficit from 15.22% of GDP to 2% of GDP, and Spain turned its deficit of 9.63% of GDP into a surplus of 1.52% of GDP. See Figure 6.

[24] See Merler & Pisani-Ferry (2012) for a discussion of sudden stops during the Eurocrisis. Edwards (2004) provides evidence regarding the relationship between sudden stops and current-account reversals using panel data.

[25] Depreciation is calculated according to fixed accounting rules. In the data, the capital-output ratio is countercyclical which then implies that if GDP is decreasing, capital depreciation will constitute a higher fraction

$C = DNI$-net savings (credit market channel). I add a fifth channel to the decomposition by introducing $Adj.C$ as the consumption level after adjusting the current account balances for TARGET finance, i.e. (Adj.C=DNI-net savings-TARGET transfers) and (C=Adj.C+TARGET transfers). That is, I decompose GDP according to

$$GDP_t^i = \frac{GDP_t^i}{GNI_t^t}\frac{GNI_t^i}{NI_t^i}\frac{NI_t^i}{DNI_t^i}\frac{DNI_t^i}{Adj.C_t^i}\frac{Adj.C_t^i}{C_t^i}C_t^i \tag{35}$$

Taking logs and differences on both sides of the equation, multiplying both sides by $\Delta \log GDP_t^i$, and taking the cross-sectional average gives the following variance decomposition

$$\begin{aligned} var\{\Delta \log GDP_t^i\} =& cov\{\Delta \log GDP_t^i - \Delta \log GNI_t^i, \Delta \log GDP_t^i\} \\ &+ cov\{\Delta \log GNI_t^i - \Delta \log NI_t^i, \Delta \log GDP_t^i\} \\ &+ cov\{\Delta \log NI_t^i - \Delta \log DNI_t^i, \Delta \log GDP_t^i\} \\ &+ cov\{\Delta \log DNI_t^i - \Delta \log Adj.C_t^i, \Delta \log GDP_t^i\} \\ &+ cov\{\Delta \log Adj.C_t^i - \Delta \log C_t^i, \Delta \log GDP_t^i\} \\ &+ cov\{\Delta \log C_t^i, \Delta \log GDP_t^i\} \end{aligned} \tag{36}$$

Dividing by $var\{\Delta \log GDP_t^i\}$ we get that

$$1 = \beta_f + \beta_d + \beta_t + \beta_s + \beta_{TARGET} + \beta_u \tag{37}$$

where

$$\beta_{TARGET} = \frac{cov\{\Delta \log Adj.C_t^i - \Delta \log C_t^i, \Delta \log GDP_t^i\}}{var\{\Delta \log GDP_t^i\}} \tag{38}$$

is the ordinary least square estimate of the slope in the cross-sectional regression of $\Delta \log Adj.C_t^i - \Delta \log C_t^i$ on $\Delta \log GDP_t^i$. This approach implies that β_u measures the fraction of GDP shocks which are not smoothed. β_f denotes the fraction of shocks to GDP smoothed through the capital market channel, β_d through capital depreciation channel, β_t through the international transfers channel, β_s through the credit market channel, and β_{TARGET} through the common currency channel. β_{TARGET} is thus interpreted as the fraction of shocks absorbed through TARGET transfers. It measures the incremental amount of smoothing achieved through the common currency channel.

The following (panel) equations are estimated:

$$\Delta \log GDP_t^i - \Delta \log GNI_t^i = \nu_{f,t} + \beta_f \Delta \log GDP_t^i + \epsilon_{f,t} \tag{39}$$

$$\Delta \log GNI_t^i - \Delta \log NI_t^i = \nu_{d,t} + \beta_d \Delta \log GDP_t^i + \epsilon_{d,t} \tag{40}$$

$$\Delta \log NI_t^i - \Delta \log DNI_t^i = \nu_{t,t} + \beta_t \Delta \log GDP_t^i + \epsilon_{t,t} \tag{41}$$

$$\Delta \log DNI_t^i - \Delta \log Adj.C_t^i = \nu_{s,t} + \beta_s \Delta \log GDP_t^i + \epsilon_{s,t} \tag{42}$$

$$\Delta \log Adj.C_t^i - \Delta \log C_t^i = \nu_{T,t} + \beta_{TARGET} \Delta \log GDP_t^i + \epsilon_{T,t} \tag{43}$$

$$\Delta \log C_t^i = \nu_{f,t} + \beta_u \Delta \log GDP_t^i + \epsilon_{u,t} \tag{44}$$

of GDP. As a result, this channel tends to be dis-smoothing. As this channel is mechanical, it is usually not given much attention in the literature (Asdrubali et al. (1996) did not include it in their analysis). See Sørensen & Yosha (1998) for a discussion.

	2003-2007	2008-2009	2010-2014
Factor Income (β_f)	0.334	-0.268	0.007
	(0.337)	(0.338)	(0.073)
Capital Depreciation (β_d)	0.026	-0.143	-0.110***
	(0.037)	(0.160)	(0.032)
International Transfers (β_t)	0.083	0.078	-0.051
	(0.187)	(0.075)	(0.055)
Savings (β_s)	0.222	0.402	0.586***
	(0.587)	(0.562)	(0.088)
TARGET (β_{TARGET})	0.064	0.392*	-0.251**
	(0.090)	(0.223)	(0.118)
Not Smoothed (β_u)	0.272***	0.362***	0.804***
	(0.087)	(0.018)	(0.076)

Standard errors are in brackets. *p<0.1; **p<0.05; ***p<0.01.

Table 3: Risk Sharing Channels: Entire Sample

Note: The table shows the results from performing the regressions in (39)-(44) for the 12 Eurozone countries in the sample and for the three different subperiods: before Eurocrisis (2003-2007), first stage of Eurocrisis (2008-2009), and second stage of Eurocrisis (2010-2014). Each coefficient is interpreted as the incremental increase in consumption risk sharing through the corresponding channel. Values can be negative if a channel is dis-smoothing. Values for each time period add up to one.

where $\nu_{\cdot,t}$ are time fixed effects. The time fixed effects capture year specific impacts on growth rates, most importantly the impact of growth in aggregate Eurozone output. The β-coefficients are weighted averages of the year by year cross-sectional regressions, obtained through OLS estimation. Standard errors are obtained from a two step Generalized Least Square procedure, allowing for autocorrelation in residuals and for state specific variances of the error terms in the estimation. Table 3 reports the results from the estimation for the entire sample.[26]

In the entire sample, the TARGET channel was quantitatively not important between 2003 and 2007. During the early stages of the Eurocrisis (2008-2009), the TARGET channel became quantitatively and statistically significantly important for risk sharing between Eurozone countries. In fact, in these two years, the channel accounts for around 60% of the consumption smoothing achieved within the Eurozone. Without TARGET transfers, 75.4% of shocks to GDP would have been unsmoothed, while with TARGET transfers this number drops to 36.2%.[27] After 2009, the channel still has a significant impact, but its sign turns negative: TARGET transfers are dis-smoothing between 2010 and 2014. This result is explained by the fact that TARGET transfers are positively correlated with current account deficits which are

[26] Appendix B.3. reports additional results for the subsample of Core and Periphery countries.

[27] This implies that TARGET transfers contribute to $\frac{0.392}{1-0.362} = 0.614$, i.e. 61.4% of total risk sharing among Eurozone countries in 2008 and 2009.

positively correlated with GDP in the data after 2009. This tends to make TARGET transfers countercyclical, especially at the later stages of the Eurocrisis (2010-2014) where current account deficits are decreasing. More specifically, TARGET transfers are high when a significant amount of current account deficits are financed through TARGET flows. As Periphery countries reduced their current account deficits during the Eurocrisis at the same time as these countries experienced recessions (decrease in GDP), the data shows that the growth in TARGET transfers is negatively correlated with GDP growth, thus having a dis-smoothing effect. However, this procyclicality only shows after 2010. In 2008 and 2009, Periphery countries already experienced a reversal of capital outflows and a significant fraction of their current account deficits was financed through TARGET balances. During those years, GDP growth was slowing down which makes TARGET transfers countercyclical, thereby contributing to risk sharing.

6 Extensions

In this section, I extend the model in different ways. First, I address the issue of time inconsistency of optimal monetary policy. Second, I elaborate on why a monetary environment with different currencies will not lead to risk sharing. Third, I contrast the common currency channel of risk sharing with the capital market channel. I establish that this channel is ineffective in the model economy described in section 2.

6.1 Central Bank Commitment

As demonstrated in Proposition 4, the central bank implements the second best allocation by following a state-contingent schedule for its policy rate r_{CB}. The reason why the central bank should not always refinance money deficit at zero cost ($r_{CB} = 0$) is that this would destroy incentives for reason ex ante to exert effort. Instead, the central bank provides incentives at the beginning of period t by announcing its policy rate schedule $\boldsymbol{r}_{\boldsymbol{CB}}^{(m)}$. However, this schedule is not necessarily time-consistent. More specifically, if the benevolent central bank has provided incentives by announcing the optimal schedule, it finds it optimal to perfectly share risks ex post after the regional shock have been realized, i.e. to set $r_{CB} = 0$ at every possible state of the world. Anticipating this, regional bankers will not exert effort. Hence, the central bank suffers from a time-inconsistency problem which is novel to the literature on central bank commitment (see Barro & Gordon (1983) and Chari & Kehoe (2008) for other examples of central bank time inconsistencies).

As there is one central bank setting the monetary policy rate for many regions, assume that each region has one vote in determining the central bank policy rate decision. More specifically, assume that the central bank's *governing council* consists of all the regional bankers in the currency union. Further, assume that regional bankers vote anonymously over the policy rate schedule $\boldsymbol{r}_{\boldsymbol{CB}}^{(m)}$ and potential deviations from it at the end of every period t.

Definition 8 (Anonymous Voting)**.**
A voting rule F in the central bank council is anonymous if regional bankers are treated symmetrically: $F(R_1, ..., R_n) = F(R_{\pi(1)}, ..., R_{\pi(n)})$ for any profile R and any permutation $\pi : \mathbb{N} \to \mathbb{N}$.

Under anonymous voting, each regional banker has one vote and each banker's vote counts equally towards determining the central bank policy rate. The following Proposition shows how the central bank's time-inconsistency problem can be overcome by a proper design of decision making within the central bank governing council.

Proposition 8 (Central Bank Commitment)**.**
Assume that at the end of t, regions have a preference profile $R = (R_1, ..., R_n)$ over the policy parameter r_{CB} and assume that decision making within the central bank follows anonymous voting. Then, the central bank can overcome its commitment issue if ex post changes to announced policies require unanimity among union members.

Regions with a low productivity shock will want the central bank to change its policy at $t = 1$ to $r_{CB} = 0$. On the other hand, a region with a high productivity shock will want the central bank to increase the policy rate from what was announced at $t = 0$. Proposition 8 establishes that neither of these two regions will be able to change the announced policy rate if decisions are to be taken unanimously. This allows the central bank to overcome its time-inconsistency problem.

6.2 Monetary Equilibrium with Different Currencies

Assume that each region issues its own currency. This implies that there is no central bank. The equilibrium of the monetary economy with multiple currencies is defined as follows.

Definition 9 (Monetary Equilibrium with Multiple Currencies)**.**
A monetary equilibrium with multiple currencies consists of an aggregate production realization m, regional banker effort levels $(e_1, e_2, ..., e_n)$, money creation levels $(M_1, M_2, ..., M_n)$, price levels $(P_1, P_2, ..., P_n)$, and $(c_1, c_2, ..., c_n)$ such that the regional bankers maximize household utility and the N different goods markets clear.

As regional firms need to pay back loans in their regional currency, the value of the money issued by regional banker i is ultimately determined by the output produced in region i. Effectively, with N different currencies, there are N goods markets which clear at N price levels. Each goods market clears according to the quantity equation:

$$M_i = Y_i P_i \tag{45}$$

Thus, at the end of the period, the real value of i-currency is given by

$$\frac{1}{P_i} = \frac{Y_i}{M_i} = \begin{cases} A_H & \text{if } \xi_i = H \text{ and } e_i = 1 \\ A_L & \text{if } \xi_i = L \text{ or } e_i = 0 \end{cases} \tag{46}$$

The different regional price levels give rise to real exchange rates between different currencies. Consider any generic region i and region j. The real exchange rate between i-currency and j-currency is given by

$$\frac{P_i}{P_j} = \begin{cases} 1 & \text{if } A_i = A_j \\ \frac{A_H}{A_L} > 1 & \text{if } \{A_i, A_j\} = \{A_L, A_H\} \\ \frac{A_L}{A_H} < 1 & \text{if } \{A_i, A_j\} = \{A_H, A_L\} \end{cases} \tag{47}$$

which is in line with the standard theory of purchasing power parity. The fact that real exchange rates between different currencies is not equal to 1 for all states of the world prevents risk sharing between regions. The next subsection shows that currency swaps as a form of Arrow security trades at the beginning of each period will not generally be able to implement the second best allocation due to moral hazard either.

6.3 Capital Market Channel of Risk Sharing

An integrated capital market allows risk sharing through the cross-border ownership of assets. Consider Arrow security trades as such a risk sharing arrangement. Assume that at the beginning of the period, regions are allowed to trade claims on each other's output, thereby diversifying their idiosyncratic production risk. The following Proposition shows that such Arrow security trades cannot generally implement the second best allocation.

Proposition 9 (Risk Sharing Through Capital Markets).
In the case of unobservable banker effort, $\exists\ \bar{N} \in [1, \infty)$ *such that*

1. *If security trades are unobservable:*
   $\forall N > \bar{N}, Y^{(m)} = NA_L\ \forall m = (0, ..., N)$, $c_i = A_L\ \forall i = (0, 1, ..., N)$ *and*
   $\forall N \leq \bar{N}, Y^{(m)} = mA_H + (N - m)A_L, c_i = \frac{mA_H + (N-m)A_L}{N}\ \forall i = (0, 1, ..., N)$.

2. *If security trades are observable:*
   Regions trade Arrow securities in groups of $\bar{N}$ *regions in which* $Y^{(m)} = mA_H + (\bar{N} - m)A_L, c_i = \frac{mA_H + (\bar{N}-m)A_L}{\bar{N}}\ \forall i = (0, 1, ..., \bar{N})$

With unobservable banker effort, regional bankers are inclined to join a risk sharing coalition consisting of many other regions, and then free-ride on other bankers' effort. If security trades are unobservable,[28] then regional bankers will do exactly that. This will lead to an under-provision of effort, all regions end up in the low state and hence, the risk sharing coalition actually reduces welfare as regional bankers are 'over-diversified'. If the number of regions is sufficiently small ($N \leq \bar{N}$), then regional bankers internalize their impact on aggregate output and as a result, they will provide effort. Similarly, if security trades are observable, regions can prevent each other from over-diversifying by restricting trade to regions which have up to $\bar{N} - 1$ trading partners. This ensures that every region has an incentive to exert effort. However, the risk sharing value of such small-scale coalitions / security trades is limited (if $\bar{N}$ is very small, potentially close to 1), and, in general, welfare dominated by a currency union in which the central bank actively manages the common currency. In a broader sense, Proposition 9 implies that the second best allocation will generally not be achieved through fully-integrated capital markets in which different regions freely trade assets.

[28] See Kocherlakota (1998) for a discussion about the role of asset trade observability in an environment with moral hazard but otherwise complete markets.

7 Conclusion

The contribution of this paper is threefold. First, I study the mechanics of risk sharing through a common currency. Second, I derive rules for a central bank which operates the common currency channel of risk sharing in the face of moral hazard and aggregate production risk. Third, I argue that the common currency channel of risk sharing has been put to practice by the European Central Bank during the Eurocrisis between 2008 and 2014. I show theoretically that a common currency is able to efficiently share consumption risk between its member countries arising from idiosyncratic productivity shocks. Real resource transfers through the common currency are based on an unequal distribution of seigniorage revenue that accrues to the central bank through its refinancing operations. Optimal monetary policy is determined by (i) a moral hazard problem arising from the insurance though a common currency and (ii) the realization of aggregate production in the currency union. The second best risk sharing allocation implies that the central bank creates an agency wedge to incentivize union members to prevent them from free-riding on each other's production effort. Furthermore, optimal monetary policy is described by a policy rate schedule which implies that the central bank should reduce its real refinancing rate in response to a negative shock to aggregate production. It is through this reduction in its policy rate that the central bank provides the optimal amount of insurance through the common currency. Revisiting the ECB policies during the Eurocrisis, I show that the common currency channel accounted for up to 60% of total risk sharing among Euro countries at the early stages of the Eurocrisis. I conclude from this that the common currency channel is of particular relevance as an insurance mechanism when more traditional risk sharing channels are not effective or not well developed, as was the case in the Eurozone before the financial crisis in 2008. The broader point of this paper is that the central bank of a currency union can share residual risk which is not shared through the traditional channels of risk sharing via its refinancing operations. Conceptualizing this notion and studying the trade-offs arising from it are the main contributions of this paper.

It seems promising to explicitly include the common currency channel of risk sharing into the discussion of optimum currency areas. As a first step, it would be interesting to include heterogeneous regions into the model and study the consequences for optimal monetary policy. A larger or more productive region internalizes more of its impact on aggregate output and hence, it is easier to be incentivized. On the other hand, smaller or less productive regions are more inclined to free-ride in the presence of larger regions. It might be worthwhile to study the ideal composition of a currency union which maximizes the risk sharing value of the common currency. This would allow to address the question whether the Eurozone is an optimum currency area through the lens of risk sharing through a common currency. Furthermore, the common currency channel of risk sharing presented in this paper could be incorporated into a standard New Keynesian model with price rigidities. In such models, the common currency comes at the cost of the loss of exchange rates adjustments as shock absorbers which may lead to inefficiencies in labor market outcomes. Weighing the benefits of consumption risk sharing through the common currency against the costs of missing price adjustments through exchange rates allows a more comprehensive evaluation of optimum currency areas.

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Appendix

A. Proofs

A.1. Proof of Lemma 1

The Lagrangian for the first-best social planner program is given by

$$\begin{aligned} L =& q\sum_{m=0}^{N-1}\binom{N-1}{m}q^m(1-q)^{N-1-m}\frac{\left(c_H^{(1+m)}\right)^{1-\eta}}{1-\eta} + (1-q)\sum_{m=0}^{N-1}\binom{N-1}{m}q^m(1-q)^{N-1-m}\frac{\left(c_L^{(m)}\right)^{1-\eta}}{1-\eta} \\ & -\sum_{m=0}^{N}\mu^{(m)}\left[mc_H^{(m)} + (N-m)c_L^{(m)} - N - mA_H - (N-m)A_L\right] \end{aligned} \tag{48}$$

It is obvious that the RC will be binding in optimum. The first-order conditions with respect to $c_H^{(m)}$ and $c_L^{(m)}$ are then given by

$$\frac{\partial L}{\partial c_H^{(m)}} = q\binom{N-1}{m-1}q^{m-1}(1-q)^{N-m}\left(c_H^{(m)}\right)^{-\eta} - \mu^{(m)}m = 0 \tag{49}$$

$$\frac{\partial L}{\partial c_L^{(m)}} = (1-q)\binom{N-1}{m}q^m(1-q)^{N-1-m}\left(c_L^{(m)}\right)^{-\eta} - \mu^{(m)}(N-m) = 0 \tag{50}$$

which when combined imply that $c_H^{(m)} = c_L^{(m)}$ and thus,

$$c_H^{(m)} = c_L^{(m)} = \frac{N + mA_H + (N-m)A_L}{N} \quad \forall m = (0, 1, ..., N) \tag{51}$$

□

A.2. Proof of Proposition 1

1. Existence of $\bar{N}$: Assume that there is perfect risk sharing between N regions. Then, regional banker i exerts effort if

$$\sum_{m=0}^{N} \binom{N}{m} q^m (1-q)^{N-m} \frac{\left(x^{(m)}\right)^{1-\eta}}{1-\eta} - k \geq \sum_{m=0}^{N-1} \binom{N-1}{m} q^m (1-q)^{N-1-m} \frac{\left(x^{(m)}\right)^{1-\eta}}{1-\eta} \tag{52}$$

with

$$x^{(m)} = \frac{N + mA_H + (N-m)A_L}{N} \tag{53}$$

Using Pascal's rule, this condition can be rearranged to obtain

$$q^N \left[\left(\frac{\left(x^{(N)}\right)^{1-\eta}}{1-\eta} - \frac{\left(x^{(N-1)}\right)^{1-\eta}}{1-\eta} \right) - \left(\frac{\left(x^{(1)}\right)^{1-\eta}}{1-\eta} - \frac{\left(x^{(0)}\right)^{1-\eta}}{1-\eta} \right) \right] + q \left[\frac{\left(x^{(1)}\right)^{1-\eta}}{1-\eta} - \frac{\left(x^{(0)}\right)^{1-\eta}}{1-\eta} \right] \geq k \tag{54}$$

where the left-hand side is monotonically decreasing in N and approaching 0 for $N \to \infty$. As $k > 0$, this implies that $\exists \bar{N} \in [1, \infty]$ such that the constraint holds with equality.

2. Assume that $N > \bar{N}$. For the economy with aggregate production risk (finite N), the Lagrangian for the second-best social planner program is given by

$$\begin{aligned} L =& q \sum_{m=0}^{N-1} \binom{N-1}{m} q^m (1-q)^{N-1-m} \frac{\left(c_H^{(1+m)}\right)^{1-\eta}}{1-\eta} + (1-q) \sum_{m=0}^{N-1} \binom{N-1}{m} q^m (1-q)^{N-1-m} \frac{\left(c_L^{(m)}\right)^{1-\eta}}{1-\eta} \\ &+ \lambda \left[q \sum_{m=0}^{N-1} \binom{N-1}{m} q^m (1-q)^{N-1-m} \left(\frac{\left(c_H^{(m+1)}\right)^{1-\eta}}{1-\eta} - \frac{\left(c_L^{(m)}\right)^{1-\eta}}{1-\eta} \right) - k \right] \\ &- \sum_{m=0}^{N} \mu^{(m)} \left[m c_H^{(m)} + (N-m) c_L^{(m)} - N - mA_H - (N-m)A_L \right] \end{aligned} \tag{55}$$

The Karush-Kuhn-Tucker conditions are obtained as

$$\frac{\partial L}{\partial c_H^{(m)}} = q\binom{N-1}{m-1}q^{m-1}(1-q)^{N-m}\left(c_H^{(m)}\right)^{-\eta} + \lambda\left[q\binom{N-1}{m-1}q^{m-1}(1-q)^{N-m}\left(c_H^{(m)}\right)^{-\eta}\right] - \mu^{(m)}m = 0 \tag{56}$$

$$\frac{\partial L}{\partial c_L^{(m)}} = (1-q)\binom{N-1}{m}q^{m}(1-q)^{N-m-1}\left(c_L^{(m)}\right)^{-\eta} \tag{57}$$

$$- \lambda\left[q\binom{N-1}{m}q^{m}(1-q)^{N-1-m}\left(c_L^{(m)}\right)^{-\eta}\right] - \mu^{(m)}(N-m) = 0 \tag{58}$$

$$mx_H^{(m)} + (N-m)x_L^{(m)} \leq N + mA_H + (N-m)A_L,\ \mu^{(m)} \geq 0,\ \text{and} \tag{59}$$

$$\mu^{(m)}\left[mx_H^{(m)} + (N-m)x_L^{(m)} - N - mA_H - (N-m)A_L\right] = 0$$

$$q\sum_{m=0}^{N-1}\binom{N-1}{m}q^m(1-q)^{N-1-m}\left(\frac{\left(c_H^{(m+1)}\right)^{1-\eta}}{1-\eta} - \frac{\left(c_L^{(m)}\right)^{1-\eta}}{1-\eta}\right) \geq k, \tag{60}$$

$$\lambda \geq 0,\ \text{and}\ \lambda\left[q\sum_{m=0}^{N-1}\binom{N-1}{m}q^m(1-q)^{N-1-m}\left(\frac{\left(c_H^{(m+1)}\right)^{1-\eta}}{1-\eta} - \frac{\left(c_L^{(m)}\right)^{1-\eta}}{1-\eta}\right) - k\right] = 0$$

Setting $\lambda = 0$ (non-binding IC) and $\mu^{(m)} > 0$ (binding RC) leads to perfect risk sharing which is not an incentive-compatible allocation. Setting $\mu^{(m)} = 0$ (non-binding RC) and $\lambda > 0$ (binding IC) cannot be optimal as the resulting allocation is welfare dominated by allocating additional output to regions. Setting $\lambda = \mu^{(m)} = 0$ (neither IC nor RC bind) can never be optimal for the same reason. Thus, the only solution candidate is $\mu^{(m)} > 0\ \ \forall m$ and $\lambda > 0$ such that both RC and IC bind. Combining the first-order conditions with respect to $c_H^{(m)}$ and $c_L^{(m)}$ gives

$$c_H^{(m)} = \underbrace{\left(1 + \frac{\lambda}{1-q-q\lambda}\right)^{\frac{1}{\eta}}}_{\equiv\gamma} c_L^{(m)} \tag{61}$$

Using this expression in (RC) yields

$$c_H^{(m)} = \gamma\frac{N + mA_H + (N-m)A_L}{N + (\gamma-1)m} \tag{62}$$

$$c_L^{(m)} = \frac{N + mA_H + (N-m)A_L}{N + (\gamma-1)m} \tag{63}$$

The second-best transfers $t_H^{(m)}$ and $t_L^{(m)}$ follow from $t_H^{(m)} = c_H^{(m)} - (1 + A_H)$ and $t_L^{(m)} = c_L^{(m)} - (1 + A_L)$.

□

A.3. Proof of Corollary 1

The optimal agency wedge γ solves the incentive constraint:

$$\underbrace{q\sum_{m=0}^{N-1}\binom{N-1}{m}q^m(1-q)^{N-1-m}\left[\frac{\left[c_H^{(m+1)}\right]^{1-\eta}}{1-\eta}-\frac{\left[c_L^{(m)}\right]^{1-\eta}}{1-\eta}\right]-k=0}_{\equiv F(\gamma,A_H,A_L,\eta,k,q,N)} \tag{64}$$

with

$$c_H^{(m)}=\gamma\frac{N+mA_H+(N-m)A_L}{N+(\gamma-1)m},\quad c_L^{(m)}=\frac{N+mA_H+(N-m)A_L}{N+(\gamma-1)m} \tag{65}$$

The comparative statics of γ with respect to any parameter x are obtained using the implicit function theorem according to which

$$\frac{\partial\gamma}{\partial x}=-\frac{\frac{\partial F}{\partial x}}{\frac{\partial F}{\partial\gamma}} \tag{66}$$

It holds that

$$\frac{\partial F}{\partial\gamma}=q\sum_{m=0}^{N-1}\binom{N-1}{m}q^m(1-q)^{N-1-m}\left[\left[c_H^{(m+1)}\right]^{-\eta}\underbrace{\frac{\partial c_H^{(m+1)}}{\partial\gamma}}_{>0}-\left[c_L^{(m)}\right]^{-\eta}\underbrace{\frac{\partial c_L^{(m)}}{\partial\gamma}}_{<0}\right]>0 \tag{67}$$

$$\begin{aligned}\frac{\partial F}{\partial A_H}&=q\sum_{m=0}^{N-1}\binom{N-1}{m}q^m(1-q)^{N-1-m}\left[\left[c_H^{(m+1)}\right]^{-\eta}\frac{\partial c_H^{(m+1)}}{\partial A_H}-\left[c_L^{(m)}\right]^{-\eta}\frac{\partial c_L^{(m)}}{\partial A_H}\right]\\&=q\sum_{m=0}^{N-1}\binom{N-1}{m}q^m(1-q)^{N-1-m}\left[\left(\frac{N+mA_H+(N-m)A_L}{N+m(\gamma-1)}\right)^{-\eta}\frac{m}{N+m(\gamma-1)}\left[\gamma^{1-\eta}-1\right]\right]>0\end{aligned} \tag{68}$$

since $\gamma>1$.

$$\frac{\partial F}{\partial\eta}=q\sum_{m=0}^{N-1}\binom{N-1}{m}q^m(1-q)^{N-1-m}\left[\left[c_H^{(m+1)}\right]^{-\eta}-\left[c_L^{(m)}\right]^{-\eta}\right]<0 \tag{69}$$

$$\frac{\partial F}{\partial k}=-1<0 \tag{70}$$

$$\frac{\partial F}{\partial q}= \tag{71}$$

due to the fact that $\gamma>1$ and the concavity of the utility function. This implies that

$$\frac{\partial\gamma}{\partial A_H}<0,\quad\frac{\partial F}{\partial A_L}<0,\quad\frac{\partial F}{\partial\eta}<0,\quad\frac{\partial F}{\partial k}<0 \tag{72}$$

Further, from the proof of the first part of Proposition 4 we know that $F(N+1)>F(N)$ so that $\gamma(N+1)>\gamma(N)$. □

A.4. Proof of Lemma 2

Let the realization of aggregate production be given by m. Goods market clearing implies that $P^{(m)} = \frac{N}{mA_H+(N-m)A_L}$. Each region obtains $\frac{1}{P^{(m)}} = \frac{mA_H+(N-m)A_L}{N}$ units of goods from the goods market. Then,

$$CA_i^{(m)} \equiv y_i - \frac{1}{P^{(m)}} = \begin{cases} A_L - \frac{mA_H+(N-m)A_L}{N} = \frac{m(A_L-A_H)}{N} < 0 & \text{if } A_i = A_L \\ A_H - \frac{mA_H+(N-m)A_L}{N} = \frac{(N-m)(A_H-A_L)}{N} > 0 & \text{if } A_i = A_H \end{cases} \quad (73)$$

It follows that

$$NET_i^{(m)} \equiv P \cdot CA_i^{(m)} = Py_i - 1 = \begin{cases} A_L \frac{N}{mA_H+(N-m)A_L} - 1 = \frac{m(A_L-A_H)}{mA_H+(N-m)A_L} < 0 & \text{if } A_i = A_L \\ A_H \frac{N}{mA_H+(N-m)A_L} - 1 = \frac{(N-m)(A_H-A_L)}{mA_H+(N-m)A_L} > 0 & \text{if } A_i = A_H \end{cases} \quad (74)$$

Obviously, $mCA_H^{(m)} + (N-m)CA_L^{(m)} = mNET_H^{(m)} + (N-m)NET_L^{(m)} = 0$. □

A.5. Proof of Proposition 2

Consider two regions, i and j. Hypothetical price levels are given by $P_i = \frac{1}{y_i}$. In the currency union, it holds that $P = \frac{2}{y_1+y_2}$. Net money flows between regions in the currency union are given by

$$NET_i = P \cdot y_i - 1 = \frac{P}{P_i} - 1 = \frac{P - P_i}{P_i} \quad (75)$$

which is greater than zero if $P_i < P$ and less than zero if $P_i > P$. This condition boils down to

$$P > P_i \quad (76)$$

$$\Leftrightarrow \quad \frac{2}{y_1 + y_2} > y_1 \quad (77)$$

$$\Leftrightarrow \quad y_2 < y_1 \quad (78)$$

$$\Leftrightarrow \quad P_2 > P_1 \quad (79)$$

□

A.6. Proof of Lemma 3

A region in low state ($y_i = A_L$) incurs a deficit with the central bank at the end of t given by $NET_L^{(m)} = P^{(m)}A_L - 1 = \frac{m(A_L-A_H)}{mA_H+(N-m)A_L}$. At the rate r_{CB}, the central bank stands ready to refinance the net deficit at a real cost $r_{CB}NET_L^{(m)}$. The deficit region transfers the corresponding amount of consumption goods to the central bank which forwards them to surplus regions. The nominal market value of these real resource transfers is given by $P^{(m)} \cdot r_{CB} \cdot NET_L^{(m)}$. That is, if $r_{CB} < \frac{1}{P^{(m)}}$, then not all nominal deficits will be covered through corresponding good flows at market rate. The difference is accounted for by overdraft balances.

□

A.7. Proof of Proposition 3

The central bank achieves risk sharing through the common currency if

$$1+\frac{1}{P^{(m)}}+r_{CB}NET_H^{(m)}<1+A_H \tag{80}$$

where $\frac{1}{P^{(m)}}=\frac{Y^{(m)}}{N}$ and $NET_H^{(m)}=P^{(m)}A_H-1$. This can be rearranged to obtain

$$r_{CB}<\frac{P^{(m)}A_H-1}{P^{(m)}\left(P^{(m)}A_H-1\right)}=\frac{1}{P^{(m)}} \tag{81}$$

Further, this solution for r_{CB} implies that

$$1+\frac{1}{P^{(m)}}+r_{CB}NET_L^{(m)}>1+A_L \tag{82}$$

Furthermore, since $B^{(m)}=m(1-P^{(m)}r_{CB})NET^{(m)}$, $r_{CB}<\frac{1}{P^{(m)}}$ implies that $B^{(m)}>0$.

□

A.8. Proof of Proposition 4

The central bank implements

$$1+\frac{1}{P^{(m)}}+r_{CB}NET_H^{(m)}=c_H^{(m)} \tag{83}$$

where

$$P^{(m)}=\frac{N}{mA_H+(N-m)A_L} \tag{84}$$

$$c_H^{(m)}=\gamma\frac{N+mA_H+(N-m)A_L}{N+(\gamma-1)m} \tag{85}$$

$$NET_H^{(m)}=\frac{(N-m)(A_H-A_L)}{mA_H+(N-m)A_L} \tag{86}$$

Using these expressions to solve for r_{CB} gives

$$r_{CB}^{(m)}=\underbrace{\frac{mA_H+(N-m)A_L}{N}}_{=\frac{1}{P^{(m)}}}\underbrace{(\gamma-1)\frac{N+mA_H+(N-m)A_L}{(N+(\gamma-1)m)\,(A_H-A_L)}}_{=\frac{c_H^{(m)}-c_L^{(m)}}{A_H-A_L}} \tag{87}$$

which implies that $r_{CB}^{(m)}<\frac{1}{P^{(m)}}$ since $c_H^{(m)}-c_L^{(m)}<A_H-A_L$ in any risk sharing allocation. Using $B^{(m)}=m(1-P^{(m)}r_{CB}^{(m)})NET_H^{(m)}$ gives

$$B^{(m)}=\frac{mN(N-m)\left[1+A_H-\gamma(1+A_L)\right]}{(mA_H+(N-m)A_L)(N+(\gamma-1)m)} \tag{88}$$

which simplifies to the expression provided in the Proposition. □

A.9. Proof of Proposition 5

1. For given m: Consider first the optimal policy rate r_{CB}. It holds that

$$\frac{\partial r_{CB}^{(m)}}{\partial \gamma} = \frac{(A_H m + A_L(N-m))(A_H m + A_L(N-m) + N)}{((\gamma-1)m+N)^2(A_H - A_L)} > 0 \tag{89}$$

We know from Proposition 1 that $\frac{\partial \gamma}{\partial q} < 0$ and $\frac{\partial \gamma}{\partial k} > 0$. Thus, $\frac{dr_{CB}}{dq} < 0$ and $\frac{dr_{CB}}{dk} > 0$. Further, $\frac{\partial \gamma}{\partial N} > 0$ and

$$\frac{\partial r_{CB}}{\partial N} = \frac{m(A_H - \gamma A_L)(A_H - (1+A_L)\gamma + 1)}{(A_H - A_L)((\gamma-1)m+N)^2} + \frac{m(A_L - A_H)}{N^2} < 0 \tag{90}$$

so that $\frac{dr_{CB}}{dN} = \frac{\partial r_{CB}}{\partial N} + \frac{\partial r_{CB}}{\partial \gamma}\frac{\partial \gamma}{\partial N} \lesseqgtr 0$. We further get

$$\frac{\partial r_{CB}}{\partial A_L} = \frac{(\gamma-1)\left(N^2\left(2A_H A_L + A_H - A_L^2\right) - m^2(A_H-A_L)^2 + 2mN(A_H-A_L)^2\right)}{N(A_H-A_L)^2((\gamma-1)m+N)} > 0 \tag{91}$$

which is unambiguously positive since $m < N$ and $A_H > A_L$. Further,

$$\frac{\partial r_{CB}}{\partial A_H} = \frac{(\gamma-1)\left(m^2(A_H-A_L)^2 - A_L(A_L+1)N^2\right)}{N(A_H-A_L)^2((\gamma-1)m+N)} \tag{92}$$

which is negative if $m < \frac{N}{A_H - A_L}\sqrt{A_L^2 + A_L}$ and (weakly) positive if $m \geq \frac{N}{A_H-A_L}\sqrt{A_L^2+A_L}$. We know from Proposition 1 that $\frac{\partial \gamma}{\partial A_H} < 0$ and $\frac{\partial \gamma}{\partial A_L} > 0$. Hence, $\frac{dr_{CB}}{dA_L} > 0$, $\frac{dr_{CB}}{dA_H} < 0$ if $m < N\frac{A_L}{A_H - A_L}$ and $\frac{dr_{CB}}{dA_H} \lesseqgtr 0$ if $m \geq N\frac{A_L}{A_H-A_L}$.
Now consider optimal balances B. It holds that

$$\frac{\partial B}{\partial A_H} = \frac{mN(N-m)\left((1+A_L)(\gamma-1)m + NA_L\right)}{(N+(\gamma-1)m)\left[mA_H + (N-m)A_L\right]^2} > 0 \tag{93}$$

$$\frac{\partial B}{\partial A_L} = -\frac{mN(N-m)\left((1+A_H)(\gamma-1)m + (1+A_H-\gamma)N\right)}{\left[mA_H+(N-m)A_L\right]^2(N+(\gamma-1)m)} < 0 \tag{94}$$

$$\frac{\partial B}{\partial \gamma} = \frac{m(m-N)N(mA_H + (N-m)A_L + N)}{\left[(\gamma-1)m+N\right]^2(mA_H + (N-m)A_L)} < 0 \tag{95}$$

and

$$\frac{\partial B}{\partial N} = -\frac{m^2(-A_H + \gamma A_L + \gamma - 1)\left(A_H\left((1-\gamma)m^2 + 2(\gamma-1)mN + N^2\right) + A_L(\gamma-1)(m-N)^2\right)}{((\gamma-1)m+N)^2(A_H m + A_L(N-m))^2} > 0 \tag{96}$$

We know from Proposition 1 that $\frac{\partial \gamma}{\partial k} > 0$, $\frac{\partial \gamma}{\partial q} < 0$, $\frac{\partial \gamma}{\partial N} > 0$, $\frac{\partial \gamma}{\partial A_H} < 0$, $\frac{\partial \gamma}{\partial \eta} > 0$, and $\frac{\partial \gamma}{\partial A_L} > 0$. Thus, $\frac{\partial B}{\partial k} < 0$, $\frac{dB}{dq} > 0$, $\frac{dB}{dA_H} > 0$, $\frac{dB}{dA_L} < 0$, $\frac{\partial B}{\partial \eta}$¡0, and $\frac{dB}{dN} \lesseqgtr 0$.

2. For given $\{k, \eta, A_L, q, A_H\}$: We have that

$$\frac{\partial r_{CB}^{(m)}}{\partial m} = (\gamma-1)\frac{(\gamma-1)m^2(A_H-A_L)^2 + 2mN(A_H-A_L)^2 + A_H(2A_L+1)N^2 - A_L N^2(A_L\gamma + A_L + \gamma)}{N((\gamma-1)m+N)^2(A_H-A_L)} > 0 \tag{97}$$

For optimal balances B, we get

$$\frac{\partial B}{\partial m} = \frac{(\gamma(1+A_L) - (1+A_H))\left[A_H \gamma m^2 - A_L(m-n)^2\right] N^2}{[(\gamma-1)m+N]^2\,[mA_H + (N-m)A_L]^2} \tag{98}$$

where $\gamma(1+A_L) - (1+A_H) < 0$. This implies that there is a $\bar{m} \in (0, N)$ given by

$$\bar{m} \equiv \frac{N\sqrt{A_L}}{\sqrt{A_L} + \sqrt{\gamma A_H}} \tag{99}$$

such that $\frac{\partial B}{\partial m} > 0$ if $m < \bar{m}$, and $\frac{\partial B}{\partial m} \leq 0$ if $m \geq \bar{m}$.

□

A.10. Proof of Proposition 6

Seigniorage is given by $S^{(m)} = B^{(m)} \frac{Y^{(m)}}{N}$ where optimal balances $B^{(m)}$ are given by

$$B^{(m)} = \frac{(N-m)Nm(A_H - \gamma A_L)}{[(\gamma-1)m+N]\,[mA_H + (N-m)A_L]} \tag{100}$$

and $Y^{(m)} = mA_H + (N-m)A_L$. Using these two expressions yields the expression for S provided in the Proposition. □

A.11. Proof of Proposition 7

The fiscal authority will transfer all tax revenue to regions with a low shock. The optimal tax rate t then follows from the fiscal authority's budget constraint:

$$t\,[N + mA_H + (N-M)A_L] = (N-m)\left[c_L^{SB} - (1-t)(1+A_L)\right] \tag{101}$$

$$\Leftrightarrow \quad tm(1+A_H) = (N-m)(c_L^{SB} - (1+A_L)) \tag{102}$$

where the expression for c_L^{SB} is taken from Proposition 1. This expression gives the term for t provided in the Proposition. Further, it holds that $S = \frac{B}{P} = (N-m)(c_L^{SB} - (1+A_L))$. □

A.12. Proof of Proposition 8

Follows immediately from the assumption of anonymous voting. □

A.13. Proof of Proposition 9

Definition: A competitive equilibrium with complete markets and with aggregate risk is a vector of consumption levels, asset holdings and asset prices $\{c_H^{(m)}, c_L^{(m)}, a_H^{(m)S}, a_H^{(m)D}, p_H^{(m)}, p_L^{(m)}\}$ where $m = \{0, 1, ..., N\}$ denotes the number of regions with a high productivity shock, $\boldsymbol{c_H^{(m)}} = (c_H^{(0)}, ..., c_H^{(N)})$, $\boldsymbol{c_L^{(m)}} = (c_L^{(0)}, ..., c_L^{(N)})$, $\boldsymbol{a_H^{(m)S}} = (a_H^{(1)S}, ..., a_H^{(N-1)S})$, and $\boldsymbol{a_H^{(m)D}} = (a_H^{(1)D}, ..., a_H^{(N-1)D})$ such that

(a) households solve their maximization problem:

$$\max_{c_H^{(m)},c_L^{(m)}} \quad q\sum_{m=0}^{N-1}\binom{N-1}{m}q^m(1-q)^{N-1-m}\frac{\left(c_H^{(m+1)}\right)^{1-\eta}}{1-\eta}+(1-q)\sum_{m=0}^{N-1}\binom{N-1}{m}q^m(1-q)^{N-1-m}\frac{\left(c_L^{(m)}\right)^{1-\eta}}{1-\eta} \tag{103}$$

$$s.t. \qquad c_H^{(m)} = A_H-(N-1)a_H^{(m)S}+(m-1)a_H^{(m)D} \quad \forall m\in\{1,...,N-1\} \tag{104}$$

$$c_L^{(m)} = A_L+ma_H^{(m)D} \quad \forall m\in\{1,...,N-1\} \tag{105}$$

$$A_H+(m-1)a_H^{(m)D}\geq(N-1)a_H^{(m)S} \quad \forall m\in\{1,...,N-1\} \tag{106}$$

(b) the allocation is feasible in every state of the world:

$$mc_H^{(m)}+(N-m)c_L^{(m)} = mA_H+(N-m)A_L \quad \forall m\in\{0,...,N\} \tag{107}$$

(c) the asset market clears (each security is in zero net supply):

$$(N-1)a_H^{(m)D} = (N-1)a_H^{(m)S} \quad \forall m\in\{1,...,N-1\} \tag{108}$$

In equilibrium, we have that

$$c_H^{(m)} = \frac{mA_H+(N-m)A_L}{N} \quad \forall m\in\{0,...,N\} \tag{109}$$

$$c_L^{(m)} = \frac{mA_H+(N-m)A_L}{N} \quad \forall m\in\{0,...,N\} \tag{110}$$

$$a_H^{(m)D} = a_H^{(m)S} = \frac{A_H-A_L}{N} \quad \forall m\in\{0,...,N\} \tag{111}$$

i.e. regions issue $N-1$ own Arrow securities at a quantity of $\frac{A_H-A_L}{N}$ per security and buy $N-1$ Arrow securities from other regions at a quantity of $\frac{A_H-A_L}{N}$ per security. Each region holds a portfolio of securities from all other regions, thereby perfectly sharing risk. If asset trades are unobservable, however, individual regions will 'overinsure' and not provide effort. □

B. Empirical Section

B.1. Data Sources

Current Account and National Account Data is obtained from National Accounts of OECD Countries, Volume I, Main Aggregates and National Accounts of OECD Countries, Volume II, Detailed. Calculations are made for real per capita values. Population data as well as CPI deflator data (2015=100) is obtained from the OECD. The TARGET balance data is retrieved from the Institute of Empirical Economic Research - Osnabrück University (eurocrisismonitor.com). Finally, the import partner data comes from the World Integrated Trade Solution (WITS) software at the World Bank (wits.worldbank.org).

B.2. TARGET transfers for Core Countries

Country	Year	Implied TARGET Transfer (% of GDP)
Germany	2008	-0.4%
Germany	2009	-0.3%
Germany	2010	-0.5%
Germany	2011	-0.5%
Germany	2012	-0.07%
Netherlands	2008	-0.6%
Netherlands	2009	-0.4%
Netherlands	2010	-0.8%
Netherlands	2011	-0.8%
Netherlands	2012	-0.1%
Finland	2008	-0.3%
Finland	2009	-0.2%
Finland	2010	-0.2%
Finland	2011	-0.2%
Finland	2012	-0.03%
Luxembourg	2008	-0.5%
Luxembourg	2009	-0.3%
Luxembourg	2010	-0.6%
Luxembourg	2011	-0.5%
Luxembourg	2012	-0.1%

Table 4: Implied TARGET Transfer for Core during Eurocrisis

B.3. Additional Regression Results

Table 5 reports the results of the estimation for the subsample of Periphery countries (Greece, Ireland, Italy, Portugal, Spain). For this subsample, TARGET transfers contributed to around 80% of total consumption smoothing during the years 2008 and 2009.[29] Finally, Table 6 shows the results of the estimation for the Core countries subsample. It is apparent that for these countries, TARGET transfers did not play any meaningful role in consumption smoothing. In general, it is noteworthy that for core countries only 15% of shocks to GDP are unsmoothed in 2008 and 2009 while 52% are unsmoothed for Periphery countries during the same time period. Without the TARGET transfers, these differences in consumption smoothing would have been even more pronounced. Without these transfers, 90% of shocks would have been unsmoothed in the Periphery while only 23% would have been unsmoothed in the Core. This illustrates both the absence of effective traditional risk sharing mechanisms in the Eurozone in general as well

[29] The results for the years 2008 and 2009 in the Periphery subsample are not significant due to the small sample size. The coefficient on β_{TARGET} is significant at the 15% level.

as the quantitative importance of the common currency channel during the early stages of the Eurocrisis.

	2003-2007	2008-2009	2010-2014
Factor Income (β_f)	0.035	-0.034	0.032
	(0.091)	(0.123)	(0.099)
Capital Depreciation (β_d)	0.124***	0.048	-0.063*
	(0.027)	(0.045)	(0.033)
International Transfers (β_t)	-0.000	-0.031*	-0.002
	(0.026)	(0.016)	(0.023)
Savings (β_s)	0.191	0.107	0.560***
	(0.245)	(0.339)	(0.144)
TARGET (β_{TARGET})	0.152	0.385	-0.326***
	(0.179)	(0.273)	(0.109)
Not Smoothed (β_u)	0.498***	0.525***	0.799***
	(0.050)	(0.086)	(0.078)

Standard errors are in brackets. *p<0.1; **p<0.05; ***p<0.01.

Table 5: Risk Sharing Channels: Periphery Countries

Note: The table shows the results from performing the regressions in (39)-(44) for the subset of Periphery countries (Greece, Ireland, Italy, Portugal, Spain) in the sample and for the three different subperiods: before Eurocrisis (2003-2007), first stage of Eurocrisis (2008-2009), and second stage of Eurocrisis (2010-2014). Coefficient interpretation is as before.

	2003-2007	2008-2009	2010-2014
Factor Income (β_f)	0.730	-0.696	-0.028
	(0.530)	(0.541)	(0.171)
Capital Depreciation (β_d)	-0.032	-0.512***	-0.171**
	(0.083)	(0.190)	(0.080)
International Transfers (β_t)	0.220	0.868	-0.263**
	(0.305)	(0.155)	(0.126)
Savings (β_s)	-0.126	1.108**	1.161**
	(0.837)	(0.512)	(0.524)
TARGET (β_{TARGET})	0.002	0.080	-0.000
	(0.003)	(0.062)	(0.003)
Not Smoothed (β_u)	0.206*	0.153***	0.302
	(0.124)	(0.002)	(0.188)

Standard errors are in brackets. *p<0.1; **p<0.05; ***p<0.01.

Table 6: Risk Sharing Channels: Core Countries

Note: The table shows the results from performing the regressions in (39)-(44) for the subset of Core countries (Austria, Belgium, Finland, France, Germany, Luxembourg, Netherlands) in the sample and for the three different subperiods: before Eurocrisis (2003-2007), first stage of Eurocrisis (2008-2009), and second stage of Eurocrisis (2010-2014). Coefficient interpretation is as before.